Lower Duwamish Waterway Superfund Site
Terminal 117 Early Action Area

REVISED ENGINEERING EVALUATION/COST ANALYSIS

~~DRAFT FINAL~~

Prepared for:

The Port of Seattle
and
The City of Seattle

For submittal to:

US Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, WA 98101

~~January 19~~June 3, 2010

Prepared by:

Windward environmental LLC
integral consulting inc.
AECOM
CRETE CONSULTING, INC.
Dalton, Olmsted & Fuglevand, Inc.
Environmental Consultants

Table of Contents

Appendices

List of Tables

List of Figures

List of Maps

All maps are included in a separate folio.

Acronyms and Abbreviations

AcronymACRONYM	Definition
AOC	Administrative Order on Consent
ARAR	applicable or relevant and appropriate requirement
ASAOC	Administrative Settlement Agreement and Order on Consent
AST	aboveground storage tank
ATSDR	Agency for Toxic Substances and Disease Registry
Basin Oil	Basin Oil Company, Inc.
BBP	butyl benzyl phthalate
BEHP	bis(2-ethylhexyl) phthalate
bgs	below ground surface
BMP	best management practice
BTEX	benzene, toluene, ethylbenzene, and xylene
Boeing	The Boeing Company
CCC	criteria continuous concentration
CD	compact disk
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)
CFR	Code of Federal Regulations
cfs	cubic feet per second
City	City of Seattle
CMC	criteria maximum concentration
COC	contaminant of concern
COPC	contaminant of potential concern
County	King County
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSGWPP	Comprehensive State Ground Water Protection Program
CSL	cleanup screening level
CSM	conceptual site model
CSO	combined sewer overflow
CSS	combined sewer system
CUL	cleanup level
cy	cubic yard
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DOF	Dalton, Olmsted & Fuglevand, Inc.
DPD	Department of Planning and Development
DU	decision unit

AcronymCRONYM	Definition
dw	dry weight
EAA	early action area
Ecology	Washington State Department of Ecology
EE/CA	engineering evaluation/cost analysis
EFH	essential fish habitat
EPA	US Environmental Protection Agency
FRTR	Federal Remediation Technologies Roundtable
FS	feasibility study
FSP	field sampling plan
HHRA	human health risk assessment
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
HQ	hazard quotient
Integral	Integral Consulting, Inc.
KCBOH	King County Board of Health
KCCWD1	King County Commercial Waterway District No. 1
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
LNAPL	light non-aqueous-phase liquid
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
Malarkey	Malarkey Asphalt Company
Marina	South Park Marina
MCL	maximum contaminant level
MIS	multi-increment sampling
MLLW	mean lower low water
MTCA	Model Toxics Control Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRDA	natural resource damage assessment
NTCRA	non-time-critical removal action
O&M	operation and maintenance
OC	organic carbon
OMMP	operation, maintenance, and monitoring plan
ORP	oxidation-reduction potential
OSWER	Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbon
RBTC	risk-based threshold concentration
PCB	polychlorinated biphenyl
PCE	tetrachloroethylenes

AcronymCRONYM	Definition
Port	Port of Seattle
PQL	practical quantitation limit
PRG	preliminary remediation goal
PSDDA	Puget Sound Dredged Disposal Analysis
QAPP	quality assurance project plan
QA/QC	quality assurance/quality control
RAA	recontamination assessment area
RAL	remedial action level
RAO	removal action objective
RBTC	risk-based threshold concentration
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RM	river mile
ROD	Record of Decision
ROW	right-of-way
RvAL	removal action level
SAIC	Science Applications International Corporation
SCAP	source control action plan
SCL	Seattle City Light
SCWG	Source Control Work Group
SL	screening level
SMC	Seattle Municipal Code
SMS	Washington State Sediment Management Standards
SOW	statement of work
SPCC	South Park Community Center
SPU	Seattle Public Utilities
SQS	sediment quality standards
STAR	sediment transport analysis report
STM	sediment transport model
SVOC	semivolatile organic compound
T-117	Terminal 117
TBT	tributyltin
TCDD	tetrachlorodibenzo-*p*-dioxin
TCLP	toxicity characteristic leaching procedure
TCRA	time-critical removal action
TEE	terrestrial ecological evaluation
TEF	toxic equivalency factor
TEQ	toxic equivalent
TOC	total organic carbon
TPH	total petroleum hydrocarbons

AcronymCRONYM	Definition
TPH-D	diesel-range total petroleum hydrocarbons
TPH-O	lube oil-range total petroleum hydrocarbons
TSCA	Toxic Substances Control Act
UCL	upper confidence limit on the mean
USACE	US Army Corps of Engineers
USFWS	US Fish and Wildlife Service
UST	underground storage tank
VOC	volatile organic compound
WAC	Washington Administrative Code
WSDOH	Washington State Department of Health
Windward	Windward Environmental LLC

1 Introduction

Terminal 117 (T-117) is a site within the Lower Duwamish Waterway (LDW) Superfund site that was selected for early action in 2003 to address polychlorinated biphenyl (PCB) contamination in sediment. An upland portion of T-117 was historically used for the manufacture of asphalt products, as well as other activities associated with former tenants. Asphalt manufacturing operations at the site included the use of recycled oils, some of which contained PCBs, and these oils are believed to be a source of contaminants released to the surrounding soil and sediment.

In 2005, the Port of Seattle (Port) and the City of Seattle (City) prepared an engineering evaluation/cost analysis (EE/CA) for a non-time-critical removal action (NTCRA) for the sediment and adjacent shoreline bank area, which was submitted to the US Environmental Protection Agency (EPA). EPA approved the 2005 EE/CA (Windward et al. 2005c) for the T-117 Early Action Area (EAA) sediment and adjacent bank and issued an action memorandum (EPA 2006a), which set forth the implementation of the NTCRA. At that time, it was assumed that only minor revisions to the upland side of the sediment removal action boundary would be needed. However, in 2006, additional PCB contamination was discovered in the T-117 upland property, the extent of which was broader than originally anticipated. This resulted in an increased scope for the NTCRA. In addition, in 2004-2005, PCBs were discovered in the streets adjacent to the T-117 upland property and removed from two residential yards.;, and in 2008, PCBs and dioxins and furans were discovered in residential yards near the T-117 EAA. In March of 2007, the Washington State Department of Ecology (Ecology) notified EPA that it supported incorporating the work proposed by the City for Dallas Avenue S into EPA's T-117 NTCRA (Ecology 2007). Thus, the T-117 EAA was expanded by EPA to include three areas, hereafter referred to as the T-117 Sediment Study Area, the T-117 Upland Study Area, and the Adjacent Streets and Residential Yards Study Area.

In 2008, LDW source control samples collected in 2004-2005 were evaluated for dioxins and furans, and concentrations were determined to be above the Model Toxics Control Act (MTCA) Method B cleanup level (CUL) at two locations near T-117. EPA ordered additional analysis for PCBs and dioxins and furans in 2008, and both contaminants were discovered above the MTCA Method B CUL in streets, rights--of--way (ROWs), and residential yards. As a result, EPA directed the Adjacent Streets portion of the T-117 EAA to be expanded to include the area bounded by Dallas Avenue S to the north and east, 14th Avenue S to west, and S Donovan Street to the south (EPA 2009c). This area is now referred to as the Adjacent Streets and Residential Yards Study Area. The scope of the T-117 EE/CA includes the evaluation of removal action alternatives for all three of the T-117 study areas.

The scope of this EE/CA is set forth in the *Terminal 117 Early Action Area Work Plan for Revised Engineering Evaluation/Cost Analysis* (Windward et al. 2008), hereafter referred to as the EE/CA Work Plan. This EE/CA is being prepared by the Port and the City pursuant to an Administrative Settlement Agreement and Order on Consent (ASAOC) with EPA (Docket No.10-2006-0103, December 22, 2005 (EPA 2005b)) and in accordance with Amendment No. 1 to the statement of work (SOW) dated September 28, 2007 (EPA 2007c) (Appendix A).

The SOW also required an assessment of the potential for recontamination of the T-117 EAA by the adjoining Basin Oil Company, Inc. (Basin Oil), property and South Park Marina (Marina), collectively referred to as the recontamination assessment areas (RAAs). Map 1-1 shows the T-117 EAA and the RAAs. An evaluation of the RAAs is included in this EE/CA, which is necessary to ensure the long-term permanence of the selected removal alternative.

In addition, the scope of this EE/CA complies with the requirements set forth in EPA's *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (1993), including a comprehensive compilation of existing site data to support the identification and analysis of contaminants of concern (COCs), site risks, and the removal alternatives necessary to address those contaminants and associated risks. EPA has specifically requested that the EE/CA include removal action alternatives that are compatible with the anticipated future unrestricted land use (EPA 2007b) (Appendix A). The presentation of removal action alternatives includes a discussion of different ways in which the removal action can be completed in order to meet EPA's future land use request. Removal action technologies are similar to those presented in the 2005 EE/CA (Windward et al. 2005c) and the 2008 EE/CA Work Plan (Windward et al. 2008) and are further developed and refined in this EE/CA.

The overall goal of the T-117 EAA NTCRA is to significantly reduce the exposure of ecological and human receptors to sediment and soil contamination and thereby reduce or eliminate adverse effects on resources in the EAA. The NTCRA will also reduce risks to human health by removing or isolating bioaccumulative and toxic chemicals that are present in sediment and soil at the T-117 EAA (EPA 2005c). In addition, the removal of contaminated soil will reduce or eliminate groundwater contamination.

1.1 CERCLA Project Progression

This section summarizes the history of the LDW as a Superfund site and the identification of the T-117 as an EAA within the LDW. T-117 has been investigated by both state and federal agencies prior to the LDW Superfund listing. Additional details on the regulatory history prior to the LDW Superfund designation are presented in Sections 2.1.2 and 2.2, respectively. A timeline showing project history and regulatory milestones is presented in Figure 1-1.

Slipsheet (11 x 17)

Figure 1-1. Timeline of T-117 project history and regulatory milestones

1.1.1 Lower Duwamish Waterway and early action areas

The T-117 EAA is within the LDW Superfund site. The LDW was added to EPA's National Priorities List (NPL) defined under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund, on September 13, 2001. The Phase 1 remedial investigation (RI) report for the LDW (Windward 2003a) presented a summary of available data for the waterway. One of the primary objectives of the Phase 1 RI was to identify candidate areas within the LDW for early removal action. The Port, the City, King County (County), and The Boeing Company (Boeing), working together as the Lower Duwamish Waterway Group (LDWG), prepared a technical memorandum (Windward 2003b) that recommended seven areas, one of which was T-117, to EPA and ~~the Washington State Department of Ecology (~~Ecology~~)~~ for early removal action. In 2003, EPA required that T-117 be investigated as an EAA, primarily because of the high concentrations of PCBs and the potential for those PCBs to contaminate LDW sediment (EPA 2005b).

1.1.2 Initial early action area investigations and 2005 EE/CA

Since T-117 was selected as an EAA, the Port and the City have conducted a series of environmental investigations to further characterize environmental conditions in the Sediment Study Area, identified a removal action boundary, and investigated potential sources of contamination. The results of these efforts have included a summary of existing information and data gaps report (Windward et al. 2003), several data reports (Windward et al. 2005b, d, e), and the 2005 EE/CA (Windward et al. 2005c). These investigations (and the resulting reports) for the T-117 EAA were conducted under the existing LDW Administrative Order on Consent (AOC) (EPA 2003) signed by all of the LDWG members, as well as by EPA and Ecology. Although all four members of LDWG are responsible for the LDW RI (Windward 2009), work at the T-117 EAA is conducted by only the Port and the City.

After the approval of the 2005 EE/CA (Windward et al. 2005c) on July 22, 2005, EPA issued a removal action memorandum (EPA 2005a) to implement the NTCRA design and removal activities. The removal action memorandum requested further characterization of PCB contamination in the northern portion of the bank necessary to finalize the removal action boundary prior to NTCRA implementation. The additional bank characterization sampling resulted in the discovery of higher-than-expected PCB concentrations in the bank at the northern part of the T-117 EAA. This led EPA to require further sampling to delineate the extent of PCBs in the upland soil. An ASAOC (CERCLA 10-2006-0072) (EPA 2005c) was issued solely to the Port on October 17, 2005, for an additional T-117 upland soil investigation to determine the nature and extent of upland PCB soil contamination. In an effort to continue moving forward on NTCRA activities, on December 22, 2005, an ASAOC (EPA 2005b) was issued jointly to the Port and the City with a SOW for the NTCRA design and removal. However, in January

2006, additional site characterization investigations conducted by the Port found high concentrations of PCBs in soil (Windward and DOF 2006). These ~~data~~ concentrations prompted a time-critical removal action (TCRA) to remove contaminated soil from specific areas within the T-117 Upland Study Area prior to conducting the NTCRA, which postponed the joint Port and City NTCRA activities.

1.1.3 2006 time-critical removal action

At the direction of EPA, the Port implemented the TCRA for the T-117 Upland Study Area to remove upland ~~source material~~contaminated soil that could potentially recontaminate the sediment and affect the success of the planned NTCRA for the Sediment Study Area. A TCRA memorandum (EPA 2006a) to address risks posed by the upland soil contamination was issued by EPA on June 15, 2006. EPA concluded that the scope of the TCRA would be limited to those areas of T-117 with the highest documented concentrations of PCBs in soil, as well as a limited area near the bank with exposed contaminated soil (i.e., an unpaved area), and that the rest of the upland contamination would be more efficiently addressed as in the T-117 EAA NTCRA. The SOW (EPA 2006b) for the implementation of the TCRA to address the most contaminated areas of the T-117 Upland Study Area was issued to the Port on August 11, 2006. The Port completed the TCRA in November 2006 (RETEC 2007b). The SOW required the implementation of the post-TCRA site operation and maintenance (O&M) program, which is currently ongoing (RETEC 2007a). Semi-annual O&M reports are submitted to EPA. Details, such as excavation volumes and depths, of the 2006 TCRA removal activities are discussed in Section 2.2.3.

1.1.4 Inclusion of the Adjacent Streets

In 2007, the City requested that Ecology support the inclusion of the Adjacent Streets and ROWs in EPA's NTCRA with the intention that the temporary measures implemented as part of~~t~~ the City's previous independent cleanup actions (i.e., temporary asphalt and gravel on roads and ROWs and surface water collection system routed to Baker tanks) would be replaced and longer needed after implementation of the NTCRA.

1.1.~~4~~5 Dioxin investigations and PCB boundary refinement

The City's source-tracing program for the LDW (Herrera 2004) included the analysis of 11 samples, including ~~two~~ 2 samples collected near T-117, for dioxins and furans. The two samples included one street dust (i.e., fine soil accumulated on street surfaces and shoulders) sample collected at the intersection of Dallas Avenue S and 16th Avenue S (within the area now designated as the Adjacent Streets portion of the T-~~-~~117 EAA) and a sample collected from a settling tank (later replaced by an oil-water separator) located on the Basin Oil property. The LDW source-tracing samples were analyzed for a suite of chemicals. Dioxin congener concentrations from this sampling program were used to calculate toxic equivalents (TEQs),[1] ~~concentrations,~~ which were reviewed by the City in 2008 (Integral 2008b). The dioxin/furan TEQs for the street dust and the settling tank samples were 90.5 ng/kg and 15.2 ng/kg, respectively. The street dust sample dioxin/furan TEQ- was more than twice the maximum TEQ of the other 11 samples and was found in an area where PCB concentrations were above the MTCA Method B CUL. Because these data are not related to the T-117 EAA, their significance is uncertain.~~two source-tracing samples, it is unclear if these samples reflect isolated areas with higher levels of dioxin/furan TEQs.~~

As a result of these findings, the City proposed an additional investigation (Integral 2008a) ~~of residential yards~~ to examine the presence of dioxins and furans in the vicinity of the street dust sample, which was to include the collection of samples in several yards and from borings in the streets. EPA requested that additional investigations be conducted in all three T-117 EAA study areas. These investigations were conducted in 2008 and 2009 (Windward and Integral 2009; Integral 2009). The 2008 investigation resulted in detections of dioxins and furans, and PCBs in sediment, upland soil, streets, parking strips, and yards. These results led to EPA's request for additional sampling in yards and the Adjacent Streets using multi-increment sampling (MIS) techniques in order to refine the boundaries and determine mean exposure concentrations in the yards. The 2008-2009 MIS soil sampling effort resulted in the detection of PCB concentrations above 1 -mg/kg in portions of the Adjacent Street and in some Residential Yards. Dioxin/furan TEQs exceeded the MTCA CUL of 11 ng/kg at many locations and ranged from 0.495 to 84.0 ng/kg. One TEQ of 395 ng/kg was considered to be an outlier (see Section 2.3.3). As a result of these investigations, EPA directed that the Adjacent Streets portion of the T-117 EAA be expanded to include the area bounded by Dallas Avenue S to the north and east, 14th Avenue S to west, and S Donovan Street to the south (EPA 2009c). As shown on Map 1-1, this area is now referred to as the Adjacent Streets and Residential Yards Study Area.

1.1.~~5~~6 Expanded T-117 EAA and the revised EE/CA

This EE/CA is being prepared in accordance with the EE/CA Work Plan (Windward et al. 2008) and SOW Amendment 1 (EPA 2007c), the latter replacing in its entirety the SOW appended to the NTCRA ASAOC issued on December 22, 2005. SOW Amendment 1, issued on September 28, 2007, states that the revised EE/CA will include the information presented in the previous EE/CA (Windward et al. 2005c) and will also include new information that has been generated since the 2005 EE/CA. Such information includes the following datasets, which are discussed in greater detail in Sections 2.2 and 2.3.

[1] Dioxin/furan TEQs were calculated in accordance with Ecology's calculation guidance (WAC 173-340-900, Table 708-1).

- Data collected by the Port in support of its investigation of the T-117 Sediment Study Area
- Data collected by the Port in support of its investigation and removal action activities within the T-117 Upland Study Area
- Pertinent information from the river-wide LDW RI/feasibility study (FS)
- Data collected by the City in support of its investigation and independent cleanup action activities within the Adjacent Streets and Residential Yards Study Area
- Data collected by Ecology and EPA in support of their dioxin and furan investigation within the Adjacent Streets and Residential Yards Study Area
- Data collected as part of the T-117 data gaps assessment, including groundwater monitoring activities set forth in the SOW
- Data collected by Ecology and EPA in conjunction with past and ongoing investigation and cleanup actions at Basin Oil
- Data collected by Ecology as part of its investigation of the Marina

This EE/CA includes an identification and analysis of removal action technologies and alternatives for the expanded T-117 EAA as well as previously analyzed sediment removal alternatives, taking into consideration all new information from the above-noted sources. Following the completion of this EE/CA, EPA will issue an amended action memorandum for the T-117 EAA NTCRA, which will replace the action memorandum issued on July 22, 2005.

1.2 EE/CA Organization

This EE/CA is organized in accordance with SOW Amendment 1 (EPA 2007c), which is an appendix of the ASAOC (EPA 2005c). The contents and EE/CA approach are detailed in the approved EE/CA Work Plan (Windward et al. 2008). The remaining sections of this EE/CA are organized as follows:

- **Section 2, Site Characterization –** Presents a summary of historical operations, previous investigation and removal actions, current site conditions, land use, geology, and hydrogeology. This section also discusses the nature and extent of contamination based on sediment, soil, and groundwater for the T-117 EAA and the RAAs.
- **Section 3, Streamlined Risk Assessment –** Presents the conceptual site model (CSM), which shows the current and potential sources, transport mechanisms and exposure pathways to potential receptors. The contaminants of potential concern (COPCs) presented in the EE/CA Work Plan (Windward et al. 2008) are further evaluated, and specific contaminants were selected as COCs through a streamlined risk assessment.

- **Section 4, Identification of Removal Action Scope, Goals, and Objectives –** Presents the development of removal action levels (RvALs) for sediment and soil necessary to address the removal action goals and objectives. These goals include contaminant removal sufficient to allow for a broad range of final site uses at T-117, including possible upland and aquatic habitat. This section also presents the removal boundaries for each of the T-117 EAA areas.

- **Section 5, Recontamination Assessment –**Provides an overview of the source control strategy, identifies potential recontamination sources and pathways, and evaluates the potential for the pathways to recontaminate the post-NTCRA site. This section also describes the results of the recontamination assessments for the Basin Oil property and Marina, which were initially presented in the EE/CA Work Plan (Windward et al. 2008), and has been updated based on identified data needs and recent investigations by Ecology.

- **Section 6, Identification, Evaluatio~~i~~n, and Screening of ~~Removal Action~~ Technologies –** Identifies, discusses, and screens the potentially applicable removal action technologies for soil and sediment removal, treatment, and offsite disposal. Technologies retained after screening are intended for use as part of the assembled removal action alternatives presented in Section 7.

- **Section 7, ~~Description and Analysis of~~ Removal Action Alternatives –** Presents the removal action alternatives and describes how they will be applied in each removal area of the EAA. Each alternative is also discussed in terms of its implementability, effectiveness, and cost to facilitate the comparative analysis in Section 8.

- **Section 8. Comparative Analysis of Removal Action Alternatives –** Provides a comparative discussion of the removal alternatives based on the CERCLA criteria of effectiveness, implementability, and cost.

- **Section 9. Recommended Removal Action Alternative and Implementation –** Describes and presents the rational for the recommended alternative for the NTCRA. Presents the preliminary removal action sequencing concepts, short-~~term~~ and long-term monitoring objectives, and ~~general~~ a description of NTCRA activities to be conducted during design and during and after construction. Section 9 includes a description of the long-term operation, maintenance, and monitoring plan (OMMP) that will be developed and implemented to ensure the long-term performance of the selected removal action alternative. The section also includes a discussion of the data ~~gaps~~ that will be needed prior to the removal action.

- **Section 10, References –** Includes references for published documents and other sources cited in this EE/CA.

The following appendices support the text:

- Appendix A. SOW ~~and Reasonably Anticipated Future Land Use Letter~~
- Appendix B. Groundwater
- Appendix C. Data Tables
- Appendix D. Data Management
- Appendix E. COC Screening
- Appendix F. RAA Data ~~Summary~~ Tables
- Appendix G. ARARs~~S~~ and Other Requirements to be Considered
- Appendix H. Risk-Based Disposal Application
- Appendix I. ~~Combined Early Life Stage Adjustments and Soil Exposure Factors for Residential and Recreational PRG for cPAHs~~Soil Risk Calculation Supporting Details
- Appendix J. Cost Details
- Appendix K. Detailed Technology Evaluation
- Appendix L. MIS Variance
- Appendix M. Dioxin Technical Workgroup Presentations
- The appendices are provided only on a compact disk, (CD) which is located on the inside back cover. The CD also includes a copy of this report and the figure and map folio.

2 Site Characterization

This section presents a summary of the available environmental, physical, and ecological information relevant to the T-117 EAA. The section also includes a description of the historical activities, regulatory history, and current site features. The current site uses and activities occurring in the vicinity are also described. There is also discussion of~~on~~ the LDW and the geology in~~of~~ this area. Finally, the previous environmental investigation and clean~~-~~up actions in the T-117 EAA and RAAs are summarized.

2.1 Site Description

2.1.1 Location and characteristics

The T-117 EAA is situated on the west bank of the LDW, between approximately River Mile (RM) 3.5 and RM 3.7 (relative to the southern tip of Harbor Island) (Map 1-1). The EAA is located approximately 6 miles south of the Seattle downtown area and is across the LDW from Boeing Plant 2 and Jorgensen Forge, which together form another EAA. The T-117 Upland Study Area is located within a narrow strip of unincorporated King County that lies between the LDW to the east and the South Park neighborhood of Seattle to the west. The ~~Port's T-117 property, which includes the~~ T-~~-~~117 Upland Study Area~~,~~ is located at 8700 Dallas Avenue S and is immediately south of the 16th Avenue S bridge (also known as the South Park Bridge) (Map 1-1).

The T-117 EAA is characterized by gently sloping intertidal mudflat habitat, a steep vegetated riprap bank, and a relatively flat adjacent upland area. The T-117 EAA encompasses approximately 15.2 acres and consists of the three defined areas: the Sediment Study Area within the LDW, the T-117 Upland Study Area ~~(Port-owned T-117 property),~~ and the Adjacent Streets (City ~~rights-of-way [~~ROWs~~]~~) and Residential Yards Study Area. Each area of the T-117 EAA is described in further detail in the subsections that follow.

The T-117 EAA is also adjacent to the Marina and Basin Oil properties, which are being evaluated as potential sources of recontamination to the T-117 EAA. These areas are also shown on Map 1-1 and are discussed in detail in Section 2~~.3~~.4.

2.1.1.1 Sediment Study Area

The T-117 Sediment Study Area is the aquatic portion of the T-117 EAA. Located within the LDW (Map 1-1), the study area is approximately 1.4 acres in size and consists primarily of intertidal sediment with some subtidal sediment. The study area extends from the top of the shoreline bank, at an elevation of approximately+13.8 ft mean lower low water (MLLW), into the LDW (60 to 80 ft), at an elevation between 0 and -5 ft MLLW. This area is bordered by the LDW to the north and south, the LDW navigation channel to the east, and the T-117 Upland Study Area to the west.

2.1.1.2 T-117 Upland Study Area

The T-117 Upland Study Area consists of the Port's T-117 upland property located between the T-117 Sediment Study Area and the Adjacent Streets and Residential Yards Study Area (Map 1-1). This property, which includes the former Malarkey Asphalt Company (Malarkey) Plant property, is located at 8700 Dallas Avenue S. In 1963, the Port accepted the assets of the King County Commercial Waterway District No. 1 (KCCWD1) (Map 2-1), which included limited rights in a 50~~0~~-ft-wide strip of upland property along the T-117 shoreline. ~~ROW acquired to create a portion of the LDW.~~ In 2000~~1999~~, the Port acquired two inland parcels that included the former Malarkey property between the shoreline KCCWD1 parcel and Dallas Avenue S. These properties were consolidated to form the present-day footprint of T-117, which encompasses approximately 3.3 acres. This area is relatively flat with an elevation that ranges from approximately +13.8 ft MLLW at the top of the bank to approximately +21 ft MLLW along the property boundaries at Dallas Avenue S and the Marina. The T-117 Upland Study Area is bordered by the Marina to the north, Boeing South Park to the south, Dallas Avenue S to the west, and the T-117 Sediment Study Area and the LDW to the east.

2.1.1.3 Adjacent Streets and Residential Yards Study Area

The Adjacent Streets and Residential Yards Study Area consists of two subareas: the Adjacent Streets and the Residential Yards. The Adjacent Streets portion is the street and ROW areas bounded by Dallas Avenue S, S Donovan Street, and 14th Avenue S. These streets and ROWs are relatively flat with the exception of S Donovan Street. The lanes of this street are separated by a steep bank and the southern-most lane is elevated relative to other streets in the area.

The Adjacent Streets are bordered by the T-117 Upland Study Area to the east and the Marina to the north. The Adjacent Streets also surround, but do not include, the former Basin Oil property and Residential Yards within the bounding streets mentioned above. The Residential Yards consist of the residential properties within the boundaries of Dallas Avenue S, S Donovan Street, and 14th Avenue S. These yards are relatively flat with some local minor variations in topography.

2.1.2 Historical activities

2.1.2.1 T-117 operations

The Duwamish Manufacturing Company began manufacturing asphalt roofing materials at T-117 around 1937 and continued until 1978 at a location that generally corresponds to the western half of the T-117 Upland Study Area (URS 1994). The business and property were sold in 1978, when it became known as the Malarkey Asphalt Company. Asphalt roofing materials manufacturing continued until 1993. Since that time, several environmental site investigations were~~had been~~ conducted until the asphalt plant was decommissioned in 1997. During the Duwamish

Manufacturing Company's operation of the asphalt manufacturing facility from the late 1960s through the mid 1970s, used oils, some of which contained PCBs, were used as fuel for the asphalt manufacturing process (URS 1994). Some used oils came from Seattle City Light.

Features formerly associated with the asphalt plant (Map 2-1) but no longer present at the site include underground and aboveground storage tanks (USTs and ASTs) and associated piping, reaction tanks, sumps, a diesel fuel dispenser, a hot oil heater and associated shed, transfer pumps and pipes, warehouses at the east side of the plant area, a drum storage shed, and a partially buried railroad tank car (URS 1994).

A former ponding area was located just inland of the top of the shoreline bank (Map 2-1) and was reportedly used during site operations for retaining non-contact cooling water (Hart Crowser 1992; URS 1994). This area was later determined to merely be a depression in the unpaved area of the site where stormwater collected and vehicles drove through the property. The ponding area was the lowest point on the T-117 Upland Study Area and also collected all water that flowed across the site, including non-contact cooling water from the main manufacturing area. Periodic overflow from the former ponding area to the LDW was noted during extended rainy periods (EMCON 1996). The former ponding area was located within the former KCCWD1 ROW (EMCON 1996) and was subsequently excavated as part of a contaminated soil TCRA in 1999 and backfilled (Onsite 2000a) (see Section 2.2.2).

From 1989 to as late as 1995, Basin Oil leased a 10,000-gal. horizontal tank from Malarkey within the plant area for storing and processing used oil (EPA 1995). After the asphalt plant was decommissioned in 1997, portions of the property were occupied by Evergreen West Wholesale (a lumber wholesaler) for untreated lumber storage and loading (Windward et al. 2003). From 2003 to 2004, through a lease with the Port, Basin Oil also used a portion of the interior of the south building on the T-117 property for storage and oil filter processing (Windward et al. 2003). In 20001999, the Port acquired the asphalt plant parcels and related buildings located between the shoreline ROW parcel and Dallas Avenue S. This acquisition was part of an agreement in which the Port would conduct the 1999 TCRA in exchange for the parcels. The Port consolidated the asphalt plant parcels with the KCCWD1 parcel to form the present-day T-117 Upland Study Area. After the Port acquired the property, Port Construction Services used the outdoor area near the small office/carport for the storage of miscellaneous materials. International Inspection, a provider of non-destructive testing services, formerly leased the north building and the small office/carport. Second Use Building Materials, Inc., a recycling business that obtains reusable building materials from demolition projects for resale to the public, leased the south building for inventory storage. The T-117 Upland Study Area has been vacant since February 2007.

2.1.2.2 *Adjacent Streets and Residential Yards Study Area*

Aerial photographs show that the current street configuration in the South Park area was largely established as early as 1936. Available records indicate that S Cloverdale Street, between 14th Avenue S and 16th Avenue S, was paved or resurfaced with asphalt in 1947 (Allwine 2005). Other streets in the area (Dallas Avenue S, S Donovan Street, 16th Avenue S, and 17th Avenue S) remained unpaved until the mid-1970s or later, which extends into the period when used oils were handled by the Duwamish Manufacturing Company and Basin Oil (described below). Prior to an independent cleanup action conducted by Seattle Public Utilities (SPU) in 2004-2005 (Section 2.2.4), the streets surrounding Basin Oil had no formal stormwater collection system within the Adjacent Streets portion of the EAA.

Businesses historically located within the neighborhood adjacent to T-117 included Basin Oil, the Marina, Seattle Chocolate Company, Allied Bolt Company, and Fasteners, Inc; these businesses are briefly described below. Basin Oil and the Marina are further evaluated as RAAs, and additional site information and the results of environmental investigations for these properties are presented in Section 2.4.

Until 2007, the Basin Oil site was occupied by ~~the~~ Basin Oil ~~Company~~, which operated as a collector, transporter, and marketer of used oil. Used oil was delivered to the facility by tank trucks and stored in tanks prior to treatment and recycling. The property was also the former site of operations for other affiliated companies including Northwest Antifreeze Service, Frontwater Service, and Vintage Oil Inc., all of which were handlers of used oil or antifreeze products. Basin Tank and Environmental Services, Inc., also operated on the site, but that company closed in January 2002. According to Ecology records (Ecology 2004b), Basin Oil began operating at the site in 1987. Prior to development as an industrial facility, the site included residential parcels and a single-family residential structure. The site is currently inactive, and cleanup actions by the owner have been conducted since the plant closure in 2007 (EPA 2007a).

There is little information regarding historical activities at the Marina (SAIC 2007b). A portion of the land that currently comprises the Marina was a mobile home park. Boat transport and engineering operations have also been conducted in the boat yard. A&B Barrel, a barrel refurbishing and cleaning operation, was located at the site in the 1950s (Windward et al. 2003). Former occupants of the central portion of the site reportedly included North Star Trading Company (1980 to 1981), Evergreen Boat Transport (1985 to 1999), R.P. Boatbuilding (dates unknown), and Dekker Engineering (1995 to 1999).

Seattle Chocolate Company, Allied Bolt Company, and Fasteners, Inc., occupied the ~~same~~ property ~~(~~located at 8619 and 8620 17th Avenue S~~)~~ at various times; Café Umbria currently occupies the property. The City conducted a site history assessment of this property in general accordance with EPA standard practice (40 Code of Federal Regulations [CFR] 312). County records indicate the building was constructed in 1971 and first occupied in 1979. City records document a connection made to the City sewer in 1979 (at which time Allied Bolt Company was a tenant). The Allied Bolt Company and Fasteners, Inc., were classified as small-quantity generators, although and no violations were noted in association with their operations. Chemicals potentially associated with operations at the Allied Bolt Company and Fasteners, Inc., may have included volatile organic compounds (VOCs) and metals. A records search (King County 2008; Ecology 2008a; City of Seattle 2008; Ecology 2008b) did not indicate that any COPCs were associated with the Seattle Chocolate Company.

2.1.3 Current site features

2.1.3.1 Upland structures and infrastructure

Since the asphalt plant was decommissioned in 1997, the only aboveground structures that remain on the T-117 Upland Study Area are the north and south buildings, the small office/carport inside the north gate, and the truck scale at the west side of the property. The remainder of the T-117 Upland Study Area is covered with asphalt or concrete pavement with the exception of a vegetated drainage ditch along the southern boundary. Asphalt plant structures that remain at T-117 beneath the ground surface include the three closed-in-place USTs; the decommissioned large-diameter industrial water supply well; concrete foundations associated with the former warehouse structures, reaction tanks, cooling water sump, and tank pads, and underground utility corridor; and a shallow, concrete-lined ditch that has subsequently been cleaned out and backfilled with controlled density fill (Windward and Onsite 2004). Some small-diameter remnant buried piping associated with the former plant may also be present, although most of this piping was removed during plant demolition and the subsequent cleanout of the concrete-lined utility corridor. The property is fenced, and gates are locked to control public access. The buildings on T-117 are supplied with potable water from the City public water supply system. The north building and the office/carport building discharge grey water and sewage to the septic system onsite. These features are shown on Map 2-1.

An overhead power line (Seattle City Light's Dallas Avenue Crossing) was temporarily removed in 2004. This overhead power line passed through the Adjacent Streets along an existing easement across the T-117 Upland Study Area and across the T-117 Sediment Study Area. The current 12-ft-wide easement across the upland property is shown on Map 2-1, and the historical lines are visible on Map 1-1; these lines traversed the T-117 Upland Study Area, in the vicinity of the Dallas Avenue S and 17th Avenue S intersection, and extended east across T-117 and the LDW to a location near the southwest corner of the Boeing Plant 2 property. The overhead power line is scheduled for reconstruction following completion of the NTCRA.

The Adjacent Streets are paved, with gravel surfacing in some shoulder areas (along Dallas Avenue S, and 16th Avenue S). Sidewalks, with grass buffer strips and occasional trees, are present along sections of Dallas Avenue S, 16th Avenue S, and 17th Avenue S (Map 2-1). Overhead power lines and underground utilities (e.g., gas, water, telephone, combined sewer system [CSS]) exist throughout the area. Stormwater in the area east of 16th Avenue S drains to the CSS. A temporary stormwater collection system was installed and pavement improvements were completed within portions of the Adjacent Streets as part of the City's independent cleanup actions (see Section 2.2.4).

2.1.3.2 Offshore debris and structures

Waste materials that may be associated with historical upland operations are present in the riprap of the shoreline berm, on the vegetated berm crest, and in the drainage ditch at the south side of T-117 Upland Study Area. These waste materials include 55-gal. drums, semi-soft and hardened asphalt and asphalt roofing materials. Weathered chunks of asphalt are also present on the intertidal mudflat. Photographs and maps of the locations of these waste materials are included in the 2004 data report (Windward et al. 2004).

A deteriorating bulkhead located offshore of the north half of the T-117 EAA can be observed today at the base of the riprap and can also be seen in a 1946 aerial photograph (Windward et al. 2003) as a row of pilings in the intertidal area. Also, a row of treated pilings and a log boom used to divert floating debris away from the Marina is located in the intertidal area near the boundary with the Marina.

2.1.3.3 Drainage and outfalls

Map 2-2 shows the outfalls, sewer and storm drain lines, and catch basins associated with the drainage in the T-117 EAA and vicinity. Two storm drain outfalls located along the T-117 shoreline bank are owned by the Port and discharge runoff from stormwater conveyances located on the T-117 Upland Study Area. These two outfalls discharge directly to the LDW and T-117 EAA Sediment Study Area. Three~~wo~~ storm drain outfalls are located to the north of T-117~~, located~~ along the shoreline bank of the Marina and ~~,~~discharge to the LDW.~~ from the Marina. The southernmost of the ~~T~~t~~wo of the ~~Marina ~~outfalls are~~is~~ owned by the Marina and discharge stormwater from the Marina property.~~;~~ T~~t~~he ~~ownership of the ~~northernmost ~~Marina ~~outfall is ~~uncertain; however~~owned by the County and~~, the outfall~~ drains the South Park Bridge (Windward 2009). Two storm drain outfalls to the south of T-117 are located on the Boeing South Park property and are owned by Boeing.~~; the northernmost of these two outfalls is in the vicinity of T-117).~~ Stormwater in the Adjacent Streets and Residential Yards Study Area discharges to the City's CSS as described below. No combined sewer overflow (CSO) outfalls are located in the vicinity of the T-117 EAA (Map 2-2); the nearest CSO (operated by ~~King ~~the County) is located at 8th Avenue S. ~~King~~ County records show that this CSO has not overflowed in the past 10 years (Huber 2009).

T-117 Upland Study Area

The two storm drain outfalls along the shoreline of the T-117 EAA drain catch basins are located on the T-117 Upland Study Area and were field verified by the Port in 2006 (Phoinix 2007). Stormwater discharging through these outfalls primarily originates from the asphalt-paved T-117 Upland Study Area and is collected in the T-117 catch basins before discharge to the LDW. Stormwater runoff from the northern part of T-117 Upland Study Area flows to a catch basin (CB-1) that discharges to the LDW through a 6 in diameter outfall located within the shoreline riprap. Runoff from the central and southern portions of the Upland Study Area drain to several catch basins (CB-2, CB-3, and CB-4) that eventually lead to a catch basin located to the northeast of the south building (CB-5) that discharges to the LDW. Roof drainage from the warehouse building on the south end of the T-117 Upland Study Area is conveyed from the gutters to the south side of the building and eventually discharges to the drainage ditch/swale located along the southern property boundary.

Since completion of the 2006 TCRA, all of the catch basins on T-117 have been surrounded by hay bales and equipped with a filter sock. The catch basins include sumps for retaining settled solids and are equipped with inverted outlets to retain floating oil. These catch basins are inspected regularly as part of the 2006 TCRA inspection and maintenance program.

~~In early September 2009, sediments that had accumulated inside and outside of catch basins on the T-117 Upland Study Area (CB-3 and CB-5) were sampled for dioxins and furans, arsenic, copper, silver, total petroleum hydrocarbons (TPH) in the diesel and gasoline ranges, PCBs, and polycyclic aromatic hydrocarbons (PAHs).~~

In September 2009, all catch basins on the T-117 Upland Study Area were inspected and attempts were made to sample solids that had accumulated on both the outside (i.e., retained outside the catch basin by hay bales) and inside of the catch basins. Only CB-3 had accumulated sufficient solids both on the inside and outside for sampling; CB-5 had accumulated sufficient solids only on the outside. These samples were analyzed for dioxins and furans, arsenic, copper, silver, total petroleum hydrocarbons (TPH), PCBs, and polycyclic aromatic hydrocarbons (PAHs); and the results are presented on Table 2-1.

Table 2-1. Summary of 2009 T-117 Upland Study Area catch basin sampling results

	Concentration		
	CB-3		CB-5
~~Chemical~~Contaminant	O~~o~~utside	I~~i~~nside	O~~o~~utside
Metals (mg/kg)			
Arsenic	7	10.0 U	10.0 U
Copper	121	146	131

ChemicalContaminant	Concentration		
	CB-3		CB-5
	Ooutside	Iinside	Ooutside
Silver	5.2	4.2	2
Dioxin and Furans (ng/kg)			
Dioxin/furan TEQ	49.11	na	152.9
TPH (mg/kg)			
TPH – diesel range	3,050	2,900	1,830
TPH – gasoline range	14	na	5.6
PAH (mg/kg)			
cPAH TEQ	0.49	0.24	0.24
PCBs (mg/kg)			
Total PCBs	1.6	16	1.1

cPAH – carcinogenic polycyclic aromatic hydrocarbon
na – not analyzed (insufficient sample volume)
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
TEQ – toxic equivalent
TPH – total petroleum hydrocarbons
U – not detected at given concentration

Based on the higher--than--expected concentrations of PCBs and dioxins and furans detected during Based on the September 2009 catch basin sampling event,results, site inspections were conducted in early November 2009 in order to better document the site stormwater drainage and potential sediment contaminant sources. Based on these inspections, Aa stormwater solids control plan (Chen and Hainsworth 2009) was developed as a result of these in inspections. The plan included and recommendationsed that site maintenance activities be performed to reduce potential sources of contaminants to stormwater and to reduce and /control the runoff of stormwater solids. Site maintenance was conducted in late December 2009 and included the following:

- Cracks in the asphalt cap throughout the site were sealed with asphalt sealer.
- Gaps above and below the ecology block retaining wall were sealed.
- Site vegetation was cut back.
- The asphalt surrounding all catch basins was washed down.
- The interiors of all catch basins were cleaned out.
- New hay bales and sediment filter socks were installed at all catch basins.

The site maintenance activities were documented in the sixth semi-annual TCRA O&M report (AECOM 2009d), which was submitted to EPA on December 28, 2009, along with a catch basin sampling memorandum that described the September catch basin sampling events (Huntington and Hainsworth 2009).

A vegetated drainage ditch/swale on the southern boundary between Boeing South Park and T-117 Upland Study Area also collects roof drainage from ~~the warehouse~~a building on the south end of the T-117 Upland Study Area. This ditch discharges to the shoreline mudflat area in the LDW. The runoff from the hillside along the Boeing property appears to flow east along the toe of slope and then enter the trench drain on the west~~south~~ side of the building that eventually drains to CB-5 (Map 2-2).

Adjacent Streets and Residential Yards Study Area

Stormwater runoff from the Adjacent Streets and Residential Yards Study Area is currently collected in two separate systems that can be roughly divided into areas west and east of 17th Avenue S (see Map 2-2). To the west, runoff is currently discharged to the CSS. As part of its independent cleanup action in the Adjacent Streets in 2004 (see Section 2.2.4), the City installed a temporary stormwater collection and treatment system to control runoff from the newly paved streets and associated 1.8-acre catchment area adjacent to the T-117 Upland Study Area. The triangle of roadway that includes 17th Avenue S, Dallas Avenue S, and S Donovan Street currently drains to this temporary system, which is used to collect and ~~s,~~ store stormwater.~~s~~ Retained stormwater is periodically released in ~~, and~~ batch discharges ~~stormwater~~ to the CSS at S Donovan Street and 17th Avenue S (Map 2-2). Because the CSS is over capacity in this area, stormwater is only discharged to the CSS during periods of dry weather to prevent sewer backups.

During construction of the 2004 independent cleanup actions, a temporary stormwater treatment system was also installed to treat runoff during construction. Discharges to the CSS were permitted under a discharge authorization with King County Industrial Waste. Five 18,000-gal. storage tanks were installed to hold water for testing and to regulate the rate of stormwater discharge to the CSS. The permit (No. 4072-04) list conditions for both active stages and the non-active stage. Active stages are periods when active remediation and construction are occurring, and the non-active stage is the period of operation between interim and final removal actions. In addition to general stormwater permit conditions, special conditions of the permit for the non-active stage include the following:

- Collected stormwater must be pumped to appropriately sized settling tanks.
- Discharge must be monitored as follows:
  - PCBs - monthly
  - Discharge rate – daily
  - Discharge rate daily maximum – monthly

- Maximum discharge is 100,000 gallons per day
- The PCB discharge limit per Aroclor is 0.513 µg/L (parts per billion).
- SPU must contact ~~King~~ the County at least 15 days before the NTCRA (removal action) project -begins.

Initial testing of stormwater solids in 2004 and 2005 resulted in occasional detections of PCBs up to 2.3 µg/L. The treatment system was removed in April 2005 because the testing that has been conducted since January 2005 showed that PCBs were no longer detected (at a DL of 0.1 µg/L) in stormwater runoff from streets adjacent to T-117. Stormwater continues to be discharged to the CSS via this system during dry conditions through a discharge authorization with the County. The County requires the stormwater to be tested each month when discharges occur. There has been one detection (0.12 mg/kg in January 2008) since treatment was discontinued (Appendix C).

Under an arrangement with the Port, the City has a provision to discharge water from this system to the southern drainage system on the T-117 Upland Study Area as an emergency overflow during the rainy season (due to the over capacity condition of the CSS described above). Discharges to the Port system generally occur under the following conditions:

- ~~Very I~~Intense storm events that exceed the capacity of the storage tanks
- Periods of prolonged rainfall, which cause the tanks to fill up when stormwater cannot be discharged to the CSS
- Cold weather conditions when the storage tanks and associated piping must be drained to prevent the pipes from freezing and breaking. When cold weather is predicted, the valves to both the CSS and the Port drainage system are fully opened to rapidly drain the system

Since 2005, 11 emergency discharge events have occurred.[2] Given the infrequent nature of the overflows to the LDW, SPU has not tried to develop direct correlations between rainfall events and overflows from the tanks.- The tanks hold about 90,000 ft^3 of runoff.- The tanks fill up after approximately 2.25 to -2.5 in. of rain accumulates, either in a single event or multiple back--to--back storms. During the emergency discharges, runoff from the temporary system is discharged to a catch basin located at the northwest corner of the south building on the T-117 Upland Study Area. Runoff is conveyed in a pipe that runs along the north side of the building and discharges to the pavement at the northeast corner of the building. From there, runoff sheet flows approximately 60 ft across the pavement to CB-5 on the T-117 Upland Study Area.

[2] The 11 discharges occurred on December 24 ~~through~~- 27, 2005; January 1 ~~through~~ - 3, 2006;~~,~~ January 6 ~~through~~ - 16, 2006; January 29 ~~through~~ - February 1, 2006; November 6 ~~through~~ - 30, 2006; December 12, 2006 - ~~through~~ January 5, 2007; January 7, 2007; December 3 ~~through~~ - 7, 2007; December 20, 20~~/~~07 ~~through~~ - January 2, 2008; January 15 ~~through~~ - 17, 2008; October 17 ~~through~~ - 19, 2009.

The City intends to replace the temporary stormwater system with a permanent stormwater collection and treatment system in accordance with Seattle Municipal Code (SMC) 22.800 and Directors' Rule 2009-005 (SPU), 17-2009 (Department of Planning and Development [DPD]) (City of Seattle 2009b) as part of the removal action in the Adjacent Streets. Options for Aa new, permanent collection and treatment system to be installed in the Adjacent Streets following the removal action is included in the removal action alternatives describedare identified in Section 7.

South Park Marina Properties

Stormwater runoff from the south and east end of the Marina discharges directly to the LDW via a private drainage system (SAIC 2007b). The Marina operates a closed-loop boat pressure wash system in the southeast portion of the property near the T-117 Upland Study Area. The wash system is located in the vicinity of the southern-most catch basin on the Marina property that discharges through a general stormwater National Pollutant Discharge Elimination System (NPDES)-permitted shoreline outfall fitted with an oil/water separator and a sand filter (StormwateRx®) treatment system. The Marina has been sampling and analyzing the discharge from this outfall for oil and grease, total recoverable copper, and total suspended solids as required under its NPDES permit.

Stormwater from the north end of the Marina property is believed to discharges directly to the LDW (Crow 2010)., although the private drainage system on the property has not been fully mapped (SAIC 2007b). The Marina's storm drain system is shown on Map 2-2.Because the onsite catch basins are near the LDW (as shown on Map 2-2) and downgradient from the CSS on Dallas Avenue S, stormwater from these catch basins is likely discharging to the LDW rather than being pumped to the CSS. However, further site investigation (e.g., dye testing) would be needed to confirm whether these onsite catch basins discharge to the LDW.

Stormwater runoff from the Marina property located at the southeast corner of 16th Avenue S and Dallas Avenue S, which is used for additional dry boat storage, most likely enters the City catch basins located on 16th Avenue S, which convey stormwater to the City's CSS. Some drainage from this location may also flow onto Dallas Avenue S and into the LDW via the T-117 Upland Study Area catch basins.

Boeing South Park

To the south of the T-117 EAA at Boeing South Park, two privately owned outfalls discharge to the LDW. The northernmost outfall used to discharge non-contact cooling water from Boeing South Park under an NPDES permit. This practice was discontinued in 1993, and the cooling water was re-routed to the sanitary system (Ecology 1993b). Currently, both outfalls appear to discharge only stormwater; however, stormwater drainage patterns associated with Boeing South Park have not been identified.

2.1.4 Current land use, zoning, ownership, and activities

This section describes the current land use, zoning, ownership, and activities for the T-117 EAA.

2.1.4.1 Land-use, zoning, and ownership

The T-117 EAA and vicinity are zoned[3] as mixed-use for residential, commercial, and industrial activities (City of Seattle 2007a), as shown on Map 2-3. Current land use in the area is primarily manufacturing, commercial, and residential. Properties located on the east side of Dallas Avenue S in unincorporated King County include:

- The Marina, which is primarily used for boat storage and maintenance, as well as the moorage of live-aboard and recreational vessels. The upland portion of the Marina is currently owned and operated by South Park Marina Ltd. Partners. The east~~west~~ portion of the Marina lies within the Duwamish Commercial Waterway District boundary.
- The former asphalt plant parcel, which is currently owned by the Port and was formerly used for manufacturing and industrial activities, including asphalt materials manufacturing. The site has been vacant since 2007.
- A portion of the Boeing South Park facility, which is currently owned by ~~The~~ Boeing ~~Company~~ and is primarily used as a training center.

Properties to the west of Dallas Avenue S, include:

- The former Basin Oil plant (a used oil and antifreeze processing facility that ceased operations in 2004) at 8661 Dallas Avenue S, which is currently owned by Basin Oil ~~Company~~. This property was residential prior to being used for industrial purposes.
- A property at 8617 17th Avenue S formerly used by Basin Oil for excess drum storage until this parcel was purchased by the Marina for boat storage in August 2007. This property was residential until November 1998 when it was sold to Basin Oil and was subsequently used for industrial purposes.
- The former residential parcel located at 8603 Dallas Avenue S used by the Marina for boat storage.
- Commercial and residential parcels bounded by Dallas Avenue S, 16th Avenue S, and S Donovan Street, including three commercial parcels (and a boat storage area), two residential parcels, and one apartment complex. West of 16th, there are 22 residential and six commercial parcels on the east side of 14th Avenue S.
- A commercial/warehouse facility at 8620 16th Avenue S. The property has been occupied by Caffè Umbria Inc. (a wholesale coffee roaster) since 2008. Former occupants were the Seattle Chocolate Company (a chocolate confectionery

[3] Zoning designation based on a 2002 City of Seattle GIS layer, as shown on Map 2-2.

company that ceased operations in 2007), Allied Bolt Company (metal fabrication), and Fasteners, Inc. (metal fabrication).

The Basin Oil parcels and the Boeing South Park parcels within the City limits are zoned as manufacturing/industrial; the parcels between 16th Avenue S and 17th Avenue S are zoned as industrial buffer. Parcels west of 16th Avenue S and north of S Donovan Street are zoned as residential/commercial and include approximately 20 houses and one 12-unit apartment complex (Map 2-3).

2.1.4.2 Commercial and residential activities

As previously described, there are several residences as well as various commercial and manufacturing facilities within the vicinity of T-117 EAA. Because the T-117 Upland Study Area and T-117 Sediment Study Area have restricted access, public activities within these areas are limited. Access to the Sediment Study Area is restricted by a secure fence surrounding the T-117 Upland Study Area, but is accessible from the LDW by boat and kayak. The Muckleshoot Tribe has a commercial salmon fishery in the LDW, uses portions of the T-117 Sediment Study Area for tribal fishing, and thus may come in contact with the sediment. Within the Adjacent Streets and Residential Yards Study Area, residential activities could include, but are not limited to, recreation activities such as jogging or biking, or typical residential activities such as walking, yard work, or driving. Workers may also access the T-117 EAA to service utilities, which may require digging in the Adjacent Streets as well as on the T-117 Upland Study Area. Exposure scenarios associated with these site uses are evaluated in Section 3.2.

2.1.4.3 Recreational activities

The LDW is not a major recreational resource compared to other water bodies in and around the City (King County 1999b). The Duwamish River Cleanup Coalition, a consortium of environmental and citizen groups that participate in cleanup efforts, has coordinated activities to improve habitat and recreational activities. The group has been conducting kayak tours on the LDW and asserts, ~~but anecdotal evidence from community members suggests~~ that recreational use of the LDW has been increasing, ~~including guided kayak tours of the LDW and shoreline access~~ at new parks and restoration sites (EPA 2010). Few data that quantify the frequency with which people use the river for recreational purposes have been identified. The County's human health risk assessment (HHRA) (King County 1999b) discussed the human use of both the LDW and Elliott Bay, but presented quantitative data only for fishing. The County study assumed that few, if any, people engage in activities such as swimming, scuba diving, and windsurfing within the LDW. There are several public access points along the LDW and recreational boating and kayaking in the LDW have been observed as part of a survey for the LDW RI (Windward 2005b). The Marina and a public boat launch north of the Marina are the closest recreational boating access points to the T-117 EAA. There is no known use of T-117 as a boat put-in or haul-out location. Such use is unlikely because the T-117 shoreline is steep and overgrown and the T-117 Upland Study Area is secured by a fence. However, the T-117 shoreline and intertidal mudflat is accessible from the LDW by boat.

In the County survey of fishing and seafood consumption practices (King County 1999b), none of the LDW sites identified as locations where recreational fishing occurred were near the T-117 EAA. However, recreational fishing may occur from the Marina or from boats in the vicinity of the T-117 EAA. There are no recent data on seafood consumption rates specific to the LDW, but current consumption rates may be suppressed. There are several possible explanations for such suppression, including the current advisory against the consumption of resident fish and shellfish, media coverage of the published risks from the consumption of LDW seafood, and the close proximity of more desirable fishing locations outside the LDW. The T-117 EAA is within tribal Usual and Accustomed fishing areas, and the tribes desire the restoration of shellfish and fisheries resources.

2.1.5 Physical environment

This section describes the physical features associated with both the aquatic and upland portions of the T-117 EAA. Sections 2.1.5.1 and 2.1.5.2 discuss the aquatic portion of the site; Section 2.1.5.3 focuses on the upland environment.

2.1.5.1 Currents, circulation, and estuarine features

River currents in the Sediment Study Area have not been specifically measured. However, the results of a site-wide hydrodynamic model developed as part of the LDW RI (Windward 2007c) can be generally applied to T-117 insofar as the model provides information regarding the currents of the LDW as a whole. The model may be less useful for capturing hydrodynamics in near-shore and shallow areas within the T-117 Sediment Study Area.

Water currents within the LDW are driven by tidal actions and river flow; the relative influence of each is highly dependent on seasonal river discharge volumes. Fresh water flowing downstream overlies the tidally influenced salt water that enters the system. The LDW is tidally influenced to the head of the estuary at RM 12.0 (Kerwin and Nelson 2000), with the degree of tidal influence varying depending on stream flow and tidal stage.

Tidal action significantly influences currents and water elevation in the LDW. The average tidal range is -0.91 to 12.81 ft MLLW.[4] Typical of tidally influenced estuaries, the LDW has a relatively sharp interface, or wedge, between the freshwater outflow at the surface and saltwater inflow at depth. Tidal effects and the volume of river flow also control the movement of the saltwater wedge. The toe of the saltwater wedge is

[4] Information based on National Oceanic and Atmospheric Administration (NOAA) Center for Operational Oceanographic Products and Services National Tidal Datum from 1993 to 2003.

generally located between Slip 4 (approximately 0.8 RM north of T-117) and Turning Basin 3 (approximately 1 RM south of T-117) (Santos and Stoner 1972). Salinity measurements by Santos and Stoner (1972) at RM 3.2, just downstream from T-117, indicated that at this location, the estuary had freshwater at all points in the vertical profile only when there was a combination of very low tide and high rates of river flow. Dye studies indicated that downward vertical mixing over the length of the saltwater wedge was almost nonexistent (Schock et al. 1998).

The Green River is the main source of water for the LDW. Average downstream flow for the Duwamish River measured at the Tukwila gauging station was 1,533 cubic feet per second (cfs) during 2003-2004, ranging from 327 cfs in August to 3,290 cfs in June (Clemens 2007). Flow at the Auburn gauging station ranged from 152 to 11,600 cfs (the record high) between 1962 and 2004 (Clemens 2007). Between 2000 and 2006, the annual average flow rate measured at the Auburn gauging station was 1,190 cfs, ranging between 850.6 cfs and 1,413 cfs (USGS 2007). Flow rates are greatest in the winter because of seasonal precipitation and lowest throughout the late summer dry season.

Stream flow to the LDW is also influenced by water diversions, particularly by the City of Tacoma's Headworks Dam, located on the Green River, which diverts at least 113 cfs daily for municipal use. The Howard Hanson Dam (located upstream of the City of Tacoma's Headworks Dam) also influences flows in the river. Information on the estimated influence of the Howard Hanson Dam on flow rates (Kerwin and Nelson 2000) indicates flow rates in the Duwamish River have been reduced by 33 to 60%, depending on the season. ~~The historical diversion of the White, Black, and Cedar Rivers from the Green/Duwamish River system resulted in a reduction of contributing flow by approximately 70% to the system, and an a accompanying reduction in total discharge for the Duwamish River.~~

LDW Stream flow is also influenced by inflows from surface water sources such as storm drains, CSOs, tributary creeks, and nonpoint inputs, although these sources are expected to be less than 1% of the total discharge, even during peak flow events (Windward 2007c). Two main tributary creeks drain into the LDW: Puget Creek at approximately RM 0.7 (downstream of the T-117 EAA) and Hamm Creek at approximately RM 4.2 (upstream of the T-117 EAA).

2.1.5.2 Sediment transport

LDW-wide investigations have been conducted that provide some insight into hydrodynamic and sediment transport conditions ~~at T-117~~ within the river. Sediment transport within the LDW, including the T-117 EAA, is influenced by many variables, including hydrodynamic forces attributable to currents and circulation driven by tidal actions and river flow, the saltwater wedge, sediment loading from upstream and upland sources, channel morphology, and resuspension processes (i.e., propeller scour, bioturbation, bed shear stress, and dredging). As part of the LDW RI, sediment transport data were collected throughout the LDW (Windward and QEA 2005) to enable a better understanding of the LDW sediment transport process and the development of a LDW-wide sediment transport model (STM) (QEA 2008). The results of these investigations and analyses can also be used to evaluate sediment transport conditions in specific areas of the LDW, such as the T-117 EAA, but the accuracy of the model at such small scales is highly uncertain. Consequently, predictions from the STM for the T-117 Sediment Study Area did not influence the development of removal action alternatives. The LDW-wide STM indicated that the T-117 Sediment Study Area was net depositional over annual time scales. Along most of the T-117 Sediment Study Area, the predicted net sedimentation rate for a 30-yr period ranged from 0 to 0.5 cm/yr, except along the northern portion of the T-117 EAA at the Marina interface, where the net sedimentation rate was estimated to be > 3 cm/yr.

~~The LDW-wide STM included simulations of high-flow events (i.e., events with return periods of 2, 10, and 100 years) that occur over time scales of several days and simulations that focused on sediment deposition patterns over longer time scales (i.e., 30 years). A separate model was used to evaluate ship-induced mixing of surface sediment (QEA 2008).~~

~~The simulation of high-flow events indicated that in the southern and central portion of the Sediment Study Area, no more than 2 cm of net erosion is estimated to occur during the 2- and 10-yr high-flow events (Map 2-4), while up to 6 cm of net erosion is estimated to occur during the 100-yr event (Map 2-4). In contrast, no net erosion is predicted for the northern portion of the site, even during the 100-yr high-flow event (Map 2-4).~~

~~The LDW-wide STM evaluated deposition patterns over a 30-yr time scale. Although short-term events such as those described above may cause periodic erosion, results of the longer-term analysis indicated that the T-117 EAA Sediment Study Area was net depositional over annual time scales. Along most of the T-117 EAA, the predicted net sedimentation rate for a 30-yr period ranged from 0 to 0.5 cm/yr, except along the northern portion of the EAA at the Marina interface, where the net sedimentation rate was estimated at > 3 cm/yr (Map 2-5). Although the results from this LDW-wide modeling effort provide insight into broader trends in the vicinity of the T-117 EAA, the spatial heterogeneity of the model predictions within and adjacent to the T-117 EAA suggests that the area is in a transitional location with regard to both erosion and sedimentation rates. The modeling results also indicate that some net erosion, on the order of 0 to 6 cm, may occur along most of the T-117 EAA shoreline during high-flow events, but net deposition may occur in the vicinity of the Marina.~~

The investigations of ship traffic presented in the STM report indicated that ship activity is not a major cause of sediment transport in the LDW (except in ship berthing areas) or in the T-117 EAA (QEA 2008).

Several organizations have measured current velocities within the LDW as part of environmental investigations. The most extensive measurements within the LDW have been conducted by the County. Current velocity meters were placed at two locations in the LDW (RM 1.1 and RM 3.5) for a 3-month period and recorded currents at 15-minute intervals along a vertical profile (King County 1999a). During this study, measured current velocities within the LDW rarely exceeded 40 cm/s (1.3 ft/s). Another study of current velocities involved the deployment of two current velocity meters for two 4-week periods at RM 1.1, which is a straight portion of the LDW located just south of Kellogg Island (King County 2005). One meter was placed near the center of the navigation channel; the other was placed on a shallower channel side slope. Reported mean net current speeds for meters placed in the center of the channel ranged from 2.5 cm/s (0.082 ft/s) (at 25% channel depth) to 18 cm/s (0.59 ft/s) (at 10% channel depth). Mean net current speeds for meters placed at the channel side slope locations ranged from 1.3 cm/s (0.043 ft/s) (at 25% depth) to 8.9 cm/s (0.29 ft/s) (at 10% depth). Currents were predominately oriented along the channel, and velocities were generally slower along the side slopes.

2.1.5.3 Geology

Geology of the Duwamish Basin

The Greater Duwamish Valley was formed by the carving action of glaciers that last advanced into this area from British Columbia approximately 15,000 years ago. When the ice sheets began to retreat approximately 5,700 years ago, the waters of Puget Sound extended up the Duwamish Valley as far south as Auburn, about 32 km (19 mi) upstream of the present mouth of the LDW at Elliott Bay. Around that same time, the Osceola Mudflow descended from Mount Rainier, depositing a massive layer of sediment into the then marine waters near present-day Auburn and Kent. The mudflow diverted the historical course of the White River, at that time a tributary of the Puyallup River, to the Green River (Booth and Herman 1998).

The alluvial fill within the Duwamish Valley deepened over time from the deposition of upstream fluvial sediments of the White, Green, and Black Rivers, advancing the mouth of the Duwamish River farther to the north. The fill included beds of fine silts and sands deposited as riverine and floodplain deposits, with coarser sands and gravels deposited near the water's edge. These sediments eventually buried the post-glacial form of the valley so that only a few outcroppings of bedrock remain exposed at the ground surface. As the river flooded and migrated back and forth across the floodplain, these sediments were re-deposited by the river and continually intermixed with additional riverine and floodplain deposits (Booth and Herman 1998).

In the late 1800s and early 1900s, extensive modifications were made to the river, including the filling of tide flats and floodplains to straighten the river channel, resulting in the abandonment of almost 6 km (3.7 mi) of the original meandering river bed (Map 2-~~6~~4). Several current side slips in the LDW are remnants of these old river meanders. The channel was dredged for navigational purposes, and the excavated material was frequently used to fill the old channel areas and the lowlands to bring them above flood levels. The portion of the LDW at the T-117 EAA was a new alignment, dredged and excavated as part of the "straightening" of the river. A former filled meander (oxbow) intercepts the shoreline in the vicinity of the north portion of T-117. Because the dredge fill materials were similar to the native deposits, they are difficult to distinguish from the native silts and sands. Subsequent filling of the lowlands for continued development resulted in a surficial layer of fill over most of the lower Duwamish Valley. Although the sediment types encountered in the LDW are variable (either from changing regional or local hydrodynamics or anthropogenic disturbances), basic sedimentary patterns of interbedded silts and sands are present in the LDW (Booth and Herman 1998).

The three principal geologic assemblages within the Greater Duwamish Valley that establish the regional hydrogeologic system, from oldest to youngest, are:

- Bedrock
- Glacial and non-glacial sedimentary units (glacially overridden and dense units that make up the plateaus to the east and west of the Duwamish Valley)
- Undifferentiated quaternary alluvial deposits (principal aquifer and groundwater pathway for the Duwamish basin)

Bedrock

Bedrock in the Greater Duwamish Valley provides the lower boundary of the aquifer system and limits groundwater flow in the basin. At the north end of the Duwamish Valley, the elevation of the bedrock unit ranges from roughly 60 m (200 ft) to over 500 m (1,640 ft) below ground surface (bgs). Exposed bedrock in the eastern and southern areas of the Duwamish Valley is predominantly marine and continental sedimentary rocks intermixed with isolated areas of igneous rock deposited during the Tertiary period. Sedimentary rock units within the Greater Duwamish Valley are not an important source of groundwater because the predominantly cemented, fine-grained nature of the material precludes rapid groundwater movement. However, igneous rock layers are extensive in the area and can store and move water much more readily (Booth and Herman 1998).

Glacial and Non-Glacial Sedimentary Deposits

The glacial and non-glacial sedimentary units within the Duwamish basin are complex sequences of interbedded and unconsolidated deposits. In areas where bedrock occurs at significant depth below the river valley, these glacial sedimentary deposits serve as the lower boundary of the alluvial deposits in the Greater Duwamish Valley. The upland plateau areas to the east and west of the valley are formed predominantly of these glacially deposited sedimentary units (Booth and Herman 1998).

Little information on the glacially overridden sedimentary units within the LDW study area is available. These overridden deposits are mainly fine-grained materials; their maximum depth is unknown (Booth and Herman 1998). Although these deposits provide a geologic boundary to the overlying alluvial deposits, they also provide a potential hydraulic pathway for the flow of upland groundwater to the Duwamish Valley alluvial sediments.

Thick sequences or silt beds (transitional beds) could potentially limit the upland inflow of groundwater where these deposits occur. The presence of saline water in the deeper alluvial sediments outside of current tidal influence areas suggests that there is little influx of fresh water into the original marine delta deposits. The lack of fresh groundwater in these deep alluvial sediments may indicate that the inflow of upland groundwater in this layer is limited (Booth and Herman 1998).

Duwamish Valley Alluvial Deposits

The near-surface alluvial deposits in the Duwamish River valley extend to a depth of roughly 60 m (200 ft) bgs within a trough bounded between the bedrock unit and the very dense upland glacial and non-glacial sedimentary deposits. The geologic history of this valley suggests that the alluvial deposit sequences include estuarine deposits, typically fine sands and silts (often including shell fragments), which progress upward into more complex, interbedded river-dominated sequences of sand, silt, and gravel. These layers of alluvial deposits delineated the areas of advancing river delta sedimentation that increase in thickness from south to north (Booth and Herman 1998).

Geology of the T-117 EAA and Vicinity

A summary of geotechnical information for the west shore of the LDW indicates that upland portions of the T-117 EAA consist of shallow fill. The alluvium underlying the fill extends to a depth of approximately 95 ft (29 m) bgs and consists of discontinuous silt units with interbedded sands, silty sands, and some gravel. Thin peat deposits have also been encountered. A fine-grained lower unit that contains shell fragments has been observed in borings beneath the lower silt, and dense sand and gravel were reportedly observed at depths below 95 ft (29 m) bgs (Wilbur Consulting 2003). ~~A~~ Geologic cross sections of the T-11 EAA are~~is~~ provided as Figures 2-1 through 2-5.

Slipsheets (11 x 17)

Figure 2-1. Geologic cross section of the T 117 EAA

Figure 2-1. Cross section locations

Slipsheet (11 x 17)

Figure 2-2. Geologic cross section A-A′ of the T-117 EAA

Slipsheet (11 x 17)

Figure 2-3. Geologic cross section B-B′ of the T-117 EAA

Slipsheet (11 x 17)

Figure 2-4. Geologic cross section C-C′ of the T-117 EAA

Slipsheet (11 x 17)

Figure 2-5. Geologic cross section D-D′ of the T-117 EAA

Geology of the T-117 Upland Study Area and Adjacent Streets

According to the results of previous site characterization activities at the T-117 Upland Study Area (Parametrix 1991; RETEC 2007b; SECOR 1997; Windward and DOF 2006), subsurface soil at the T-117 EAA consists of fine to medium sand, sand/silt mixtures, and silt. Shallow soils typically consist of fill material that ranges from 3 to 10 ft in thickness, with the fill thickness increasing toward the LDW. This fill consists of sand with varying amounts of silt mixed with anthropogenic materials (e.g., bricks, rubble, and wood). Shallow boreholes typically terminate in a silt unit present beneath the fill. All stratigraphic information from below the fill/silt contact has been provided by a geotechnical borehole advanced along the west bank of the LDW (Hart Crowser, 2003). This borehole indicated that the silt unit is 10 ft thick and is underlain by a sand unit that is about 20 ft thick. Silt and sand interbeds are present beneath the sand unit.

A bedrock outcropping, which is unique within the Duwamish valley, is present immediately south of the T-117 EAA (Booth and Herman, 1998). This bedrock ~~was~~ has been encountered during geotechnical explorations on the Boeing South Park property at elevations above 40 ft MLLW (Dames and Moore, 1980a and b), which is above the ground surface elevation of the T-117 Upland Studay Area ~~the installation of MW-13 by Ecology~~. The influence of this formation can be seen in the upper elevation of the till in the geologic cross sections (Figures 2-1 through 2-5). This formation may also influence local hydrogeology.

T-117 Upland Study Area soil has been modified by the 1999 and 2006 TCRAs. The removal area that was excavated for the 1999 TCRA (Onsite 2000a) was backfilled with fill and quarry spalls (i.e., large angular rocks) to depths ranging from approximately 2 to 6 ft. This backfill was overlain with an asphalt pavement system (i.e., gravel subgrade and bituminous pavement) that was approximately 1 ft thick. The removal area that was excavated for the 2006 TCRA (RETEC 2007b) was backfilled with crushed rock to depths ranging from approximately 2 to 7 ft and covered with asphalt pavement.

Site characterization work conducted by the City in the Adjacent Streets determined that the soil gradation is generally fill material (asphalt and gravel with fines) in the top 1 to 2 ft underlain by silts, sandy silts, and a characteristic native sand deposit observed throughout most of the site (Integral 2006b). The depth to the native sand unit varied approximately as follows:

- 4 to 6 ft at Dallas Avenue S, between 14th Avenue S and 17th Avenue S
- 2 to 5 ft at Dallas Avenue S, between 17th Avenue S and S Donovan Street
- 9 to 10 ft at S Donovan Street, between 17th Avenue S and Dallas Avenue S

2.1.5.4 Hydrogeology

The shallow unconfined aquifer in the Duwamish River valley is generally located within the native alluvium unit. At T-117, shallow groundwater extends upward into the overlying sand and silt fill, and water table fluctuations are influenced by river level fluctuations in the LDW. Groundwater is recharged from the upland areas to the west (Wilbur Consulting 2003), and net groundwater flow is toward the LDW as shown on Map 2-~~7~~5.

Recent groundwater level data collected in 2008 and 2009 (ENSR | AECOM 2008; AECOM 2009a) indicate that the groundwater table within the T-117 EAA occurs between approximately 7.4 and 13.0 ft MLLW (Map 2-~~7~~5). Tidal influence has been observed in all monitoring wells on the T-117 Upland Study Area (MW-2 through MW-8) and was confirmed by tidal study piezometric measurements made in 1998, 2003, 2006, and 2008 (SECOR 1998; Windward et al. 2005b; Windward unpublished; ENSR | AECOM 2008). During these tidal studies, the water levels in the LDW varied by up to 13 ft, from extreme high to extreme low tide, and water levels in the T-117 shoreline wells typically varied by 3.2 to 8 ft. The magnitude of the water level variation decreased inland with no tidal influence observed in the wells located on Dallas Avenue S (MW-01, MW-09, and MW-10) (ENSR | AECOM 2008). Based on this information, tidal influence becomes negligible somewhere between about 80 ft (MW-03) and 230 ft (Dallas Avenue S) from shore. An earlier investigator reported that the tidally influenced area adjacent to the waterway is generally within 300 to 500 ft of the shoreline (Booth and Herman 1998).

At T-117, the groundwater gradient reverses during high tide, causing water from the LDW to flow into the aquifer and mix with groundwater. Once the tide has ebbed, groundwater flowing from the aquifer into the LDW is a mixture of groundwater and surface water from the LDW. The degree to which surface water enters and exits the aquifer during the tidal cycle has ramifications for groundwater characterization. Tidal influence was measured in all shoreline wells and in well MW-03, which is located approximately 100 ft from the LDW (Map 2-~~7~~5). ~~In addition, the use of a pumping well at this location could create a drawdown at significant distance, though much less than the 1,000 ft noted by Herman and Wineman (1997).~~ Under these conditions, the infiltration of surface water from the adjacent LDW would occur across the entire vicinity of the T-117 Upland Study Area. Appendix B discusses this issue in more detail and provides an estimate of tidal mixing based on empirical data and modeling studies.

Groundwater and surface water interactions also affect the salinity of the groundwater at the T-117 EAA. Specific conductance, a proxy for salinity, is elevated in shoreline wells. This is likely due to the infiltration of brackish surface water from the LDW. Specific conductance is also elevated in several other wells that are not adjacent to the LDW. The highest specific conductance measurements were taken at MW-13, which is located near a bedrock outcropping at the Boeing property to the south. It is likely that the elevated specific conductance is due to upwelling of more saline groundwater from the lower aquifer along preferential flow paths adjacent to the bedrock in the vicinity of MW-13 (Booth and Herman 1998). The lower aquifer in this area is more saline because of historical interactions with Puget Sound (Herman and Wineman 1997) (see Appendix B for a full discussion of specific conductance in groundwater at the T-117 EAA).

Horizontal groundwater gradients were determined based on the net groundwater flow (Map 2-5). Two horizontal gradients were determined for the site, one between MW-10 and MW-12 and a second between MW-03 and the shoreline well MW-05R. The horizontal gradient in the vicinity of MW-10 and MW-12 is 0.076 ft/ft, and the horizontal gradient in the vicinity of MW-03 and MW-05R is 0.009 ft/ft.

Hydraulic conductivities for typical silty sand units, such as the T-117 EAA fill soil, range from 10^{-1} to 10^{-5} cm/s. Site-specific data for groundwater in the upper portion of the native alluvium was used to estimate ~~Silt units, such as the upper portion of the native alluvium that is immediately below the fill unit, typically have~~ hydraulic conductivities ranging from 10~~$^{-3}$~~$^{-1}$ to 10~~$^{-7}$~~$^{-3}$ cm/s ~~(Freeze and Cherry 1979)~~.

Seeps have been observed at the base of the shoreline riprap (at the mudline) near the central portion of T-117 Sediment Study Area and south of the Marina boat ramp during low tides. Two seeps appear to be well established, as demonstrated by the channels that have been cut into the tide flats between the seep locations and the main river channel. Several minor seeps have also been observed along the T-117 EAA shoreline, but the flow is intermittent and not as pronounced. One of the well established groundwater seeps (Seep 2 (SW-2), shown on Map 2-1) appears to emerge adjacent to a wooden pile, which suggests that the pile may have intercepted a locally confined lower sand unit. The possible sources and control of these seeps will be addressed during the remedial design phase of the NTCRA.

2.1.6 Sensitive ecosystems and habitat

Sensitive ecosystems and habitat in the T-117 EAA are limited to the aquatic sediment portion of the site. The upland portion of the EAA is developed and lacks sufficient substantial habitat to support wildlife, as described in a terrestrial ecological evaluation (TEE) conducted for the Adjacent Streets (Integral 2006b).

Estuarine intertidal and near-shore subtidal ecosystems in the LDW provide important habitat for juvenile salmonid growth, physiological transition, and predator avoidance during their outmigration. The estuarine environment also provides refuge for various marine fish during larval stages and supports an array of preferred prey for all salmonid life stages. The intertidal zone in the LDW is located approximately between -4 ft and +13 ft MLLW, and the near-shore subtidal zone is just slightly deeper than the intertidal zone.

Within the intertidal areas, mudflats serve many ecosystem functions, including providing food and habitat for benthic invertebrates, fish, shorebirds, and aquatic mammals. A diverse assemblage of invertebrate species, including larvae, clams, worms, and crustaceans, can be found in these habitats, which typically consist of unconsolidated silts and clays and sand flats of unconsolidated sandy sediments (Simenstad et al. 1991). Mudflats containing gravel may support high densities of bivalve populations.

The features of the T-117 EAA intertidal mudflat make the area suitable habitat for the organisms described above as well as provide potentially important habitat for organisms within the juvenile salmonid food web. The intertidal mudflat of the T-117 EAA extends approximately 15 to 65 ft (4.6 to 20 m) from the immediate shoreline, around +5 ft MLLW, to a depth of approximately -4 ft MLLW. The T-117 intertidal mudflat includes more than 43,000 ft^2 (4,000 m^2) of gently sloping, fine-grained sediment. An LDW clam survey (Windward 2004) conducted in 2003 identified harvestable clams within the T-117 intertidal area.

2.2 PREVIOUS REMOVAL ACTIONS

This section provides an overview of historical removal action activities and environmental investigations pertinent to the T-117 EAA.

Prior to the Port's acquisition of the asphalt plant ~~T-117 Upland Study Area~~ parcel in 2000~~1999~~, the Malarkey asphalt plant was closed, and a number of storage tanks were removed or abandoned (i.e., closed in place) as required by EPA in a 1996 AOC for Removal Action at Malarkey (EPA 1996a). In 1996 and 1997, Malarkey performed tank and equipment decommissioning and decontamination and removed soil from ditch areas and the utility corridor (i.e., hot spot removals). Product ~~also~~ was also removed from a large-diameter well prior to Port ownership (SECOR 1998).

All of the tanks were decommissioned and removed from the property prior to the Port's acquisition in 2000~~1999~~. The three USTs, which contained diesel and waste oil, were filled with concrete slurry and closed in place; a partially buried railroad car, which was used to hold waste oil, was excavated and removed. Sixteen ASTs were also removed from the site. Soil samples were taken from the tanks and tested for TPH (Hart Crowser 1992). The former locations of these tanks are shown on Map 2-~~8~~6.

In 1999, ~~immediately~~ prior to the Port's acquisition of the site, a TCRA for upland soil was conducted within the T-117 Upland Study Area pursuant to an EPA AOC (No. 10-2000-0222) (EPA 2000) to remove PCB-contaminated soil from the former ponding area (see Section 2.2.1 for additional details). Since the 1999 TCRA and the Port's 2000 acquisition of the former asphalt plant, several actions that focus on the removal of asphalt plant residues and PCB-contaminated soil from within the T-117 Upland Study Area and Adjacent Streets have been performed by the Port. In 2003, several old drums and other large debris were removed from the offshore intertidal area. In 2004, a below-grade utility corridor was cleaned out. In 2006, under the terms of a separate ASAOC, the Port carried out an additional TCRA to remove additional impacted soil with the highest concentrations of the newly discovered PCBs within the T-117 Upland Study Area.

In 2004 and 2005, the City implemented a series of independent cleanup actions to address PCBs discovered in soil in the Adjacent Streets and Residential Yards and three neighboring residential properties near the T-117 EAA (City of Seattle 2005). The City removed soil that had PCB concentrations exceeding 1 mg/kg from the residential yards and unpaved street shoulders and placed a temporary asphalt cap over residual contamination within the street ROW areas. The action level of 1 mg/kg was based on the MTCA Method A CUL for PCBs. The ~~current removal action~~NTCRA boundary for the Adjacent Streets includes the areas where~~addresses~~ ~~remaining~~ contamination may still be present~~in this area~~.

The above removal actions conducted in the T-117 EAA are described in greater detail in the following subsections. The locations of previous removal actions are shown on Map 2-~~8~~6. Removal actions conducted in the T-117 EAA are also presented on the timeline (Figure 1-1).

2.2.1 1999 ~~TCRA~~time-critical removal action

PCBs were initially detected in surface and subsurface soil in the upland shoreline parcel (former ponding area) during several investigations in the 1990s. A TCRA (Map 2-~~8~~6) was conducted by the Port in 1999 (Onsite 2000a) to remove PCB contaminated soil from an area within the shoreline parcel that contained elevated concentrations of PCBs based on previous sampling efforts (SECOR 1998, 1997). The TCRA was performed in accordance with the EPA AOC (No. 10-2000-0222) (EPA 2000) and associated SOW. Tasks included:

- Mobilization and site preparation (including installation of drainage controls and the establishment of controlled work areas)
- Removal, storage, testing, and treatment of water from the ponding area prior to soil removal
- Containment, testing, and removal (for offsite treatment) of approximately 50,000 gal. of water during excavation
- Removal from the work area and disposal of several drums that contained asphalt
- Excavation and disposal of 2,061 tons of contaminated soil with PCB concentrations that ranged up to 500 mg/kg
- Removal of shallow (i.e., top 0.5 ft) soil from exposed areas around the former asphalt plant structures
- Backfilling
- Installation of an asphalt pavement cap

- Improvement of storm drains (e.g., new catch basins in excavated area)
- Abandonment of the large-diameter industrial water supply well
- Replacement of three monitoring wells removed during the soil excavation

All material removed from the property was disposed of at approved facilities. The project's target action level for PCBs in soil was 25 mg/kg, and remaining soil at the T-117 Upland Study Area was capped with asphalt pavement. The project's target action level was negotiated with EPA and was premised on the "spill cleanup policy" value (25 mg/kg) for soil in restricted-access sites set forth under the Toxic Substances Control Act (TSCA). However, concentrations of PCBs above the action level were left in removal grids A-1 and B-2 (Map 2-~~8~~6) because of the potential undermining of old building foundations. A 375-gal. (1,420-L) non-leaking diesel tank was also discovered during the project and removed (Onsite 2000a). Two soil samples from the tank excavation had elevated concentrations of diesel-range TPH (TPH-D) (462 and 2,780 mg/kg). Other samples did not contain detectable concentrations of TPH.

2.2.2 2004 utility corridor cleanout

The Port removed contaminated and structurally unsuitable fill materials, debris, and waste from approximately 150 ft of a 2-ft-wide, 2.5-ft-deep, below-grade utility corridor in the T-117 Upland Study Area (Map 2-6). This project was conducted independently by the Port, without oversight under either the MTCA or CERCLA. The work was conducted to prevent further settling of the pavement surface along the concrete-lined corridor and to stem extrusions of asphalt material that were caused by heavy vehicles (high surface loading) during warm weather and appeared at several locations along the alignment. Soft asphalt was observed extruding up through the pavement in the truck parking area and there was concern that this material could be tracked and spread by vehicles. ~~This project was conducted independently by the Port without oversight under either the Model Toxics Control Act (MTCA) or CERCLA.~~

The Port removed the residual asphalt, contaminated soil, debris, and abandoned asphalt plant-era pipes and backfilled the corridor with controlled density fill, without oversight under either the MTCA or CERCLA. The overlying surface was repaved with asphalt to restore the pavement surface. Soil removed from the south portion of the concrete-lined corridor was found to contain elevated concentrations of TPH-D and lube oil-range TPH (TPH-O), as well as large amounts of roofing asphalt. Concentrations of PCBs in excavated soil did not exceed 10 mg/kg, and the soil was not designated as a dangerous waste as a result of PAH or metals concentrations. Approximately 26 tons of TPH-contaminated soil were excavated and disposed of offsite at an approved landfill. Asphalt, pipe and metal debris, and oil were also removed (Windward and Onsite 2004). All material removed from the property was disposed of, treated, or recycled at approved facilities.

2.2.3 2006 time-critical removal actionTCRA

The Port conducted a second TCRA (Map 2-6) to remove hazardous substances from the T-117 Upland Study Area from September to November 2006. EPA determined that a TCRA was required because of the high concentrations of PCBs in soil on the T--117 Upland Study Area. The objectives of the TCRA were to prevent or reduce the potential for human exposure to contaminants and to prevent or reduce the potential for contaminants to migrate into the LDW.

The TCRA was performed in accordance with the Superfund ASAOC (No. -10--2006--0072) SOW (EPA 2006b). The TCRA included the excavation of PCB-contaminated soil, offsite disposal of PCB-contaminated soil at approved landfills, offsite disposal of construction debris (e.g., asphalt), backfilling of excavations with clean soil, environmental controls, monitoring to ensure there were no releases of PCB--contaminated soil to the adjacent neighborhood and to the LDW, and site restoration (e.g., new asphalt cap, street sweeping). TCRA activities were overseen by EPA and closely coordinated with EPA and the neighborhood, with regular meetings being held throughout the duration of the project.

Three areas with elevated PCB concentrations (up to 9,200 mg/kg) were excavated: one area along the riverbank and two areas west of the riverbank (Map 2-6). Excavation along the riverbank consisted of the removal of the upper 2 ft of surficial soil, including the existing asphalt and pavement. Excavation depths in the remaining two areas varied from 2.5 to 7 ft bgs based on the depth needed to achieve the PCB removal action level of 25 mg/kg (RETEC 2007b). All material removed from the property was disposed of, treated, or recycled at approved facilities. The following quantities were removed:

- 3,030 tons of Toxic Substances Control Act (TSCA) soil (concentrations > 50≥ 50 mg/kg total PCB)
- 78 tons of Resource Conservation and Recovery Act (RCRA) Subtitle D (concentrations < 50 mg/kg total PCB) soil
- 533 tons of RCRA Subtitle D asphalt and concrete debris
- 91,472 gal. of onsite runoff/decontamination water
- 2.7 tons of metal debris
- 1.2 tons of cleared and grubbed vegetative debris

Clean backfill was placed in all of the excavation areas after the analytical results for each excavation area had been reviewed. A non-woven geotextile was installed on top of the excavation subgrade as an identifying marker layer. Asphalt pavement (i.e., a temporary cap) was installed after the backfill had been placed and compacted (RETEC 2007b).

In 2008, bank repair work was performed as part of maintenance activities associated with the TCRA. This work included stabilizing approximately 25 linear ft of the upper shoreline bank by reinforcing the area with a riprap revetment. In addition, to minimize erosion, clean gravel was removed from the top of the bank to reduce the load on adjacent areas of the bank. The localized bank failure was first noted during a scheduled maintenance visit on March 7, 2008. A temporary repair of the bank was implemented on March 13, 2008, which included covering the eroded area with plastic and securing the plastic with sandbags. Final repair and maintenance activities began on June 16 and were completed on June 20, 2008. The repair work involved site preparation, vegetation removal, geotextile placement, silt fence repair, the removal of existing plastic, riprap and gravel cobble mix placement, and the removal of existing gravel. The shoreline bank repair and maintenance work was performed in accordance with the May 29, 2009, scope of work described in the request for authorization approved on June 9, 2008, by EPA (ENSR 2008b; EPA 2008b). A complete summary of work performed is included in the *Bankline Repair and Maintenance Activities Completion Report, Terminal 117, Port of Seattle* (ENSR 2008a).

2.2.4 Independent cleanup actions in the Adjacent Streets and Residential Yards Study Area

The City completed a series of independent cleanup actions between December 2004 and October 2005 (City of Seattle 2005) to reduce potential human exposure to PCB-impacted soil in the streets, ROWs, and yards in the vicinity of T-117 EAA (Map 2-6~~8~~). These actions were conducted independently by the City without oversight under either MTCA or CERCLA. The independent cleanup actions are described in a site characterization data report (Integral 2006b) and briefly summarized below.

- Soil with PCB concentrations that exceeded 1 mg/kg was removed from residential yards at 8601 and 8609 17th Avenue S, the boat storage yard at 8603 Dallas Avenue S, and from along the west side of 16th Avenue S (Hart Crowser 2005). The action level of 1 mg/kg was based on MTCA's Method A ~~cleanup level (~~CUL~~)~~ for PCBs. The depth of soil removal was based on confirmation sampling ~~.~~(King County and SPU 2005).
- A 100-ft section of the road shoulder on the north side of the 8500 block of Dallas Avenue S was paved to cover soil that contained PCB concentrations above 1 mg/kg~~improve drainage~~.
- Shallow excavations (i.e., between 6 and 12 in.) and the placement of clean gravel were completed in the unpaved road shoulders along selected portions of Dallas Avenue S, between 14th Avenue S and 17th Avenue S; on 16th Avenue S, between Dallas Avenue S and S Cloverdale Street; and in a boat storage area located within the public ROW on Dallas Avenue S, between 14th Avenue S and 16th Avenue S.

- The City street ROWs surrounding the Basin Oil property bounded by Dallas Avenue S, 17th Avenue S, and S Donovan Street were graded and paved with asphalt.
- The existing catch basin located near the south driveway entrance to the T-117 Upland Study Area was cleaned, and a catch basin near 8609 17th Avenue S was removed. Basin Oil removed two catch basins and an oil/water separator on their property within the same time frame.Contaminated sediment was removed from three existing catch basins (located around the perimeter of the Basin Oil property); a catch basin near 8609 17th Avenue S was also removed. The existing catch basin in the boat storage yard was also cleaned.
- The following streets were pressure washed, and the existing catch basins serving those streets were cleaned: S Cloverdale Street, between 14th Avenue S and 16th Avenue S; S Donovan Street, between 16th Avenue S and 17th Avenue S; and in front of the building located at 8620 16th Avenue S.
- A temporary stormwater collection and treatment system was installed to capture runoff from the ROW independent cleanup action area. This work included the installation of the drainage features described above in Section 2.1.3.3, including five catch basins, two small pump stations, five 18,000-gal. storage tanks, and a temporary treatment system (i.e., settling followed by sand and granular activated-carbon filtration). All runoff from the area is now collected in the five storage tanks and released at a controlled rate to the City's CSS at 17th Avenue S and S Donovan Street. The temporary treatment system, associated with the storage tanks, was installed during the independent cleanup action to treat construction and post cleanup runoff and was removed in April 2005, when repeated sampling confirmed that PCBs were not detected in the incoming runoff. The City obtained discharge authorization from the County's Industrial Waste Program for this discharge. As part of the authorization, SPU tests the quality of water discharged to the CSS every month in which discharge occurs. The temporary stormwater collection system remains in place and will be maintained until removal action construction.

2.3 Previous Environmental Investigations and Summary of Environmental Data

This section summarizes the chemistry data associated with the investigations presented in Table 2-1 2 for each study area of the T-117 EAA and the two RAAs. These investigations and other milestones are also presented on the timeline (Figure 1-1). Map 2-9 7 presents an overview of the sampling locations in all three study areas of the T-117 EAA.

Data summarized in this section are presented along with screening levels (SLs) discussed in Section 3, where they are used to identify COPCs. PCBs, PAHs, and TPH are the most prevalent chemicals that exceed their respective the SLs in soil and sediment within the T--117 EAA. The large quantity of data for the T-117 EAA indicates that the current environmental conditions at the site are likely the result of historical site use and operations.

All available data are presented in Appendix C. However, not all samples are representative of current conditions as a result of previous removal actions (described in Section 2.2) and subsequent sampling results (i.e., MIS) that has superseded previous sampling results. Numbers of samples provided in this section are for only the actual field samples and do not include the quality assurance/quality control (QA/QC) samples (i.e., field duplicates and triplicates and laboratory duplicates). Maps and analytical results presented in the following sections present mean concentrations that include the results of QA samples. In addition, multiple samples may have been collected from a single location if samples were collected from multiple depth intervals at that location. A complete description of all the data management rules used in this step is provided in Appendix D.

Table 2-21. Summary of previous investigations at T-117 Early Action Area

Activity	Date	Summary	Analyses	No. of Samples from the T-117 EAA and Vicinity Used in the EE/CA[a]	Source
Summary of T-117 Historical Investigations – Data Ttoo Oold or Nnot Aapplicable for Uuse in EE/CA					
Metro inspection – sampling of roadway ponding area and shoreline seep	1984	Water and sediment samples were collected from the LDW, roadway ponding area, catch basin 5 outfall, and an apparent groundwater seep at the shoreline. PCBs, PAHs, and metals were detected in one or more of the water and sediment samples. No PCBs were detected in the seep sample. The ponding area was reportedly receivedused for non-contact cooling water during the period that the asphalt plant operated.discounted by subsequent investigators.	PCBs, PAHs, and metals	na	URS (1994)
Ecology sediment sampling and inspections	1985 and 1986	Sediment samples were collected from an onsite drainage ditch. Results showed elevated concentrations of lead (1,666 mg/kg), arsenic (2,027 mg/kg), and zinc (5,416 mg/kg).	metals	na	URS (1994)
EPA TSCA inspection	1989	Samples were collected from a waste oil tank and another tank that contained usable light oils. No PCBs were detected. However, total halogenated hydrocarbons (as total chlorine) were reportedly detected at levels up to 1,160 mg/kg in the sampled product. No materials were noted at the facility to qualify for PCB regulation.	PCB and halogenated hydrocarbons	na	URS (1994)
Malarkey site inspection	1994	One surface sediment sample was collected at the toe of the bank. Onsite and offsite soil, sediment, groundwater, and surface water were sampled. PCBs and PAHs were detected in soil at the former ponding/waste areas. Three monitoring wells and a groundwater seep were also sampled. PCBs were detected in all wells, and PAHs were detected in MW-03. PCBs were not detected in the seep sample.	PCBs and PAHs	na	URS (1994)
Asbestos survey	March 1996	An asbestos-containing material survey was conducted. Twelve suspect materials were found to contain detectable amounts of asbestos.	asbestos	na	EMCON (1996)
Sediment Study Area – Sediment					
Duwamish Waterway Phase 1 site characterization	1997	Site-wide LDW surface and subsurface sediment samples	metals, PCB Aroclors, and SVOCs	4	Exponent (1998)

Table 2-~~1~~2. Summary of previous investigations at Terminal-117 Early Action Area (cont.)

Activity	Date	Summary	Analyses	No. of Samples from the T-117 EAA and Vicinity Used in the EE/CA[a]	Source
Duwamish Waterway sediment characterization study	1997	Site-wide LDW surface and subsurface sediment samples	PCB Aroclors, selected PCB congeners, and total polychlorinated terphenyls	3	NOAA (1998)
EPA site inspection: Lower Duwamish River	1998	Site-wide LDW surface and subsurface sediment samples	metals, pesticides, PCB Aroclors and selected PCB congeners, dioxins and furans, TBT, SVOCs, and VOCs	5	Weston (1999)
LDW RI Benthic	2004	Site-wide LDW chemical analyses of benthic invertebrate and clam tissue samples and co-located sediment samples	metals, SVOCs, and PCB Aroclors,	2	Windward (2005a)

Table 2-~~1~~2. Summary of previous investigations at Terminal-117 Early Action Area (cont.)

Activity	Date	Summary	Analyses	No. of Samples from the T-117 EAA and Vicinity Used in the EE/CA[a]	Source
T-117 EAA investigation	December 2003	An initial sediment investigation was conducted to determine the nature and extent of contamination in the T-117 EAA. All surface and subsurface sediment were analyzed for PCBs and select locations were also analyzed for SMS chemicals and TBT.	metals, PCB Aroclors, SVOCs, VOCs, TBT	137	Windward et al. (2005b)
	March 2004	Additional subsurface and surface sediment samples were collected from the northern portion of T-117 to further refine the removal boundary. Large asphalt deposits and other major debris located in the shoreline bank were identified, described, and mapped.	PCB Aroclors	12	Windward et al. (2005b)
	June 2004	Surface sediment samples collected outside the offshore northern portion of the preliminary sediment boundary in the 2005 EE/CA were analyzed for PCBs, and archived samples collected in December 2003 that were either outside of the boundary or below the vertical extent of PCB contamination were analyzed for all other SMS chemicals.	metals, PCB Aroclors, SVOCs, and VOCs	8	Windward et al. (2005b)
	September 2004	Surface and subsurface samples were collected in the northern portion of the site that extends into the proposed Marina dredge area. This sampling event was conducted to satisfy both the EPA T-117 EAA boundary definition and the PSDDA sediment characterization requirements for the Marina.	metals, pesticides, PCB Aroclors, SVOCs, and VOCs	12	Windward (2005a)
	August 2008	Surface sediment samples collected near the proposed sediment boundary for the 2008 EE/CA were analyzed for dioxins and furans and PCBs to determine if there were any dioxin/furan TEQ exceedances outside of the boundary and to refine the extent of the sediment removal boundary presented in this EE/CA. Two surface sediment samples were also collected for mercury and dieldrin to evaluate potential soil to sediment contamination from the Marina.	PCB Aroclors, dioxins and furans, mercury and dieldrin	18	Windward and Integral (2009)
T-117 Upland Study Area – ~~-~~Soil					
Ecology site hazard assessment	May 1991	Work included review of Ecology and Malarkey ~~Asphalt~~ files, installation of three monitoring wells (MW-01, MW-02, and MW-03), soil sampling and analysis of borehole samples, groundwater sampling, sampling of product in USTs and ASTs. Metals, PCBs, pesticides, and VOCs were found in soil. Results of TCLP analyses on soil were below dangerous waste criteria.	metals, total PCBs, pesticides, SVOCs, VOCs	8	Parametrix (1991)

Table 2-~~1~~2. Summary of previous investigations at Terminal-117 Early Action Area (cont.)

Activity	Date	Summary	Analyses	No. of Samples from the T-117 EAA and Vicinity Used in the EE/CA[a]	Source
UST decommissioning and site assessment	1992	Four USTs containing diesel and waste oil were decommissioned, including a partially buried railroad tank car. Three USTs were closed in place by filling with concrete slurry. The railroad tank car was removed. Soil samples were taken from the tanks and tested for TPH.	TPH	6	Hart Crowser (1992)
Malarkey ~~Asphalt Company~~ site inspection	1994	One surface sediment sample was collected at the toe of the bank. Onsite and offsite soil, sediment, groundwater, and surface water were sampled. PCBs and PAHs were detected in soil at the former ponding/waste areas. Three monitoring wells and a groundwater seep were also sampled. PCBs were detected in all wells, and PAHs were detected in MW-03. PCBs were not detected in the seep sample.	total PCBs and PAHs	na	URS (1994)
Soil and water sampling	September 1995	Surface soil samples were collected from locations near the ponding area, former railroad tank car, and storm drain ditches.	total PCBs	7	EMCON (1996)
Focused site characterization	July 1997	Surface soil samples were collected from locations near the ponding area and former railroad tank car to delineate the extent of contamination.	total PCBs, PAHs, and TPH	55	SECOR (1998)
Utility corridor soil sampling	October 1999	Three borehole locations were sampled along a utility alignment that extended from the former tank area to the south building.	PCB Aroclors	3	Windward and Onsite (2004)
PCB soil removal and containment – roadway area (1999 TCRA)	October 1999 to February 2000	Actions included the removal and treatment of impounded stormwater, the excavation and disposal of over 2,000 tons of PCB-contaminated soil with concentrations ranging up to 500 mg/kg, backfilling, installation of a pavement cap, and storm drain improvements. Also included was the abandonment of the large-diameter well and replacement of three monitoring wells. PCB removal action target level in soil was 25 mg/kg.	total PCBs	14	Onsite (2000a)
Underground diesel storage tank removal	January 2000	A 375-gal. (1,420-L) non-leaking diesel tank was removed. Two soil samples from excavation indicated elevated TPH diesel levels (462 and 2,780 mg/kg).	TPH	2	Onsite (2000b)

Table 2-~~1~~2. Summary of previous investigations at Terminal-117 Early Action Area (cont.)

Activity	Date	Summary	Analyses	No. of Samples from the T-117 EAA and Vicinity Used in the EE/CA[a]	Source
T-117 EAA investigations	December 2003	Soil samples were collected from the top of the shoreline, the southern drainage ditch, and the adjacent Dallas Avenue S roadway area. Solid samples were collected from catch basins. PCBs were detected in most soil samples.	metals, PCB Aroclors, and SVOCs	40	Windward et al. (2005b)
	March 2004	To better define the extent of contamination, shallow soil borings were collected from the northern upland bank. All these samples were analyzed for PCBs and compared to SMS to assess the risk from potential erosion. Soil sampling was also conducted to estimate concentrations of PCBs in the roadway along the entrance area of the T-117 property and determine if these materials were the likely source of elevated PCBs in and around catch basin 5. Roadway soil samples and catch basin samples were analyzed for PCBs. Large asphalt deposits and other major debris located in the south ditch were identified, described, and mapped.	PCB Aroclors	16	Windward et al. (2005b)
T-117 South building planter soil sampling	November 2004	Four shallow soil grab samples were obtained from the concrete-enclosed soil-filled planter areas at the north side of the south building at T-117. PCB concentrations in the four soil samples ranged from 0.03 to 0.22 mg/kg. Soil in the west planter was subsequently covered over with a layer of clean gravel. Soil in the east planter was covered with asphalt pavement.	PCB Aroclors	4	Onsite (2004)
T-117 Upland soil sampling	June 2005	This work was performed as part of an iterative process to provide additional information on the nature and extent of PCBs in soil. Subsurface soil samples were collected from three upland regions of T-117: the unpaved upland area along the northern shoreline; beneath the pavement along the shoreline edge of the site; and the ditch along the southern boundary of the site.	PCB Aroclors	95	Windward et al. (2005d)
T-117 Upland soil sampling - supplemental	August 2005	Supplemental upland soil sampling was conducted from 26 soil borings (0 to 9 ft).Three soil samples (SB-26, SB-51, and SB-28) along the northern shoreline contained PCB concentrations similar to those of the previous upland sampling effort in the same area. Two soil samples located in the paved driveway area inboard of the bank extending north of the 1999 PCB removal area had two of the highest PCB concentrations (1,200 and 730 mg/kg for soil samples SB-30 and SB-50, respectively). These data identified a new area of elevated PCB contamination on the T-117 EAA not previously observed in the June 2005 soil sample results.	PCB Aroclors	89	Windward et al. (2005e)

Table 2-12. Summary of previous investigations at Terminal-117 Early Action Area (cont.)

Activity	Date	Summary	Analyses	No. of Samples from the T-117 EAA and Vicinity Used in the EE/CA[a]	Source
T-117 Upland Investigation	January 2006	Soil borings were collected throughout the upland property. PCBs were detected in several samples. The results of this investigation led to the 2006 TCRA for PCB contaminated soil.	PCB Aroclors, metals SVOCs, pesticides and TPH	230	Windward and DOF (2006)
T-117 TCRA activities (2006 TCRA)	October to November 2006	Confirmation samples were collected in the TCRA excavation areas upon completion of the soil removal activities. Baseline samples were also collected in the roadway along Dallas Avenue S before and after the TCRA.	PCB Aroclors and TPH	79	RETEC (2007b)
T-117 EAA dioxin investigation	August 2008	Subsurface Soil samples were collected to determine the presence and concentrations of dioxins and furans in the T-117 Upland Study Area. Select subsurface samples were also analyzed for TPH and PCBs to further refine the vertical extent of the removal boundary.	PCB Aroclors, PAHs, TPH, and dioxins and furans	29	Windward and Integral (2009)
Adjacent Streets and Residential Yards Study Area					
Street dust and soil ROW sampling	2004 – 2005	Soil samples were collected of ~~right-of-way~~ROW street dust and from storm drain catch basins by ~~Seattle Public Utilities~~SPU and King County Health Department and analyzed for P~~B~~CBs. Catch basin sample CB41 and street dust sample SD52 were analyzed for dioxins that led to discovery of dioxin/furans in this area.~~.~~	PCB Aroclors and dioxin and furans	31	Integral (2006b) Integral (2008b)~~(2008)~~
Subsurface soil ROW sampling	2004 – 2005	Subsurface soil samples were collected from boreholes and test pits within the ROW by ~~Seattle Public Utilities~~SPU and King County Health Department.	PCB Aroclors	118	Integral (2006)
Yard soil sampling	2004 – 2005	Samples were collected from yards adjacent to the ROW by ~~Seattle Public Utilities~~SPU and King County Health Department.	PCB Aroclors	97	Integral (2006)
Yard soil sampling	2005	In June 2005, SPU collected confirmatory soil samples at the base of the excavation following the removal of PCB-contaminated soil from the residential lots adjacent to the impacted ROW. All confirmation samples were below 1 mg/kg.	PCB Aroclors	56 (not included in Appendix C)	Hart Crowser (2005)
Subsurface sampling in Adjacent Streets	February and March 2006	Twenty-five direct push borings were advanced up to a depth of 20 ft bgs to delineate the extent of PCB contamination and to screen for other COPCs within the Adjacent Streets. Results of the investigation were used to delineate the preliminary boundary for the Adjacent Streets.	PCB Aroclors, TPH, PAHs, BTEX, and metals	83	Integral (2006b)

Table 2-~~1~~2. Summary of previous investigations at Terminal-117 Early Action Area (cont.)

Activity	Date	Summary	Analyses	No. of Samples from the T-117 EAA and Vicinity Used in the EE/CA[a]	Source
T-117 EAA dioxin investigation	August 2008	Surface and subsurface soil samples were collected to determine the presence and concentrations of PCBs and dioxins and furans in the Adjacent Streets and Residential Yards Study Area.	PCB Aroclors and dioxin and furans	85	Windward et al. (2009)
PCB boundary refinement – Adjacent Streets	April and July 2009	Soil samples were collected from the adjacent streets and ~~right-of-ways~~ROWs as part of the PCB boundary refinement investigation. The samples consisted of direct push borings in the streets and ~~right-of-ways~~ROWs, discrete parking strip samples, and ~~multi-increment samples (~~MIS~~)~~ from ~~right-of-ways~~ROWs.	PCB Aroclors	76	Integral (2009)
PCB boundary refinement – Residential Yards	April and July 2009	MIS soil samples were collected from residential yards as part of the PCB boundary refinement investigation.	PCB Aroclors	75	Integral (2009)
Dioxin analysis – Adjacent Streets	July 2009	Ecology analyzed MIS sample splits for dioxins and furans from the MIS samples from Adjacent Streets during the PCB b~~B~~oundary r~~R~~efinement i~~I~~nvestigation as described above.	d~~D~~ioxin and furans	9	Ecology (2009)
Dioxin analysis – Residential Yards	July 2009	Ecology analyzed MIS sample splits for dioxins and furans from the MIS samples from Residential Yards during the PCB b~~B~~oundary r~~R~~efinement i~~I~~nvestigation as described above.	d~~D~~ioxins and furans	24	Ecology (2009)
Groundwater Monitoring (2003 to ~~-~~2008)					
Groundwater sampling at T-117 wells	May 2003	Groundwater was sampled from three wells in the vicinity of T-117. TPH-D (~~[~~0.70 mg/L)~~]~~, TPH-O (~~[~~1.4 mg/L)~~]~~, and six PAH compounds (at concentrations ranging from 0.013 to 1.6 µg/L) were detected in MW-03. PCBs were not detected in any of the wells.	PCB Aroclors, PAHs, and TPH	5	Onsite (2003)
T-117 EAA investigation – seeps	December 2003	Water samples were collected from intertidal seeps. Copper, zinc, and BEHP were detected in seep samples.	PCB Aroclors, SVOCs, VOCs, metals	5	Windward et al. (2005b)
T-117 EAA investigation – monitoring wells	January 2004	Water samples were collected from groundwater monitoring wells. No chemicals were detected in the monitoring well samples.	PCB Aroclors, PAHs, VOCs	5	Windward et al. (2005b)

Table 2-~~1~~2. Summary of previous investigations at Terminal-117 Early Action Area (cont.)

Activity	Date	Summary	Analyses	No. of Samples from the T-117 EAA and Vicinity Used in the EE/CA[a]	Source
T-117 Upland groundwater	June 2005	Two new groundwater monitoring wells were installed to extend the existing network northward. All shoreline monitoring wells and upgradient monitoring well (MW) 3 were analyzed for PCBs also monitored for the presence of free product. One well was also analyzed for PAHs and TPH. PCBs were detected in one well.	PCB Aroclors, PAHs, and TPH	6	Windward et al. (2005d)
T-117 Upland Investigation	January 2006	One well was sampled for PCBs to verify the detection noted in the previous event	PCB Aroclors	1	Windward and DOF (2006)
T-117 Upland groundwater	August 2006	Groundwater in was collected prior to 2006 TCRA activities	PCB Aroclors, metals, PCBs, and TPH	7	ENSR | AECOM (2008)
T-117 EAA Groundwater Monitoring 2008 1st Event	March 2008	5 new monitoring wells were installed in the T-117 EAA. Two wells were installed along Dallas Avenue S downgradient of Basin O~~o~~il and the other three wells were installed along the T-117 shore line as replacement wells for the ones removed during the 2006 TCRA.	PCB Aroclors, SVOCs, VOCs, metals	11	ENSR | AECOM (2008)
T-117 EAA Groundwater Monitoring 2008 2nd Event	June 2008	Groundwater samples were collected.	TSS, TPH, metals, BTEX, PCB Aroclors, SVOCs, VOCs, and PAHs	10	ENSR | AECOM (2008)
T-117 EAA Groundwater Monitoring 2008 3rd Event	September 2008	Groundwater samples were collected. Installed one new upgradient monitoring well in the T-117 EAA (MW-11).	TSS, TPH, metals, BTEX, PCB Aroclors, SVOCs, VOCs, and PAHs	10	ENSR | AECOM (2008)
T-117 EAA Groundwater Monitoring 2008 4th Event	December 2008	Groundwater samples were collected.	TSS, TPH, metals, BTEX, PCB Aroclors, SVOCs, VOCs, PAHs, and dioxins and furans	11	ENSR | AECOM (2008)
T-117 EAA Groundwater Monitoring 2009 1st Event	March 2009	Groundwater samples were collected.	TSS, TPH, metals, BTEX, PCB Aroclors, SVOCs, VOCs, and PAHs	13	AECOM (2009a)

Table 2-12. Summary of previous investigations at Terminal-117 Early Action Area (cont.)

Activity	Date	Summary	Analyses	No. of Samples from the T-117 EAA and Vicinity Used in the EE/CA[a]	Source
T-117 EAA Groundwater Monitoring 2009 2nd Event	May 2009	Groundwater samples were collected. Modified the groundwater monitoring program at the T-117-Upland Study Area. The Department of Ecology installed two new monitoring wells upgradient of Basin Oil (MW-12 and MW-13). These wells will be adopted into the T-117 EAA monitoring well net work in subsequent groundwater sampling events.	TSS, TPH, metals, PCB Aroclors, SVOCs, and cPAHs	7	AECOM (2009b)
T-117 EAA Groundwater Monitoring 2009 3rd Event	August 2009	Groundwater samples were collected.	TSS, TPH, metals, PCB Aroclors, SVOCs, VOCs, and cPAHs	10	AECOM (2009c)

[a] Numbers of samples in this table are for only the actual field samples and do not include the QA/QC samples (e.g., field duplicates). In addition, multiple samples may have been collected from a single location if samples were collected from multiple depth intervals at that location.

AST – aboveground storage tank
BBP – benzyl butyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
bgs – below ground surface
BTEX – benzene, toluene, ethylbenzene, and xylene
COPC – contaminant of potential concern
CSL – cleanup screening level
DOF – Dalton, Olmsted & Fuglevand
EAA – early action area
Ecology – Washington State Department of Ecology
LDW – Lower Duwamish Waterway
Marina – South Park Marina
MTCA – Model Toxics Control Act
MIS – multi-increment sampling
NOAA – National Oceanic and Atmospheric Administration
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PCP – pentachlorophenol
PSDDA – Puget Sound Dredged Disposal Analysis
ROW – right-of-way
Marina – South Park Marina
NOAA – National Oceanic and Atmospheric Administration
QA/QC – quality assurance/quality control
SMS – Washington State Sediment Management Standards
SPU – Seattle Public Utilities
SQS – sediment quality standards
SVOC – semivolatile organic compound
T-117 – Terminal 117
TBT – tributyltin
TCLP – toxicity characteristic leaching procedure
TCRA – time-critical removal action
TPH – total petroleum hydrocarbons
TSCA – Toxic Substances Control Act
TSS – total suspended solids
UST – underground storage tank
VOC – volatile organic compound

2.3.1 T-117 Sediment Study Area

Extensive sediment sampling in the T-117 EAA was conducted from 1998 to 2008. Most of the investigations focused on PCBs; however, additional chemicals analyzed included PAHs, other semivolatile organic compounds (SVOCs), pesticides, dioxin and furans, VOCs, and metals, including tributyltin (TBT). Appendix C includes a complete list of available data for each chemical analyzed in the T-117 Sediment Study Area.

2.3.1.1 PCBs

One hundred and eighty-two surface and subsurface sediment samples were analyzed for PCBs. PCB concentrations for surface grab samples are presented on Map 2-~~10~~8, and concentrations for subsurface samples are presented on Map 2-~~11~~9. PCB concentrations on both maps are compared to Washington State Sediment Management Standards (SMS) criteria. The detected PCB concentrations in surface sediment ranged from 1.9 to 2,200 µg/kg organic carbon (OC), and the detected PCB concentrations in subsurface sediment ranged from 1.4 to 2,600 µg/kg OC. Both the surface and subsurface sediment sampling data indicate a spatial trend of PCB concentrations decreasing from the bank out towards the navigation channel. The highest PCB concentrations were collected from within 100 horizontal ft of the shoreline bank and were typically confined to the upper 1 to 2 ft of sediment in the nearshore cores. PCB concentrations were also generally higher in the northern portion of the T-117 EAA (as opposed to the southern portion), at similar depths. This trend suggests the presence of a historical and ongoing upland source for these chemicals, which were subsequently conveyed to the river via stormwater runoff and direct erosion from the T-117 Upland Study Area and shoreline bank. Map 2-8 also identifies historical sampling locations that have since been re-occupied by more recent sampling locations. The more recent samples are considered to be more representative of current site conditions.

2.3.1.2 PAHs

Thirty-four surface and subsurface sediment samples were analyzed for PAHs. PAH data show that several individual PAHs and total carcinogenic PAH (cPAH) TEQ had maximum concentrations that exceeded their respective SLs. Less than 10% of the samples analyzed had PAH concentrations that exceeded the SL. These samples were collected from the toe of the shoreline bank and were co-located with samples that had PCB exceedances.

The detailed results (Appendix C) show that PAHs were detected in 3 of 34 samples at concentrations that exceeded the SL. Two of these samples were from surface sediment sampling locations (25-G and 37-G), and one was from a subsurface sampling location (25-SC). These locations are shown on Map 2-~~12~~10. The surface sediment sample from 25-G exceeded the sediment quality standards (SQS) for three individual PAHs, and the sample from 37-G had 13 individual PAH SQS exceedances. Total high-molecular-weight PAHs (HPAHs) also exceeded the SQS in 37-G, and total low-molecular-weight PAHs (LPAHs) in this sample exceeded both the SQS and cleanup screening level (CSL). The one subsurface sampling location, 25-SC, had one individual PAH (acenaphthene) concentration that exceeded the SL in the 2-to-4-ft depth interval.

2.3.1.3 Other SVOCs and VOCs

Thirty-three surface and subsurface sediment samples were analyzed for other SVOCs. SVOCs that exceeded SMS were relatively few as compared with the PCB exceedances and were in discrete locations, as shown on Map 2-120. The following SVOCs exceeded their SL: bis(2-ethylhexyl) phthalate (BEHP) and butyl benzyl phthalate (BBP) (at DR206); hexachlorobenzene (at R19); phenol; (at C10-1, C10-2, and DR 207); and benzyl alcohol (at 08-G). VOCs were not detected in any sediment sample analyzed.

2.3.1.4 Metals

Thirty-one two sediment samples were analyzed for metals. Arsenic was the only metal that exceeded its SL. Detected concentrations of aArsenic ranged from 7 to 22 mg/kg. Map 2-120 shows the locations of all samples analyzed for the full suite of SMS chemicals, which included metals.

2.3.1.5 Dioxins and Furans

Eight surface sediment samples were analyzed for dioxins and furans. These samples were collected to provide an initial indication of whether the dioxins and furans were present in the sediment and if dioxin/furan TEQs were greater than theits SL (4.5 ng/kg) at locations where PCB concentrations were below theits SL for PCBs; therefore,. no dioxin and furan analyses were performed for samples collected from sediment areas that had elevated PCB concentrations and were thus targeted for removal. The dioxin/furan TEQs ranged from 2.11 to 9.36 ng/kg and are shown on Map 2-113.

2.3.2 T-117 Upland Study Area

Soil conditions at the T-117 Upland Area have been determined through the evaluation of an extensive collection of soil samples from borings advanced from 1990 to 2008. Chemicals analyzed included PCBs, TPH, PAHs, other SVOCs (including phthalates, and phenols), pesticides, and metals. As a result of the 1999 and 2006 TCRAs, 5,200 tons of contaminated soil were removed from the Upland T-117 Area. All available soil data (including data for samples collected from soil that is remaining or has been excavated) for the T-117 Upland Study Area are provided in Appendix C.

2.3.2.1 PCBs

A total of 682 samples from 282 locations have been analyzed from the T-117 Upland Area for PCBs. During the two TCRAs, the soil associated with 83 sampling locations was excavated, leaving 539 samples that are representative of current site conditions. PCB concentrations are presented by both subarea (A through F) and by depth range (0 to ~~-~~7 ft, 7 to ~~-~~12 ft, and >15 ft) to facilitate data presentation because of the large number of sampling locations in the T-117 Upland Study Area. Subareas were delineated during the 2006 T-117 Upland Investigation (Windward and DOF 2006) and are shown on Map 2-12~~4~~. PCB concentrations associated with both remaining and excavated soil in the T-117 Upland Study Area are presented on Maps 2-1~~5~~3a through 2-1~~5~~3c by depth. Maps 2-14~~6~~ through 2-~~20~~ 18 present the PCB sample concentrations associated with the remaining and excavated T-117 Upland Study Area soil by subarea (A through F). The ~~excavated~~ data representing excavated soil are presented to illustrate chemical distribution and to facilitate the assessment of data gaps.

PCBs (predominantly Aroclor 1260) are generally found within the uppermost 2 ft of surface soil, and concentrations tend to decrease with depth (Maps 2-1~~5~~3a through 2-1~~5~~3c). Exceptions to this trend have been found at the following locations:

- Beneath the 1999 TCRA removal area (Subarea C, Map 2-16~~8~~) and the 2006 TCRA removal area (Subarea B, Map 2-15~~7~~), where the highest PCB concentrations were located at 2 to 8 ft bgs and then decreased with depth
- Near Catch Basin 5 (Subarea E, Map 2-18~~20~~), where elevated PCB concentrations ranged from 0 to 6.5 ft in depth

The highest remaining PCB concentrations (i.e., greater than 1,000 mg/kg) were detected in the upper 2 ft at location T-117-D-11 and between 2 and 5 ft bgs at location T-117-E-1. Below 7 ft, PCBs were detected above 50 mg/kg only at locations PS-7 (110 mg/kg) and T-117-6 (94 mg/kg).

The 2006 TCRA included the excavation of three areas in Subarea B (Map 2-15~~7~~) that contained the highest concentrations of PCBs in the T-117 Upland Area, including the highest PCB concentration (9,200 mg/kg) at location T-117-B-8.

2.3.2.2 TPH

A total of 377 samples have been analyzed for TPH from 162 locations. Of this total, 37 sampling locations were associated with the soil that was excavated during the 1999 and 2006 TCRAs. The site-wide ~~total~~ TPH chemical concentrations associated with samples that were collected from the remaining and excavated soil in the T-117 Upland Area are presented on Maps 2-19~~21~~a through 2-19~~21~~c. Maps 2-2~~2~~0 through 2-2~~6~~4 present ~~total~~ TPH chemical concentrations associated with samples that were collected from the remaining and excavated soil in the T-117 Upland Area by subareas (A through F).

The highest concentrations of TPH (i.e., greater than 10,000 mg/kg) were detected in the former roadway ponding area (Subarea C, Map 2-242) and in the vicinity of Catch Basin 5 (Subarea E, Map 2-246), where elevated TPH concentrations were detected as deep as 6.5 ft. Most of the shallow soil (0 to 2 ft bgs) that had elevated concentrations of TPH was removed as part of the 1999 and 2006 TCRAs (Maps 2-213 and 2-2432).

2.3.2.3 PAHs

A total of 303 samples from 81 locations have been analyzed, and soil associated with 35 of these sampling locations was excavated during the 1999 and 2006 TCRAs. Individual cPAH compounds were compared with SLs as total cPAH TEQ.[5] Twenty-one percent of soil samples exceeded the SL for total cPAH TEQ. A summary of the T-117 Upland Study Area soil cPAH concentrations associated with soil that has since been excavated are presented on Maps 2-275 and 2-286. cPAHs tended to be co-located with elevated concentrations of PCBs and TPH. The highest cPAH TEQ concentrations were detected at T-117-D-6 (22.67 mg/kg), T-117-B-4 (23.82 mg/kg), E-1 (27.89 mg/kg) and T-117-C-4 (176.3 mg/kg). Three of these samples were collected from between 2 and 5 ft bgs.

2.3.2.4 Other SVOCs and VOCs

A total of 303 samples have been analyzed from 81 locations, and soil associated with 35 sampling locations was excavated during the 1999 and 2006 TCRA. These chemicals had maximum concentrations below comparative SLs. SVOC concentrations (including PAHs) for samples collected within the T-117 Upland Area are presented in Appendix C.

2.3.2.5 Metals

A total of 141 samples from 42 locations have been analyzed for metals. Metals have been detected in the T-117 Upland Area, but only arsenic exceeded the SL. The highest arsenic concentrations were detected at locations T-117-C-8 (55 mg/kg), T-117-D-6 (40 mg/kg), and T-117-D-10 (160 mg/kg), as shown on Map 2-297. All of the samples were collected from within the upper 4 ft. Concentrations of PCBs and TPH were also elevated at these sampling locations.

2.3.2.6 Dioxins and Furans

A total of 21 samples from eight locations were analyzed for dioxins and furans. All samples contained detected concentrations of one or more dioxin or furan congeners. These concentrations, expressed as dioxin/furan TEQs, ranged from 0.272 to 296 ng/kg and are shown on Map 2-2830.

[5] cPAH TEQ benzo[a]pyrene equivalents were calculated in accordance with Ecology's calculation guidance (WAC 173-340-900 Table 708-2).

2.3.3 Adjacent Streets and Residential Yards Study Area

Between 2004 and 2009, several investigations were conducted within the Adjacent Streets to support the City's site characterization and independent cleanup actions (Integral 2006b) and in the Adjacent Streets and Residential Yards Study Area to support boundary refinement activities completed since the Adjacent Streets were included in the T-117 EAA in 2007 (Integral 2009; Windward and Integral 2009).

Samples collected prior to 2008 were generally single samples collected from surface soil, test pits, borings, street dust, and catch basins. The detection of PCBs and dioxins and furans in Residential Yards samples collected in 2008 led EPA to direct the City to conduct additional sampling using MIS in 2009. An MIS sample is a composite of small amounts of soil (soil increments) collected at many locations (30 to 44 individual soil aliquots or increments for this study) from a decision unit (DU); the laboratory analysis is performed on a sub-sample from the composite sample. A DU is a defined area for which a characterization or a decision is to be made; for example, a DU can represent an exposure unit and/or a remediation unit.

A MIS sample provides a single analytical result for each DU; that result represents an estimate of the average concentration within the DU, but provides no information on the variability (numerical or spatial) of concentrations across the DU. DUs were delineated collaboratively with EPA based on the objective of providing an average chemical concentration for soil in the DU (Integral 2009). MIS samples were collected from the surface depth interval (0.0 to 0.2 ft [0.0 to 2.0 in.]) and the subsurface depth interval (0.2 to 0.5 ft [2.0 to 6.0 in.]). Where grass was present, the surface interval began below the grass roots. The MIS increments were aggregated to form a single composite to provide an average chemical concentration for soil in a given DU (Integral 2009).

MIS sampling was conducted in two phases during 2009. Residential Yard DUs were delineated in consideration of the potential differences in how residents used their yards (potential exposures), possible differences in the soil disturbance histories of portions of yards (e.g., front versus back yards), the potential for contamination in streets to enter yards (e.g., trackout, runoff, and resuspended dusts), and the accessibility of surface soils. Residential Yard DUs for the first phase of sampling represented entire yards. In some cases, Residential Yard DUs for the second phase of sampling represented only the portions of Residential Yards adjacent to streets.

EPA determined that results from previous investigations that were based on point samples located within the 2009 DU areas were to be superseded by results of the 2009 MIS sampling in those areas.

Appendix C includes a complete list of available data for each chemical analyzed in the Adjacent Streets and Residential Yards Study Area. Appendix C also identifies samples that were removed during the City's independent cleanup actions or data that were superseded by subsequent MIS composite sampling data; these data are presented to illustrate the current spatial distribution of contaminants.

The SLs for soils discussed in the following sections are based on the MTCA Method B standard formula values for direct human contact, with the exception of lead, TPH, and PCBs. For lead and TPH, the soil SLs are based on the MTCA Method A unrestricted land use CULs. Method A provides the only applicable SLs for these chemicals. PCB SLs are based on the TSCA applicable or relevant and appropriate requirements (ARARs) (see Section -4.3.2.1).

2.3.3.1 Adjacent Streets

This section summarizes the data obtained from soil investigations conducted within the Adjacent Streets between 2004 and 2009.

Several investigations were conducted within the Adjacent Streets to support the City's site characterization and independent cleanup actions between 2004 and 2006 (Integral 2006b) and in the Adjacent Streets and neighboring residential properties to support boundary refinement activities completed since the Adjacent Streets were included in the NTCRA in 2007 (Integral 2009; Windward and Integral 2009).

Appendix C includes a complete list of available data for each chemical analyzed in the Adjacent Streets. Appendix C also identifies samples that were removed during the City's independent cleanup actions or data that were superseded by subsequent MIS composite samples; these data are presented to illustrate the current spatial distribution of contaminants.

PCBs

A total of 382 367 soil, street dust (i.e., fine soil accumulated on street surfaces and shoulders), and catch basin solids and MIS samples were collected and analyzed for PCBs within the Adjacent Streets. Maps 2-29 and 2-30 show the locations where soil was sampled from 2004 through 2006 and 2008 through 2009, respectively. (Map 2-31); tThe source materialcontaminated soil associated with 17 of these the 367 samples (i.e., 4 soil, 7 street dust, and 6 catch basin samples) was removed in conjunction with the City's independent interim cleanup actions of 2004 and 2005. Map 2-31 shows the locations of soil samples that were in areas where soil was subsequently removed as part of the City's 2004 and 2005 cleanup actions, or were superseded by subsequent sampling conducted by the City in 2008 and 2009.

The sampling locations within the Adjacent Streets that had PCB concentrations greater than the SL (1 mg/kg; MTCA Method B/TSCA) were located on Dallas Avenue S, between 16th and 17th Avenues S, the north portion of 17th Avenue S, and in other isolated areas on Dallas Avenue S and S Donovan Street. The detected PCB concentrations in point samples ranged from 0.0025 mg/kg to 480 mg/kg at TP40 (located at 8601 17th Avenue S near the intersection with Dallas Avenue S).

PCB~~s were also detected at~~ concentrations greater than 1 mg/kg were detected in street dust (e.g., upper 0.1 in. of soil) along S Cloverdale Street, along S Donovan Street near 17th Avenue S, and in ~~street dust~~ samples collected along Dallas Avenue S in conjunction with the 2006 TCRA at the T-117 Upland Study Area. PCB concentrations greater than 1 mg/kg, but less than 10 mg/kg, were generally detected only in the upper ~~12 in.~~1.0 ft of soil, although there were isolated exceedances in samples collected at depths of up to 2.0 ft~~.~~ at locations P68, P83, P85, TP12, TP20, TP21, and TP41; and ~~(~~at depths of up to ~~48~~ 4.0 ft at locations MW10~~, P65,~~ and P66. The specific depth intervals are presented on Map 2-28.

PCB concentrations greater than 10 mg/kg were limited to surface samples (0-to-6-in. depth interval) in the immediate vicinity of the T-117 Upland Study Area, with the following exceptions:

- Ten exceedances in samples with depths ranging between 0.0 and 1.0 ft ~~at 12 in.~~ bgs ~~(~~at locations P95, P100, TP6~~,~~ TP8, TP9, TP12, TP13, TP19, TP26, and TP41
- Five exceedances in samples with depths ranging between 0.0 and 2 ft bgs ~~at 24 in. bgs (~~at locations P86, P100, TP9, TP19, and P81

MIS samples were collected from 12 ~~decision units (~~DUs~~)~~ in the Adjacent Streets. ~~DUs were areas from which the MIS sample increments were aggregated to form a single composite MIS sample. DUs were delineated collaboratively with EPA based on the objective of providing an average chemical concentration for soil in the DU. MIS samples were collected from the surface (0.0-to-0.2-ft depth interval) and subsurface (0.2-to-0.5-ft depth interval). Where grass was present, the surface interval began below the grass roots.~~ Total PCBs were detected in all samples at concentrations that ranged from 0.055 mg/kg at DU30 (0.2 to 0.5 ft bgs) to 8.1 mg/kg at DU19 (0.2 to 0.5 ft bgs) (Map 2-~~32)~~30). The second highest total PCB concentration was also detected at DU19 in the 0.0-to-0.2-ft interval (5.7 mg/kg). A total of ~~18~~four Adjacent Streets DUs had total PCB concentrations (expressed as means for locations with sample replicates) that exceeded~~ing~~ 1 mg/kg ~~total PCBs~~. There were no total PCB concentrations higher than ~~exceedances of~~ 1 mg/kg in DUs at the southern (south side of upper S Donovan Street) extent of the 2009 PCB investigation. Areas designated for cleanup are identified in Section 4.

TPH

A total of ~~53~~ 63 soil, street dust, and catch basin samples were collected for the analysis of TPH within the Adjacent Streets (Map 2-~~34~~32). The contaminated soil associated with seven of these samples (i.e., one soil sample from TP48, two soil samples from TP49, street dust samples from SD20 and SD18, and catch basin samples from SD8 and CB1-DAL) was removed in conjunction with the City's independent 2004 and 2005 cleanup actions. ~~The source material (catch basin solids) associated with four of these samples (SD3, SD8, SD20, and RCB101) was removed in conjunction with the City's independent cleanup actions.~~ TPH-D exceeded the SL (2,000 mg/kg~~;~~ [MTCA

Method A soils for unrestricted land use]) at two locations – a catch basin located at the corner of Dallas Avenue S and S Donovan Street (SD3) and a five-point surface composite soil sample from the ROW area at the east end of S Donovan Street (SD4) that was previously used by Basin Oil to store equipment. TPH-O exceeded 2,000 mg/kg in eight samples, including two catch basins (SD3 and SD8), five street dust samples (SD2, SD4, SD7, SD19, and SD21), and one push probe location (P81).

TPH analyses of street dust and catch basin samples showed that of the four samples collected to the west of 14th Avenue S (SD27, SD28, SD29, and SD30), none exceeded the comparative criteriaSL for TPH-D (2,000 mg/kg). TPH-O exceeded the comparative criteriaSL of 2,000 mg/kg at one of the four sampling locations, a catch basin located at the southwest corner of S Donovan Street and 12th Avenue S (SD30). The data for tThese six four sampling locations are located outside of the Adjacent Streets boundary and therefore are not shown on Map 2-34 32 but are presented in Appendix C.

PAHs

A total of 12 soil and street dust samples from within the Adjacent Streets Area were analyzed for PAHs; two samples (SD8 and RCB101CB1-DAL) were collected from soil that was subsequently removed in conjunction with the City's independent cleanup actions. Total cPAH TEQs associated with both the remaining and excavated Adjacent Streets soil are presented on Map 2-35.33. At five locations (MW-12 [two intervals], P60, P81, and SW1-Tank), total cPAH TEQs exceeded the SL (0.14 mg/kg; [MTCA Method B]). The highest cPAH TEQ was detected at MW-12 (320 mg/kg in the, 0.0--to-60.5-ft in. depth bgsinterval). cPAHs were detected at P60, located on Dallas Avenue S (west of 16th Avenue S), where total Total cPAHs were detected in the 4-to-6-ft depth interval at P60, located on Dallas Avenue S (west of 16th Avenue S) in the 4-to-6-ft depth interval, and appeared to be associated with in a thin soil horizon between 5 and 5.5 ft bgs. At P81, located near the east end of S Donovan Street, total cPAHs were detected in the 21-to-42-ft depth interval. The individual cPAHs chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene, were also detected at concentrations greater than the SL at these sample locations and intervals (see Appendix C).

Other SVOCs and VOCs

Seven samples were collected from five locations within the Adjacent Streets (MW11, MW-12, MW-13, P72, and P78) for benzene, toluene, ethylbenzene, and xylene (BTEX) analyses. Benzene was detected at a MW-12 in two different intervals (0.0082 mg/kg at 0 to 6 in. bgs and 0.0019 mg/kg at 2.5 ft bgs). Toluene was detected at three locations (MW12, P72, and P78), with the highest concentration (11 mg/kg) at P78 on Dallas Avenue S, between 17th Avenue S and S Donovan Street (east of Basin Oil).

Phthalate esters, including BEHP, were detected in two street dust and catch basin samples. Concentrations of BEHP ranged from 0.79 mg/kg to 6.2 mg/kg (SW1-Tank).

In addition, there were detections of other miscellaneous SVOCs (4-methylphenol, and phenol) and VOCs (2-butanone, carbazole, and carbon disulfide) in street dust and catch basin samples (see Appendix C).

Metals

A total of 19 soil and catch basin/street dust samples from within the Adjacent Streets were analyzed for metals. The soil from one two of these locations (SD8 and CB1--DAL) was removed in conjunction with the City's independent cleanup actions. Arsenic was the only metal that exceeded its SL (0.67 mg/kg; [MTCA Method B/TSCA]), which occurred at two all locations (MW-12 and P81; Map 2-36). Arsenic was detected at varying depth intervals in 8 of the 19 -soil and catch basin/street dust samples analyzed (see Map 2-34 and Appendix C). Arsenic was not detected in the remaining 11 samples; however, the arsenic reporting limits for these samples were all greater than the SL. -Arsenic concentrations associated with both the remaining and excavated Adjacent Streets soil are presented on Map -2--3634.

Dioxins and Furans

Archived samples collected in 2004-2005 from catch basins, manholes, and street dust as part of the City's source-tracing program for the LDW (Herrera 2004) were later selected for the analysis of dioxins and furans. The samples included one street dust sample (SD52) collected at the intersection of Dallas Avenue S and 16th Avenue S (within the Adjacent Streets portion of the T-117 EAA) and a sediment sample (CB-41) collected from a settling tank associated with an oil-water separator located on the Basin Oil property (see Section 2.4.1). Analytical results from this sampling program were compiled in 2008 and reviewed by the City in 2008 (Integral 2008b). The dioxin/furan TEQ for the street dust sample (SD52) and settling tank sample (CB-41) both exceeded the SL (11 ng/kg; [MTCA Method B/TSCA]), atwas 90.5 ng/kg and 15.2 ng/kg, respectively., exceeding the SL (11 ng/kg). The street dust at this sampling location and the immediate vicinity was removed in 2005 based on PCBs as part of the City's independent cleanup action (Section 2.2.4).

In 2008, the City, in coordination withas directed by EPA, conducted a follow-up sampling program to assess whether there were any other locations with elevated dioxin concentrations in the vicinity of the 90.5 ng/kg result. Sixteen Fifteen samples were collected from the Adjacent Streets in 2008 (Map 2-3735) and analyzed for dioxins and furans and PCBs. Nine locations had dioxin/furan TEQs that were greater than the SL. The highest dioxin/furan TEQ was detected in borehole P94 (84 ng/kg in the 0.1--to--1.0-ft interval) on Dallas Avenue S immediately east of the intersection with 16th Avenue S (south of the Marina). The next highest dioxin/furan TEQ was detected on S Donovan Street adjacent to Basin Oil and the T-117 Upland Study Area (30 ng/kg in the 0.4-to-1.0-ft depth interval at P100), Dallas Avenue S immediately west of 17th Avenue S (32.4 ng/kg in the 0.1-to-1.0-ft depth interval at P95), and Dallas

Avenue S at the intersection with 16th Avenue S (21.4 ng/kg in the 0.4-to-1.0-ft depth interval at P90).

~~Nine~~ Eight MIS split samples collected in 2009 were analyzed for dioxins and furans by Ecology. MIS samples were collected from the surface (0.0-to-0.2-ft [0.0-to-2.0-in.] depth interval~~0.0 to 0.2 ft depth interval~~) and subsurface (0.2-to-0.5-ft [2.0-to-6.0-in.] depth interval~~0.2 to 0.5 ft depth interval~~) at DU16 and DU17, located on the west and east sides of 16th Avenue S, respectively (Map 2-~~37~~35). Dioxin/furan TEQs ranged from 9.58 ng/kg in the ~~at DU16~~ 0.0-to-0.2-ft (0.0-to-2.0-in.) depth interval of DU16 to 43.8 ng/kg in the 0.0-to-0.2-ft (0.0-to-2.0-in.) depth interval at DU17~~0.0-0.2~~. Surface and subsurface samples were collected at DU18 and DU19, located along the west and east portions of the bank, respectively, along lower S Donovan Street (Map 2-~~37~~35). Dioxin/furan TEQs ranged from 30.4 ~~ng/kg~~ to 51 ng/kg at DU18 (0.0-to-0.5-ft and 0.2-to-0.~~5~~ 5-ft ~~bgs~~depth intervals, respectively). Dioxin/furan TEQs in all samples exceeded ~~11 ng/kg,~~the SL with the exception of one sample at DU16 (9.58 ng/kg at the ~~DU16 0.0-0.2~~0.0-to-0.2-ft depth interval). Map 2-~~33~~ 386 shows the dioxin/furan TEQ soil sample locations that were in areas where soil was removed as part of the City's 2004 and 2005 clean-up actions or were superseded by subsequent sampling in 2009.~~presents the dioxin/furan TEQs in soil that were removed from or superseded by MIS results.~~

2.3.3.2 Residential Yards

This section summarizes the data obtained from soil investigations conducted within the Residential Yards between 2004 and 2009.

~~Several investigations were conducted within the Residential Yards to support the City's site characterization and independent cleanup actions between 2004 and 2006 (Integral 2006b) and to support boundary refinement activities completed since the Adjacent Streets were included in the T-117 EAA in 2007 (Integral 2009; Windward and Integral 2009).~~

~~The detection of PCBs in Residential Yards samples collected in 2008 led to a request by In the case of residential yards, DUsto encompass individual residential properties or portions thereof based on a conceptual model of land use for residential properties (i.e., differences in uses for front yards and backyards) and proximity to potential PCB track-out in streets. The MIS increments were aggregated to form a single composite to provide an average chemical concentration for soil in that DU (Integral 2009).~~

~~Some of the 2009 sampling completed in the Adjacent Streets was also completed using MIS. EPA has determined that results from previous investigations that were based on point samples located within the 2009 DU areas were to be superseded by results of the 2009 MIS sampling in that location.~~

~~Appendix C includes a complete list of available data for each chemical analyzed in the Residential Yards. Appendix C also identifies samples that were removed during the City's independent cleanup actions or data that were superseded by subsequent~~

~~MIS composite sampling data; these data are presented to illustrate the current spatial distribution of contaminants.~~

PCBs

A total of 175 point and MIS ~~206~~ soil samples collected from within the Residential Yards have been analyzed for PCBs. The source soil~~s~~ ~~from~~ for ~~which~~ ~~45~~44 of the~~se~~ 175 samples ~~were collected~~ ~~have since been~~was removed in conjunction with the City's independent 2004 and 2005 cleanup actions~~.~~, and PCB ~~concentrations~~ data for 47 of the 175 samples were superseded by the 2009 MIS sampling (as presented on Map 2-31). PCB concentrations associated with Residential Yards soil are presented on Map -2~~-~~-~~38~~367.

Sampling performed during the City's cleanup near the intersection of Dallas Avenue S and 17th Avenue S (across from the entrance to the T-117 Upland Study Area) indicated that total PCB concentrations greater than the SL extended to depths that were similar to those in the Adjacent Streets. All PCB-contaminated soil detected within the residential lots was excavated and disposed of at an offsite landfill (Hart Crowser 2005).

Thirty~~-four~~ Residential Yards point samples were collected in 2008 to assess the concentrations of PCBs in residential soils near the ROWs. Twenty-~~-eight~~ four of these point sampling results were superseded by 2009 MIS results collected from the same yards. In locations where 2008 sampling results were not superseded by 2009 MIS results~~did not supersede the 2008 results~~ for Residential Yards (YC samples) or discrete yard parking strip samples (YS samples) ~~(sampling locations YC17 and YC18, which were east of 16th Avenue S)~~, total PCB concentrations ranged from 0.12 to 0.26 mg/kg (Windward and Integral 2009).

MIS sampling conducted in 2009 was designed to identify average total PCB concentrations in soil within individual DUs. The DUs were delineated collaboratively with EPA to encompass individual residential properties or portions thereof based on a ~~conceptual site model~~CSM of land use for residential properties (i.e., differences in uses for front yards and backyards) and proximity to potential PCB track-out in Adjacent Streets (Integral 2009). Fifty Residential Yards MIS samples were collected in 2009.Total PCB concentrations ranged from 0.043 mg/kg to 2.1 mg/kg at DU32 (0.0-~~-to~~ to-0.2~~-~~-ft depth interval~~bgs~~). ~~MIS~~ DUs ~~results~~ with PCB concentrations that exceeded 1 mg/kg included ~~DU01, DU14,~~ DU32~~,~~ and DU35. Map -2-~~38~~ 367 ~~provides~~ presents the PCB ~~results~~concentrations (with replicates averaged) ~~the PCB results~~ for the Residential Yards DUs. Note that for the purposes of removal boundary delineation, total PCB concentrations for each DU were adjusted for variance at the direction of EPA (Appendix ~~K~~L) as discussed in Section 4.4.3. Map 2-~~33~~ 31 presents the total PCB concentrations in soil that were removed ~~from~~ or superseded by MIS results.

Dioxins and Furans

Dioxin/furan TEQs in soil samples collected from the Residential Yards are shown on Map 2-39 3738 and presented in Appendix C. Nineteen composite samples (0.0-to-0.5-ft depth interval) and four three discrete point samples were analyzed in 2008 to evaluate the extent of contamination in Residential Yards (Windward and Integral 2009) and had concentrations up to 395 ng/kg (the 395 ng/kg result was considered to be an outlier because of carbon fragments in the sample matrix; the next highest concentration was 50.1 ng/kg). Fourteen Thirteen of these samples, including the sample with the concentration of 395 -ng/kg, were subsequently superseded by 2009 MIS samples. Map 2-36 shows the dioxin/furan TEQ soil samplinge locations that were in areas where soil was removed as part of the City's 2004 and 2005 cleanup actions or were superseded by subsequent sampling conducted by the City in 2008 and 2009.Samples collected in Residential Yards that had soil removed or samples that were superseded by subsequent sampling are shown on Map 2-33.

Dioxin/furan TEQs of in non-superseded Rresidential Yyard composite samples (shown on Map 2-378) ranged from 4.69 ng/kg at YC16abc to 16.0 ng/kg at YC12abc. Samples from YC12abc, YC13abc, YC14abc, and YC19abc were the only Rresidential Yyard composite non-superseded samples that exceeded the SL (11 -ng/kg; [MTCA Method B]).

Twenty-four MIS sample splits were provided to Ecology for dioxin and furan analysis. The highest dioxin/furan TEQs were detected in DU01 at the west end of Dallas Avenue S (50.1 ng/kg from the 0.0--to--0.2--ft in [0.0-to-2.0-in.] depth interval and 38.2 ng/kg from the 0.2 2-to to-0.5 5-ft [2.0-to-6.0-in] in depth interval);) ((Map 2--3938). All MIS samples but one sample (in the 0.0-to-0.2-ft depth interval from DU03-0.0-0.2) exceeded the SL (Ecology 2009a).

2.3.4 Groundwater

Groundwater data have been collected from both monitoring wells and intertidal seeps throughout the T-117 EAA and vicinity since 1991. Historical (pre-2003) groundwater conditions are detailed in the data gaps report (Windward et al. 2003). Groundwater samples analyzed during sampling events conducted between 2003 and 2009 are considered most representative of current conditions and are summarized in Section 2.3.4.1this Section. Section 2.3.4.1 discusses groundwater results for the T-117 Upland Study Area, and Section 2.3.4.2 discusses the groundwater results for Adjacent Streets and Residential Yards Study Area. Section 2.3.4.3 discusses the seep water results.

The T-117 EAA monitoring well network currently consists of 13 wells. Seven wells (MW-02, MW-03, MW-04R, MW-05R, MW-06, MW-07, and MW-08R) are located on the T-117 Upland Study Area, four wells (MW-01, MW-09, MW-10, and MW-11) are located just upgradient of the T-117 Upland Study Area on Dallas Avenue S, and two wells (MW-12 and MW-13) are upgradient of Basin Oil on 17th Avenue S and

S Donovan Street. Locations of groundwater monitoring wells are shown on Map~~s~~ 2-7 ~~and 2-8~~. Several seeps discharge from the shoreline bank. Many of these seeps are seasonal, and the locations and flow rates of these seeps can vary. One seep is relatively large with a consistent location and flow rate; the locations of sampled seeps are shown on Map 2-7.

Appendix C includes all groundwater sampling data from 1991 through 2009~~ and presented in Appendix C~~. Appendix B presents the assessment and development of groundwater screening and site-specific removal action levels based on the groundwater monitoring results, groundwater quality criteria to be achieved at the point of discharge, and a detailed evaluation of the potential for contamination from former asphalt plant operations to have impacted groundwater beneath the Adjacent Streets and Residential Yards Study Area.

2.3.4.1 T-117 Upland Study Area Groundwater Data

Groundwater monitoring was occasionally conducted in the T-117 Upland Study Area between 2003 to 2005. Below is a summary of the data results from the seven consecutive quarters of groundwater monitoring conducted since first quarter 2008. The following discussion is limited to the first quarter 2008 through the third quarter 2009 groundwater monitoring events because the fourth quarter 2009 groundwater monitoring event had not been completed at the time that the EE/CA COC analysis was conducted. Appendix C includes summary tables that contain all available data, including data from the fourth quarter 2009 event.

PCBs

Total PCBs were detected in 23 of 70 samples. ~~Twenty-one of twenty-three~~All total PCB detections were above the SL~~s~~ (0.000064 µg/L) for total PCBs. The ~~maximum~~ highest total PCB concentration was 2.0 µg/L (at MW-03). PCBs were detected in six of seven T-117 Upland Study Area wells during one or more sampling events. Aroclor 1260 was detected in all ~~detected~~ samples, and Aroclor 1254 was detected in two samples (MW--05R and MW-08R).

TPH

~~Total~~ TPH was detected in 17 of 57 samples and exceeded the SL (0.5 mg/L)- in 16 samples. The maximum detected ~~total~~ TPH concentration was 22 mg/L (at MW-03). ~~Total~~ TPH exceeded the SL ~~for~~ in one or more samples ~~in~~ from two T-117 Upland Study Area wells (MW-02 and MW-03).~~of five T-117 Upland Study Area wells.~~

cPAH

cPAHs were detected in 4 of 54 samples from three of seven T-117 Upland Study Area wells (MW-03, MW-02, and MW-05R). One sample exceeded the SL (0.018 µg/L) for cPAH TEQ. The maximum cPAH TEQ was 0.20 µg/L (at MW-05R).

~~Total cPAH TEQ were detected in 4 of 54 samples. One sample exceeded the SL for total cPAH TEQ. The maximum total cPAH TEQ was 0.20 µg/L (MW-05R). Total cPAH TEQ was detected in three of seven T-117 Upland Study Area wells.~~

Other SVOCs and VOCs

The only SVOC detected above SLs in groundwater collected from T-117 Upland Study Area wells was BEHP. BEHP was detected in 15 of 52 samples and exceeded the SL (2.2 µg/L) in 4 samples from three wells (MW-04R, MW-05R, and MW-06). The maximum BEHP concentration was 16 J µg/L (at MW-04R).

Phenol has been detected but no concentrations have been above the SL (1,700,000 µg/L). Phenanthrene has also been detected; however, no applicable SL based on the protection of a surface water receptor is available. ~~BEHP was detected in 15 of 52 samples and exceeded the SL in 4 samples. The maximum BEHP concentration was 16 J µg/L (MW-04R). BEHP exceeded the SL for one or more samples in three of six T-117 Upland Study Area wells.~~ No other SVOCs or VOCs exceeded SLs for any samples.

Metals

Seven metals (arsenic, copper, cadmium, chromium, lead, silver, and zinc) have been detected in groundwater. Only Arsenic, copper, and silver have been detected in groundwater above the SLs. Arsenic was detected in all T-117 Upland Study Area wells and exceeded the SL (0.00014 mg/L) in 16 of 48 samples from all seven wells. Copper was detected in 12 of 43 samples and exceeded the SL (of 0.0031 mg/L) in six detected samples from four T-117 Upland Study Area wells (MW-03, MW-04, MW-06, and MW-08R). Silver was detected in 7 of 43 samples and exceeded the SL (of 0.0019 mg/L) in all detected samples from four T-117 Upland Study Area wells (MW-04, MW-05R, MW-06, and MW-08R). The silver reporting limits for all non-detect samples also exceeded the SL.

Dioxins and Furans

Groundwater samples collected during the fourth quarter 2008 sampling event were analyzed for dioxins and furans. Groundwater samples were collected from three wells (MW-05R, MW-08R, and MW-10). All groundwater sample dioxin and furan concentrations were below detection limits, with the exception of one congener from MW-08R (1,2,3,4,6,7,8,9-octachlorodibenzo-*p*-dioxin), which resulted in a dioxin/furan TEQ of 3.0^{-9} µg/L), exceeding the dioxin/furan TEQ SL of 5.0^{-9} µg/L.

~~No samples exceeded the groundwater SLs for dioxins and furans.~~

Light Non-Aqueous-Phase Liquid ~~(LNAPL)~~

During the 2004, 2005, and 2008 groundwater monitoring events, tidal studies were conducted with an oil-water interface probe to determine the presence or absence of light non-aqueous-phase liquid (LNAPL) in the groundwater monitoring wells. In 2004 and 2008, no LNAPL was detected in any of the wells (Windward et al. 2005d;

ENSR | AECOM 2008). In 2005, trace amounts of LNAPL (essentially a sheen [i.e., < 0.01-ft thick]), were detected in two wells (MW-02 and MW-07) (Windward et al. 2005d). During the 2009 second quarterly groundwater sampling event, a trace to heavy trace sheen (with no measurable product thickness) was observed on the groundwater at MW-03 (AECOM 2009b).

2.3.4.2 Adjacent Streets and Residential Yards gGroundwater dData

Groundwater sampling has not been conducted beneath the Adjacent Streets and Residential Yards Study Area based on the findings of the 2005 site characterization work plan (Integral 2005) and other investigations. The work plan noted that the depth of contaminants in soil was shallow (maximum depth of 8 ft) relative to the depth of groundwater (approximately 12 ft below Dallas Avenue S), the solubility and consequent immobility of PCBs in soils was low, and that PCBs were detected only infrequently and at low concentrations in groundwater from T-117 Upland Study Area wells where PCB-impacted soil was in contact with groundwater.

Although groundwater investigations have not been conducted in the Adjacent Streets Study Area, several monitoring wells have been installed in and around the Adjacent Streets, including the wells MW-01 MW-09, MW-10, MW-11, MW-12, and MW-13 and three wells installed at the Marina. The results of groundwater monitoring associated with these wells and soil conditions in the Adjacent Streets Study Area are evaluated in Appendix B. This evaluation shows that while some chemicals have been sporadically detected in groundwater below or immediately downgradient of Basin Oil, the presence of a groundwater contamination beneath the Adjacent Streets Study Area resulting from former asphalt plant operations is unlikely. Groundwater samples collected from five locations in and around Basin Oil and from three wells at the Marina indicated that PCBs were limited to a single detection (at MW-01), which was not confirmed with subsequent monitoring The solubility of PCBs, dioxins and furans, PAHs, TPH-D, and TPH-O is low, and the data indicate that where these chemicals were detected in surface and subsurface soils, they have not leached to groundwater in the 30-plus years that they have been present. The potential for contaminant leaching in the future will be further reduced by removal of soils with residual contamination as part of the permanent remedy for the site.

2.3.4.3 Seeps

Three seeps (Map 2-7) were identified and sampled in 2003 (Windward et al. 2005d). The seep water samples were analyzed for PCBs, SVOCs, PAHs, other SVOCs, and total metals. As presented in Appendix C, the only consistently detected chemicals were BEHP, copper, chromium, and zinc. PCBs were detected in one seep sample (SW3); however, it is possible that the PCBs were associated with contaminated fine particles present in the seep sample instead of the water. This seep was subsequently re-sampled, and the sample was centrifuged prior to analysis to remove any fine particles, resulting in a non-detection for PCBs. It is unknown whether the PCBs were attached to fine particles traveling with the seep water or if contaminated particles became entrained in the sample during collection.

T-117 seep sample specific conductivity measurements were compared with T-117 the groundwater and LDW surface water specific conductivity measurements to assess whether the T-117 seeps were representative of bank-stored infiltrated LDW surface water or T-117 groundwater. ~~The f~~Field parameters ~~results~~measurements for T-117 seep and groundwater well samples are summarized in Tables 2-3 and 2-4.

The average specific conductivity for the LDW in this reach of the river ~~i~~was 30,300 µS/cm based on shallow measurements at the South Park Bridge in 2005 (Mickelson and Williston 2006); these shallow measurements are more representative of water that would infiltrate at T-117 and are less saline than deeper water, which would be more influenced by salt water. The specific conductivity of the seep samples varied from 5,200 to 18,500 µS/cm, with an average of 12,200 µS/cm. Eight of the thirteen monitoring wells had average specific conductivities less than 1,000 µS/cm. The highest specific conductivities for monitoring wells were at MW-4R, MW-5R, MW-6, and MW-8R; these four shoreline wells had~~ve~~ average specific conductivities of 16,300, 6,600, 3,400, and 14,900 µS/cm, respectively. The other well with elevated specific conductivity was MW-13, located upgradient and near the bedrock outcropping describe in Section 2.1.5.2, with an average specific conductivity of 1,500 µS/cm. Based on these data, it appears that the groundwater samples may have been diluted by LDW surface water more than is typically anticipated.

Table 2-3. Summary of seep sampling field parameters at T-117 Early Action Area

Seep	Date Sampled	Temperature (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	pH	ORP (mV)	Turbidity (NTU)
Seep 1	12/23/2003	7.46	5,213	9.22	7.14	467	nc
Seep 2	12/23/2003	7.84	14,803	8.38	6.69	467	nc
Seep 3	12/23/2003	9.28	18,527	7.81	7.09	358	nc
	4/8/2004	9.6	14,781	9.72	9.11	79	1.12
Seep minimum		7.46	5,213	7.81	6.69	79	1.12
Seep maximum		9.6	18,527	9.72	9.11	467	1.12
Seep mean		8.25	12,223	8.79	7.31	384	1.12

Note: Stabilized field parameters are the values measured just prior to the collection of seep samples.

C – centigrade

nc – not collected

NTU – nephelometric turbidity unit

ORP – oxidation-reduction potential

Table 2-4. Summary of monitoring well parameters at T-117 Early Action Area

	Temperature (°C)			Specific Conductivity (µS/cm)			Dissolved Oxygen (mg/L)			pH			ORP (mV)			Turbidity (NTU)		
Well ID	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
MW-1	11.67	15.20	13.11	550	907	668	5.94	6.21	6.08	0.20	1.55	0.79	37.3	79.0	53.8	-4.4	1.8	0.0
MW-2	10.46	19.42	14.55	533	1,136	691	6.45	7.61	6.79	0.24	1.34	0.54	-132.5	48.3	-74.0	0.0	8.3	2.3
MW-3	10.41	16.86	13.72	418	502	471	6.27	6.47	6.35	0.14	1.43	0.85	-60.2	10.7	-30.9	0.0	8.9	4.0
MW-4R	8.37	16.03	11.88	8,885	25,829	16,297	6.79	8.33	7.28	2.73	8.40	5.67	-165.2	272.4	87.0	0.0	9.5	2.9
MW-5R	9.49	18.68	12.58	1,237	17,594	6,585	6.76	8.31	7.24	3.54	9.98	7.14	-64.1	192.5	103.3	0.0	2.7	0.9
MW-6	10.89	15.41	13.49	1,145	4,590	3,368	6.53	6.96	6.78	3.35	6.32	4.94	21.8	204.9	126.1	5.2	7.8	6.6
MW-7	11.99	16.76	13.95	122	268	190	5.80	6.24	6.00	2.45	6.82	4.93	24.4	164.4	124.0	0.0	7.0	2.7
MW-8R	8.76	15.86	11.91	4,214	29,248	14,896	6.73	8.84	7.72	3.64	9.06	6.27	-34.4	233.3	102.6	0.2	1.3	0.7
MW-9	12.34	13.21	12.78	307	556	432	5.95	6.11	6.03	4.75	5.67	5.21	180.1	232.4	206.3	0.65	1.04	0.85
MW-10	10.17	12.96	11.64	214	422	328	5.48	5.95	5.71	0.65	1.84	1.38	66.7	181.3	144.7	1.5	14.0	5.1
MW-11	10.44	17.61	13.64	340	825	624	5.90	7.06	6.40	0.18	0.74	0.44	-238.4	187.7	32.8	0.0	5.0	1.3
MW-12	14.51	19.70	17.06	436	868	604	7.83	8.33	8.16	0.39	3.35	1.43	10.10	105.70	69.03	0.56	90.60	31.92
MW-13	16.27	22.81	19.80	1,222	2,138	1,532	7.16	7.64	7.45	0.12	4.01	1.59	-91.40	73.30	-35.37	0.29	18.00	6.37

Note: Stabilized field parameters are the values measured just prior to the collection of groundwater samples.

C – centigrade

ID – identification

NTU – nephelometric turbidity unit

ORP – oxidation-reduction potential

2.4 RECONTAMINATION ASSESSMENT AREAS

This section describes the RAAs (Basin Oil and the Marina) and summarizes available data relative to the SLs developed in Section 3 for all media for soil and sediment and Appendix B for groundwater. The complete dataset for the RAAs is presented in Appendix ~~C~~F. The contaminants identified ~~in~~ at these RAAs at concentrations above SLs will be incorporated into the analysis of potential recontamination of the T-117 Sediment Study Area from these two areas presented in Section 5.2.

2.4.1 Basin Oil parcels

2.4.1.1 Site d~~D~~escription and h~~H~~istory

Basin Oil's primary operations occurred in the triangular-shaped property (8661 Dallas Avenue S) bounded by Dallas Avenue S to the east, Donovan Street S to the south, and 17th Avenue S to the west (Map 1-1). Basin Oil operated at the site between 1987 and 2004 (Ecology 2005a). Prior to that time, the site served as the location of a private residence. Three additional business entities are documented as having operated on the property at one time or another during the Basin Oil tenure: Frontwater, Inc.; Basin Tank and Environmental Services, Inc.; and Northwest Antifreeze Service, Inc. Basin Oil also leased property on the T-117 Upland Study Area, near the former asphalt plant facility located across the street to the east, where they stored materials in drums and in a tank. Basin Oil also stored drums and trucks at 8617 17th Avenue S, a residential property, located across the street to the west.

Basin Oil was a collector, transporter, and marketer of used oil. According to Basin Oil's spill prevention, control, and countermeasure plan (Basin Oil 1995), materials handled routinely at the facility included lubricating oil, Bunker C heating oil, diesel fuel, crude oil, jet fuel, and gasoline. Used oils are generally known to contain PAHs. Recycled and waste oils have been known to occasionally contain low concentrations of PCBs and chlorinated solvents. Based on Ecology inspection reports (Ecology 2000; Hohmann 1992), Frontwater and Basin Tank and Environmental Services handled similar materials. Northwest Antifreeze Service handled new and used antifreeze. Used antifreeze can contain metals such as lead and cadmium.

According to a site assessment conducted in 1996 (Creative Environmental Technologies 1996), the property was first developed and used for residential purposes in the 1930s and was converted to an oil recycling facility in the late 1980s. At the time of the 1996 site assessment, the northern portion of the property was paved, and the southern portion was not. Standing water and tanks without containment were both observed on the southern portion (Creative Environmental Technologies 1996).

Basin Oil was visited by regulators on at least 12 occasions between December 1992 and December 2004 in the course of site inspections or in response to incident reports or neighborhood complaints. Concerns and incidents included, but were not limited to, the items listed below (Ecology 1992a, b, 1993a, 1994b, a, 2003; Hohmann 1992).

- Improper designation and labeling of wastes, including the potential handling of hazardous wastes
- Errors, omissions, and discrepancies in waste manifests, including an allegation of forgery
- Inappropriate waste storage containers
- Insufficient secondary containment
- A spill of 500 to 600 gal. of used fuel oil that occurred during Basin Oil operations on the asphalt plant property in October 1993
- Inadequacies in the spill prevention, control, and countermeasure plan; the stormwater pollution prevent plan; and in emergency planning procedures

A more detailed discussion of selected compliance inspections and site visits is available in the T-117 summary of existing information and data gaps analysis report (Windward et al. 2003).

Prior to 2005, surface runoff from Basin Oil and the Adjacent Streets flowed onto the T-117 Upland Study Area and into the catch basins at the south side of the T-117 Upland Study Area (SAIC 2007a). As described in Section 2.1.3.3, stormwater exiting the site is now captured within the temporary stormwater collection system installed during the City's independent cleanup action in the Adjacent Streets.

Between 2004 and early 2008, the Basin Oil ~~property~~ facility underwent demolition and stabilization, including the excavation of contaminated surface soil and backfilling. Soil excavation occurred to depths of 2 to 2.5 ft across the site, with excavations as deep as 4 ft in areas with visual or olfactory evidence of petroleum (Ecology 2005a; Thomas 2008b). Site investigation samples were collected by Ecology in 2009; these results are further discussed and summarized below.

Excavation to a depth of about 6 in. was performed in the drum storage area on the residential property at 8617 17th Avenue S (Thomas 2008a). That property has been sold to the owner of the Marina and currently is being used for boat storage. An application form for Ecology's Voluntary Cleanup Program (ENSR 2006) indicates that Basin Oil is intended to be used for boat storage.

2.4.1.2 Summary of existing environmental data

Available data for Basin Oil include~~s~~ historical (e.g., pre 2008 soil removal) soil, groundwater, and liquids and sludges from tanks and drums at Basin Oil and ~~post~~ post-2008 soil and groundwater data. The historical samples are not necessarily representative of current site conditions inasmuch as some or all of the soil sampled may have been removed during the Basin Oil cleanup; however, they are discussed below because they may have been potential previous source contamination to the T-117 EAA. The most recent data are from analyses performed on investigational samples collected in 2008 and 2009 from Basin Oil following soil removal by the site owner, and one sample ~~(Drexler 2007)~~ collected in 2007 from the 8617 17th Avenue S. The recent samples are considered to be representative of current conditions and are summarized below. Both historical and recent sampling locations are shown on Map 2-39~~40~~ and results are presented in Appendix C and summarized in Appendix F. The ~~historical and~~ recent data are further evaluated in the recontamination assessment presented in Section 5.

Soil

Historical Results

The historical soil dataset for Basin Oil is limited and consists of 8 samples. One surface soil sample and two subsurface samples were collected on the Basin Oil property outside the fence line in the MW-01 boring in July 1991 (Parametrix 1991). Two surface soil samples were collected and composited during the 1996 site assessment (Creative Environmental Technologies 1996). Two samples were collected from onsite drainage structures, a settling tank associated with an oil/water separator and an area drain (CB41 and CB42, respectively), during a joint City/Ecology site visit in July 2004 (Ecology 2005a). EPA collected a surface soil sample during a site visit in May 2007 (Rodin 2007). Detected chemicals in soil collected from Basin Oil are presented in Appendix F.

Historical Basin Oil soil data were screened using the SLs developed for the T-117 EAA (Section 3). One of the 1996 composite surface samples and samples from two subsurface intervals from the 1996 MW-01 boring exceeded the PCB SL (0.5 mg/kg). TPH exceeded its SL in CB-41 and CB42.

The dioxin/furan TEQ in CB-41 also exceeded the SL. Chromium was the only metal detected in soil above the SL (which was detected in one sample from an MW-01 subsurface sample interval). A storm solids sample obtained from CB41 exceeded the SL for lead.

Current Results

In May 2009, Ecology collected surface and subsurface soil from 10 locations on the Basin Oil property (Map 2-39~~40~~) (Ecology 2009b). In May 2007, Basin Oil reported concentrations for a soil sample collected at the 8617 17th Avenue S property (Ecology 2008). Basin Oil soil data were screened using the SLs developed for the T-117 EAA (Section 3). Surface soil concentrations ~~Concentrations~~ of arsenic, TPH (lube oil and gas), cPAHs, total PCBs, ethylbenzene, and xylenes ~~in surface soils~~ were greater than their respective SLs. The total PCB concentration in one 12.5-ft-deep soil sample

(BSB-3) was greater than the SL. The results of the recent soil sampling at the Basin Oil property are presented in ~~Appendix C and summarized in~~ Appendix F.

Groundwater

Prior to 2009, only one groundwater monitoring well, MW-01, existed at Basin Oil, located on the southeast property boundary (Map 2-7~~9~~). MW-01 has been sampled eight times between 1991 and 2008 (Windward et al. 2003; ENSR | AECOM 2008). Groundwater data from MW-01 collected during sampling events between 2003 and 2009 are considered to be the most representative of current conditions and were included as part of the groundwater summary presented for the T-117 EAA in Section 2.3.4.1.

Tanks and Drums

EPA collected samples of liquid and/or sludge from two tanks and four drums during a site visit in May 2007 (Rodin 2007). The tank and drum data do not directly represent site environmental conditions but because they are indicative of past operations on the site, they provide an indication of chemicals that could be present in the site soil and groundwater. Aroclor 1260 was detected in sludge from one drum but not in sludge or liquids from the other three drums or the two tanks. Petroleum was not analyzed in the tank or drum samples. Chrysene, seven non-carcinogenic PAHs, three phthalates, BTEX, one chlorinated solvent, and two non-chlorinated solvents were detected in tank or drum samples. Arsenic, chromium, copper, lead, nickel, zinc and 16 other metals were detected in tank and drum samples. The concentrations of chemical analyses of the tank and drum samples are presented in Appendix ~~C and summarized in Appendix~~ F.

2.4.2 South Park Marina

2.4.2.1 Site d~~D~~escription and h~~H~~istory

The Marina is located at 8604 Dallas Avenue S and is adjacent to the T-117 Upland Study Area to the north. Since the early 1970s, the site has been used as a small boat marina and repair and maintenance facility. Activities at marinas elsewhere are known to result in copper, lead, TBT, PAH, and phthalate impacts. Best management practices (BMPs) are in place and Ecology has inspected the site. The Marina BMPs include the use of vacuum sanders, tarps to catch debris, routine sweeping of boat maintenance areas, and a closed-loop wash system. Ecology concluded that the potential for sediment recontamination associated with current operations is believed to be low (SAIC 2007b).

In the early to mid-1950s, A&B Barrel reconditioned and repainted drums on the southeastern portion of the Marina using sodium hydroxide as a cleaning agent. Liquid waste was discharged to an onsite pond that discharged to the LDW. The northern half of the Marina was also formerly a mobile home park. Other former operations at the Marina site included the North Star Trading Company, Evergreen Boat Transport, R.P. Boatbuilding, and Dekker Engineering.

2.4.2.2 Summary of existing environmental data

All available data collected from the Marina ~~is~~ are relatively recent and representative of current conditions. The results of the Marina samples are further evaluated in Section 5. All of the results from the Marina investigation are presented in Appendix ~~C and summarized in~~ F.

Soil and Sediment

In 2004 and 2006, the Port collected and analyzed seven soil samples for PCBs (including a duplicate sample) near the boundary between the Marina and T-117 Upland Study Area. These sampling locations are shown on Map 2-~~41~~40, and the PCB concentrations are presented in Appendix F. PCBs were detected at relatively low concentrations in samples from all locations. At two locations (T-117 A11 and T-117 A12), Aroclor 1254 was detected in addition to Aroclor 1260 (Aroclor 1260 is the predominant Aroclor at the T-117 EAA). TPH was also analyzed and detected in one sample and the field duplicate sample from location T-117-A10, but at concentrations well below the MTCA criteria (2,000 mg/kg).

Ecology recently conducted a reconnaissance-level environmental investigation of the area formerly occupied by A&B Barrel that included subsurface soil sampling throughout the area formerly occupied by A&B Barrel and soil and sediment sampling along two transects perpendicular to the shore (SAIC 2008). Thirteen subsurface soil sampling locations were collected and analyzed for PCBs, pesticides, SVOCs, VOCs and metals. Metals, PCBs, pesticides, PAHs, TPH and VOCs in soil samples collected from the Marina were detected above their respective SLs (SAIC 2009).

Three samples were collected along transects near the T-117 Upland Study Area and Marina boundary and in front of the former A&B Barrel pond location (Map 2-~~3941~~40). Two soil samples were collected along each transect (one from the top of the bank and one from just above the high water mark) and one sediment sample (collected from the toe of the riprap bank). These samples were collected primarily to determine if there were any impacts from the Marina bank soil to the sediment below. PCB concentrations in two sediment samples (identified as Sediment Transect A and Sediment Transect-B on Map 2-8~~10~~) exceeded the SL for total PCBs (as Aroclor 1260), indicating that PCBs from the Marina bank may have the potential to recontaminate the sediment below. However, the total PCB concentrations in the soil samples from Transects A and B (upgradient of the sediment samples) ranged from 0.073 to 0.17 mg/kg dry weight (dw) (0.61 to 8.5 mg/kg OC[6]).

Groundwater

Ecology's investigation of the area formerly occupied by A&B Barrel also included two rounds of groundwater monitoring at three shoreline wells. Groundwater samples collected in October 2007 and March 2008 contained pesticides (detected in MW-3) and arsenic (detected in all three site wells) above the Ecology screening criteria (SAIC 2009). One of the monitoring wells was located downgradient of a pond that reportedly was used for liquid waste disposal in the 1950s. The other two wells were installed in locations selected to characterize groundwater in other areas with a high potential for impacts. Recent tidal data collected from T-117 EAA wells suggest that groundwater flow is parallel to the Marina/T-117 Upland Study Area property line. Based on this groundwater flow pattern, migration from the Marina to the T-117 Upland Study Area is unlikely. Map 2-4140 provides the locations of the monitoring wells and Map 2-57 presents the groundwater flow pattern.

3 Streamlined Risk Assessment

This section presents the streamlined risk assessment. As described in the EE/CA guidance (EPA 1993), a streamlined risk assessment is an important component of an NTCRA. This assessment is intermediate in scope between the limited risk assessment conducted for emergency removal actions and the conventional baseline assessment normally conducted for remedial actions. The streamlined risk assessment is presented in this section, which includes:

- The identification of exposure pathways to potential receptors through the development of a CSM (Figure 3-1)
- A comparison of SLs to site-specific data to determine media- and subarea-specific COPCs for these pathways
- The identification of COCs for which site-specific removal action levels (i.e., RvALs)- are have been derived etermined in (see Section 4.3)

The purpose of this streamlined risk assessment is to support the development of the NTCRA removal area boundary and design (i.e., alternative selection) and establish the framework for post-NTCRA monitoring. The streamlined risk assessment ultimately must demonstrate that the NTCRA is protective of ecological and human receptors. This assessment is designed to be consistent with both MTCA and CERCLA risk evaluation frameworks to ensure that all areas within the T-117 EAA that pose an unacceptable risk will be addressed by the NTCRA.

As specified in the EE/CA guidance (EPA 1993), the streamlined risk assessment focuses on T-117 EAA media that are the focus of the NTCRA, including sediment in the T-117 Sediment Study Area and soils in the T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area. Groundwater considerations (i.e., groundwater potability, groundwater COCs, and RvALs) are discussed in Appendix B, and an assessment of the potential for sediment recontamination from groundwater has been incorporated into the development of groundwater RvALs presented in Section 4.X3.

3.1 Conceptual Site Model and Pathway Identification

A CSM for the T-117 EAA was developed to present the relationships among confirmed and potential sources, release mechanisms, transport mechanisms, exposure media, exposure routes, and potential receptors (Figure 3-1). A comprehensive CSM is an essential part of the streamlined risk assessment because it identifies pathways that must be considered in the design and successful implementation of an early action. The CSM focuses primarily on current release and transport mechanisms by which ecological and human receptors could be exposed. A summary of historical contaminant sources and associated site data was presented in Section 2.

As discussed in Section 1, the T-117 EAA includes the T-117 Sediment Study Area, the T-117 Upland Study Area, and the Adjacent Streets and Residential Yards Study Area (Map 1-1). The CSM includes all the study areas, although the importance of specific transport mechanisms and exposure media varies significantly by study area, as described below.

3.1.1 Primary sources

As shown in Figure 3-1, both historical and current primary sources have been identified in the T-117 EAA. The principal historical source of contaminants was the former asphalt manufacturing facility, which was located on property that is now part of the T-117 Upland Study Area. The facility has been removed and is no longer a source of contamination, although legacy contamination from the facility may still be transported within and potentially outside of the T-117 EAA via secondary transport mechanisms.

Other nearby potential primary sources of contaminants (both historical and current) include the Basin Oil property and the Marina, both of which have been identified in this EE/CA as RAAs (Map 1-1). These properties are discussed in more detail in Sections 2.4 and 5.2. Other regional sources that may have contributed to T-117 EAA contamination, and may continue to do so, may also exist within the surrounding urban area.

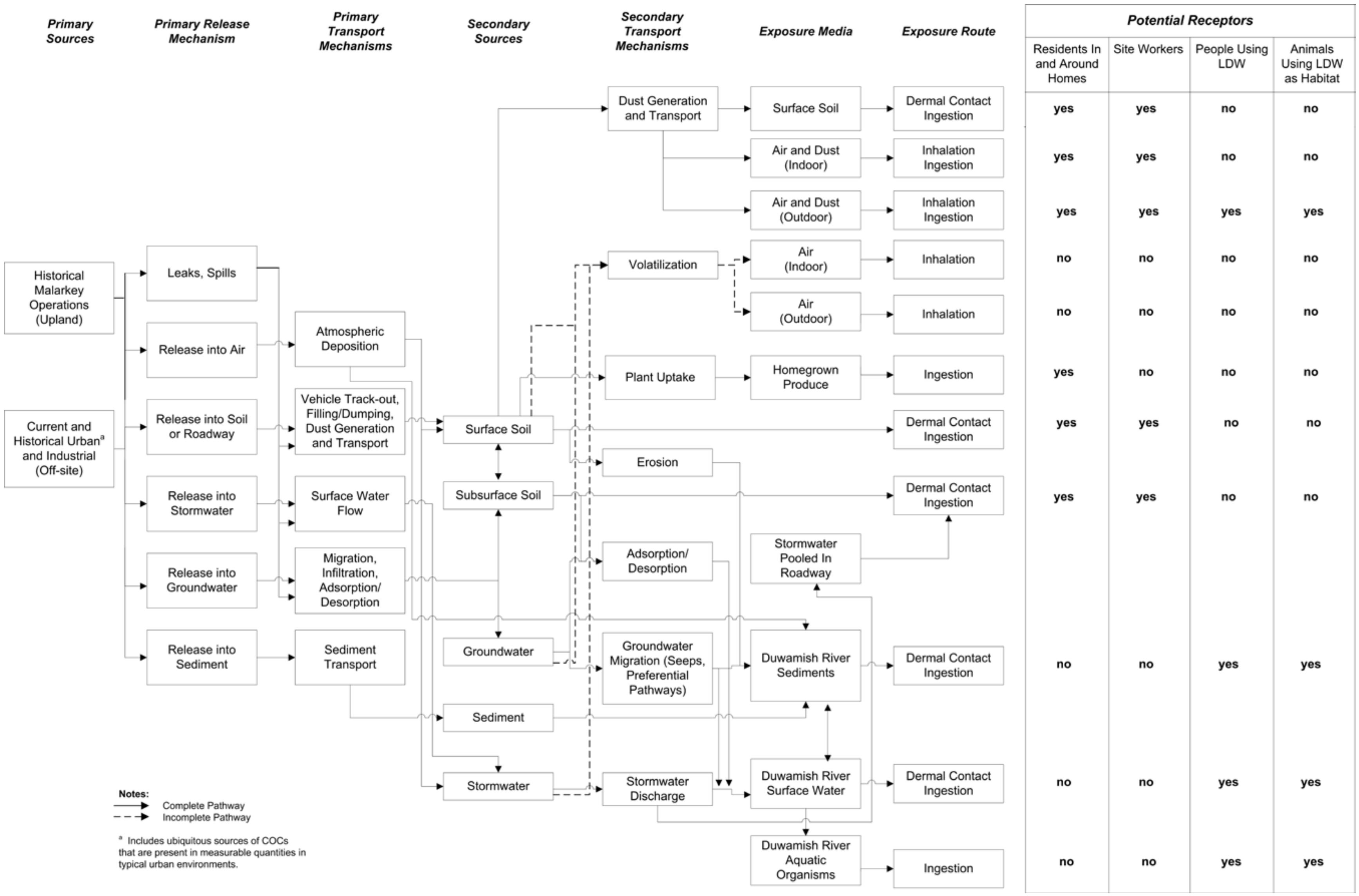


Figure 3-1. T-117 conceptual site model for current site conditions

3.1.2 Primary release and transport mechanisms

Contaminant release mechanisms refer to the manner in which contaminants are released from the primary source. Primary release mechanisms associated with the former asphalt manufacturing facility included upland process-related releases, spills, and the combustion of fuel oils, including recycled waste oils and PCB-contaminated oil. The current and historical combustion of fuel and heating oils at other properties in the vicinity of the T-117 EAA also represents a primary release mechanism. Urban and industrial sources outside the T-117 EAA could also have resulted in releases to sediment, soil, groundwater, stormwater, or air within the T-117 EAA.

Contaminant transport mechanisms refer to the physical processes that move contaminants from one area to another, including within the T-117 EAA and from outside areas to the T-117 EAA. In the T-117 CSM (Figure 3-1), a primary transport mechanism refers to a process that moves contaminants from the primary source to one or more study areas within the EAA.

The primary transport mechanism from combustion sources is atmospheric deposition, either as dry deposition (during dry weather) or as wet deposition (during rain events). This transport mechanism likely deposited contamination from the former asphalt manufacturing facility and potentially other offsite sources to sediments in the T-117 Sediment Study Area and soils in the T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area. Other primary transport mechanisms that likely moved contamination from the former asphalt manufacturing facility to areas within the T-117 EAA include track-out, filling and dumping, dust generation and transport, surface water flow (as stormwater), and groundwater migration, infiltration, and adsorption/desorption (Figure 3-1). Each of these primary transport mechanisms is briefly described below.

Track-out refers to a process whereby contaminants in soil and ponded water adhere to the tires of vehicles departing contaminated areas, such as the former asphalt manufacturing ~~facility~~ property (which was unpaved), and are transported to adjacent streets. Because the T-117 Upland Study Area is now paved, the historical mechanism for the ~~track-out~~ transport of contaminated soil (i.e., track-out) ~~is~~ no longer active. However, active sources such as spills or settled dust could still be contaminating the paved surface and could continue to be tracked out.

Filling and dumping[6] likely were also primary transport mechanisms by which soil was moved within the T-117 EAA. As discussed in Section 2.1.5.3, shallow soils in the T-117 Upland Study Area and the Adjacent Streets and Residential Yards Study Area

[6] For the purpose of the CSM, dumping is similar to filling in that potentially contaminated soil could have been moved within the T-117 EAA and placed on the surface at another location within the facility.

typically consist of fill material, primarily sand and silt, mixed with anthropogenic materials (e.g., asphalt, bricks, rubble, and wood). No specific instances of dumping have been documented in this EE/CA. Because the former asphalt manufacturing facility has been removed, these primary transport mechanisms are no longer active.

Dust generation could have also have resulted in the transport of contaminated materials within the upland portions of the T-117 EAA. During dry weather, soil particles from unpaved areas were blown throughout the T-117 EAA. Now that most of the area occupied by the former asphalt manufacturing facility has been paved (except for a margin adjacent to the bank), this mechanism is less prevalent.

The stormwater conveyance and discharge primary transport mechanism was relevant historically and continues today. Stormwater runoff from the T-117 Upland Study Area enters the LDW through a network of catch basins that discharge to two outfalls located along the bank. Historically, this mechanism was likely a significant factor in the transport of contaminants from the T-117 Upland Study Area to the T-117 Sediment Study Area. Since early 2000, improvements to the stormwater collection systems at the T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area by the Port and City have significantly controlled the stormwater pathway through infrastructure improvements. The major change was to prevent street runoff in the area around Basin Oil from running across the T-117 Upland Study Area. Routine monitoring and inspections of the stormwater infrastructure are also being conducted to verify the effectiveness of the stormwater controls. Runon to the T-117 Upland Study Area from nearby streets and all runoff from the Adjacent Streets and Residential Yards Study Area is now controlled through the use of catch basins and the redirection of stormwater, primarily to the County's CSS at a maintenance hole on 17th Avenue S and S Donovan Street.

Groundwater primary transport mechanisms, including groundwater migration, infiltration, and adsorption/desorption, were also active historically and continue today. The current impact of these mechanisms has been reduced through the removal and capping of soil in the area formerly occupied by the asphalt manufacturing facility, previous removal actions at the T-117 Upland Study Area, and other source control activities both within and outside of the T-117 EAA.

As described above, some primary transport mechanisms related to stormwater and groundwater remain active. The potential for these and other transport mechanisms to recontaminate the T-117 Sediment Study Area is discussed in Section 5.2.

The media affected by the primary transport mechanisms are designated as secondary sources of contamination (Figure 3-1). Section 3.2 describes the manner in which contaminants from these secondary sources may come in contact with people or animals in specific study areas within the T-117 EAA.

3.2 STUDY AREA-SPECIFIC TRANSPORT MECHANISMS, RECEPTORS, AND EXPOSURE PATHWAYS

The following subsections describe the secondary transport mechanisms, receptors, and exposure pathways applicable to each study area in the T-117 EAA. Secondary transport mechanisms are similar to primary transport mechanisms with respect to the physical process (e.g., stormwater discharge), but for the purpose of this discussion, a distinction has been made between the mechanisms that were prevalent when the primary source was active (i.e., primary transport mechanisms) and those that were one step removed (i.e., secondary transport mechanisms). For example, primary transport mechanisms transported contaminants from the former asphalt manufacturing facility to various locations within the T-117 EAA. Now that the former asphalt manufacturing facility is gone, the transport mechanisms are considered to be secondary because media are no longer being contaminated by the original source. This section discusses secondary transport mechanisms, although it should be recognized that each of the primary transport mechanisms discussed in Section 3.1.2 likely influenced the distribution of contaminants in each study area.

An exposure pathway focuses on the transport mechanism and exposure routes to a potential receptor. An exposure pathway is considered complete if a chemical can travel from a source to a receptor and is available to that receptor via one or more exposure routes (EPA 1997a, b). The exposure route refers to the way in which the receptor may be exposed (e.g., inhalation, ingestion).

Note that exposures of ecological receptors were not evaluated for any of the upland study areas (see Section 2.1.6). For the T-117 Upland Study Area, the current site configuration has less than 0.25 acre of contiguous undeveloped land. As a result, the current site configuration qualified the T-117 Upland Study Area for an exclusion from the TEE (Washington Administrative Code [WAC] 173-340-7491). A simplified TEE conducted for the Adjacent Streets and Residential Yards Study Area also concluded that this study area qualified for the exclusion based on lack of substantial wildlife exposure at the site (Integral 2006c). Consequently, terrestrial ecological receptors are not shown in the CSM (Figure 3-1) or discussed in the rest of the section. Aquatic ecological receptors are included.

3.2.1 T-117 Sediment Study Area

The T-117 Sediment Study Area has been contaminated by multiple sources, some of which may be ongoing. The significant transport mechanisms for the T-117 Sediment Study Area include:

- Erosion of upland surface soil, particularly on the bank
- Stormwater discharge
- Groundwater migration and seeps

- Sediment transport within the LDW[7]

Ecological and human receptors in the T-117 Sediment Study Area could be directly or indirectly exposed to contaminants in soil, sediment, and river water as follows:

- **Ecological** – Animals using the LDW for habitat, including benthic invertebrates, fish, birds, and mammals
    - **Direct exposure –** Contact with or ingestion of porewater, river water, or sediment
    - **Indirect exposure –** Consumption of benthic invertebrates or fish
- **Human** – People using the LDW for recreation or food, including fishermen (tribal and recreational), kayakers, clammers, seafood consumers, and children using the intertidal area for recreation
    - **Direct exposure –** Incidental ingestion or dermal contact with sediment, soil, seeps, or river water
    - **Indirect exposure –** Consumption of seafood

Other than incidental contact with seep water exiting the bank, there is no direct contact with groundwater in the T-117 EAA (i.e., groundwater is not currently being used for drinking water), nor is there any reasonable expectation of direct contact in the future (see Appendix B for further details).

3.2.2 T-117 Upland Study Area

The T-117 Upland Study Area has been contaminated by multiple sources, some of which may be ongoing. Contamination from the T-117 Upland Study Area may also contaminate other study areas.

Significant transport mechanisms for the T-117 Upland Study Area include:

- **Erosion of bank soil to surface water and sediment –** Portions of the upper bank at the T-117 Upland Study Area have been covered with clean gravel or stabilized with a geotextile fabric. Other portions of the upper bank are covered with vegetation, which tends to control the erosion of underlying soil. However, much of the original bank is still exposed to the river; where soil is not stabilized, the potential for erosion of soil particles to the LDW exists.

[7] Extensive sediment transport modeling done for the LDW RI/FS indicated that the majority of the sediment transported to the site originates from upriver locations. Sediment transport from downstream locations to the T-117 Sediment Study Area is unlikely to occur in any appreciable quantity (QEA 2008). Additional discussion of LDW sediment transport is provided in Section 5.2.4.

- **Stormwater outfall discharge –** Stormwater from the T-117 Upland Study Area enters the LDW through a network of catch basins that discharge to two outfalls located along the river bank.
- **Soil leaching to groundwater –** PCBs and other hydrophobic chemicals in soil are highly immobile because they are strongly sorbed to organic matter in soils and thus have low partitioning from soil to water (EPA 1990). However, PCBs and other hydrophobic chemicals may migrate in association with colloidal particles or as dissolved components in more mobile substances, such as oil, which have higher miscibility. PCBs and TPH have been detected in both soils and groundwater in T-117 Upland Study Area and thus migration to groundwater from soil may be occurring.
- **Groundwater discharge to LDW surface water and sediment –** Several active groundwater seeps are present at the base of the shoreline bank and flow out onto the intertidal mudflat. Because the shallow aquifer adjacent to the LDW is tidally influenced, groundwater discharge is a mixture of river water from the preceding high tide and groundwater. Previous groundwater monitoring has detected trace (i.e., just slightly above reporting limits) concentrations of contaminants; thus, the migration from groundwater to LDW surface water and sediment is a potential pathway.
- **Dust generation and transport –** Most soil at the T-117 Upland Study Area is covered with an asphalt cap. The asphalt cap reduces, if not eliminates, migration pathways such as erosion and ~~windblown~~ dust generation from wind or vehicle traffic ~~migration pathways~~. Also, any unpaved areas are either capped with clean gravel or heavily vegetated, which helps stabilize the soil and reduces erosion and the potential for fugitive dust generation. However, to the extent that future construction activities disturb bank soils, dust generation and transport could be a transport mechanism.

The T-117 Upland Study Area is currently closed to the public (secured by a chain link fence and locked gate) and capped to reduce direct exposure to soil. Therefore, the only current potential receptors in the T-117 Upland Study Area are workers who perform occasional maintenance associated with the 2006 TCRA. These workers could be exposed to contaminants in soil through the following exposure pathways:

- **Direct contact or ingestion with soil –** Direct contact (incidental ingestion and dermal contact) could occur in areas where soil is uncapped, such as on the bank, or where soil could become exposed during construction. Exposure during construction will be mitigated through the use of personnel protective equipment and engineering controls to prevent contact and access to soil during construction activities.

- **Inhalation and ingestion of windblown dust in outdoor air –**A small potential for windblown dust exposure exists from the relatively small areas on the top of the shoreline bank that are only covered with vegetation, or from areas associated with site maintenance or construction activities.

Currently, there is no direct contact with groundwater in the T-117 Upland Study Area, nor is there any reasonable expectation of direct contact in the future. This conclusion is supported by the potability evaluation presented in Appendix B.

3.2.3 Adjacent Streets and Residential Yards Study Area – Adjacent Streets

This section addresses the Adjacent Streets component of this study area; the Residential Yards are discussed in Section 3.2.4.

Currently, there are several secondary transport mechanisms for contaminants entering and leaving the Adjacent Streets, as follows:

- **Leaching from surface to subsurface soils –** Infiltration of rainfall through the soils can leach contaminants from surface soils to subsurface soils in street areas where pavement is not intact or does not exist.
- **Physical disturbance of soils –** Surface soils along the streets could be exposed via excavation by utility workers.
- **Dust generation and transport –** Surface soils, or subsurface soils that have been brought to the surface through excavation, could be suspended by ~~the~~ wind or vehicle traffic and deposited on nearby surface soils. ~~Windblown~~ ~~d~~Dust can also be transported by stormwater.
- **Stormwater discharge –** Most stormwater runoff from streets in this study area is currently carried to the CSS and/~~-~~or directly to the LDW from the temporary stormwater storage tanks via occasional emergency overflow events (12 events since 2005).~~-~~ Stormwater from a small portion of Dallas Avenue S flows onto the T-117 Upland Study Area during emergency discharge events (see Section 2.1.3.3), where it is collected by the T-117 storm drainage system. Water in this system is sampled on a regular basis. There has been one detection of total PCBs (0.12 mg/kg) since treatment was discontinued in 2005 (January 2008) (see Section 2.1.3.3)

As discussed in Section 3.1.2, improvements to the stormwater collection systems at the Adjacent Streets and Residential Yards Study Area by the City have significantly reduced the volume the stormwater being discharged to the LDW from this area. Soil contamination patterns discussed in Section 2.3 indicate that leaching likely has not resulted in the contamination of groundwater in the Adjacent Streets; thus, this transport mechanism is not considered to be significant for this portion of the study area. The volatilization of VOCs to outdoor and indoor air is also not expected to be a significant pathway because the chemicals detected in soil and groundwater from the Adjacent Streets are not volatile (see Section 2.3).

People who could be exposed to chemicals in the Adjacent Streets include:

- Local residents
- Workers at commercial facilities within the study area
- Street or utility maintenance workers

People could be exposed to contaminants in soil through the following pathways:

- **Direct contact with soil –** Direct contact (incidental ingestion and dermal contact) could occur in areas where soil is uncapped, such as along street shoulders. Local residents, workers at local industries, or workers performing maintenance on streets could come into contact with surface soils. Residents could also come into contact with these soils when doing maintenance or lawn/yard improvement projects in ROWs. Soils that are capped or paved pose no risk to residents or workers as long as the pavement remains intact. There is a potential for future direct contact if people (e.g., utility workers) excavate areas with contaminated soil.
- **Direct contact with stormwater –** Stormwater in ROWs may pool in some roadside areas, resulting in the potential exposure of local residents and workers.
- **Inhalation of ~~windblown~~ dust – ~~—~~**Local residents and utility workers digging trenches in the ROWs could inhale and potentially ingest ~~windblown~~ dust generated by wind or vehicle traffic. Workers at local businesses are assumed to spend most of their time indoors, so they will not be exposed in any significant way to ~~windblown~~ dust generated outside. However, dust generated outside of buildings may ultimately be tracked inside, where it could be inhaled and potentially ingested by workers.

3.2.4 Adjacent Streets and Residential Yards Study Area – Residential Yards

Currently, secondary transport mechanisms for contaminants entering and leaving the Residential Yards include:

- **Dispersal from streets – ~~—~~**Once tracked onto the streets, contaminants may have been dispersed into yards by foot traffic, residential parking, road splash, and dust from the streets.
- **Leaching to subsurface soils –** Infiltration of rainfall through the soils could potentially leach contaminants from surface soils to subsurface soils.
- **Physical disturbance of soils –** Subsurface soils could be brought to the surface by residents gardening or undertaking lawn/yard improvement projects.

- **Dust generation and transport --** Surface soils along the streets could be picked up by the wind or vehicle traffic and deposited onto surface soils in residential yards.

Soil contamination patterns discussed in Section 2.3 indicate that leaching likely has not resulted in the contamination of groundwater in the Residential Yards; thus, this transport mechanism is not considered to be significant for this study area. Volatilization of VOCs to outdoor and indoor air is not expected to be of concern because the contaminants detected in the yards are not volatile (see Section 2.3).

People who could be exposed to contaminants in residential yards include local residents and utility workers, who could be exposed to contaminated soil through the following pathways:

- **Direct contact with soil --** Direct contact is a potential pathway in areas where soil is uncapped, such as lawns, flowerbeds, and gardens, both as incidental dermal contact or ingestion (including consumption of home-grown produce). Residents could come in contact with subsurface soil through projects that involve digging, including digging through surfaces that may currently be paved or otherwise capped. Residents with pets could also be exposed to soils that may have adhered to the animals' coats. ~~Soils that are capped or paved (e.g., houses, paved driveways) pose no potential risk to residents as long as the surfacing or pavement remains intact.~~
- **Inhalation of ~~windblown~~ dust –** Local residents or utility workers digging in yards could inhale and potentially ingest ~~windblown~~ dust generated by wind or vehicle traffic. In addition, residents inhale and potentially ingest dust within households, some of which may have come from soils within the Residential Yards ~~Study Area~~. The soil ingestion rate used to derive soil CULs includes the ingestion of indoor dust derived from outdoor soil.
- People using the LDW may be local residents, which would lead to cumulative exposures between the Residential Yards and the T-117 Sediment Study Area.

3.3 Contaminants of Concern Selection Process and Results

This section presents the final COC analysis for the T-117 EAA, which was derived from the COPC analysis presented in the EE/CA Work Plan (Windward et al. 2008) and more recent data. In this analysis, COPCs were first identified based on a comparison of sediment and upland soil data to SLs relevant to the contaminant transport pathways and exposure routes discussed in Section 3.2. COCs for soil and sediment were then selected from the COPC list based on several factors, including detection frequency, age of data, and administrative decisions. The specific rationale used for COC designation is described in more detail by study area below.

SLs are health-protective risk-based values developed for specific media; they are based on specific exposure pathways to specific receptors. Because a single medium may be relevant to multiple exposure pathways (or routes), as demonstrated in the CSM (Figure 3-1), the screening process must explicitly identify the exposure pathways that are evaluated, as summarized in Table 3-1. In some cases, exposure pathways not explicitly addressed in SL development will be further evaluated in Section 4 (as part of the development of RvALs) or in Appendix B (for groundwater). Note that COCs were not identified for sediment for the seafood ingestion pathway noted in Section 3.2.1.

Table 3-1. Exposure pathways addressed by screening levels

Medium	Exposure Pathway	Incorporation of Exposure Pathway for Screening Level Development
Sediment	direct contact by aquatic organisms	**yes**, by use of SQS for the protection of benthic invertebrates
	direct contact by people	**yes**, by use of EPA risk-based goals for residential soil (to be used as surrogate for sediment)
	seafood consumption by people	**no**, to be addressed as part of RvAL development (Section 4)
Soil	direct contact by people (incidental ingestion and dermal contact)	**yes**, by use of MTCA values for residential soil
	protection of groundwater quality	**no**, to be addressed as part of the development of groundwater RvALs (Section 3.3.3 and Appendix B)
	protection of sediment quality	**no**, to be addressed as part of the recontamination assessment (Section 5)
	consumption of home-grown produce by people	**no**, risk assessments conducted for other sites with hydrophobic contaminants (e.g., PCBs along the Housatonic River) suggest that risks associated with consuming plants grown in soil containing PCBs at the concentrations present in Residential Yards are approximately 1×10^{-6}, the MTCA target risk level (see Section 3.3.2)
	~~indoor~~ dust inhalation and ingestion	**no**, exposures through the dust inhalation and ingestion pathway are much less than exposures through the soil incidental ingestion pathway (EPA Regions 3, 6, and 9 soil PRG for inhalation is 87,000 ng/kg for dioxins and 5,800 ng/kg for PCBs) so screening based on the soil incidental ingestion pathway is protective.
Groundwater	protection of surface water quality	**yes**, by use of ambient water quality criteria to protect surface water beneficial uses

EPA – US Environmental Protection Agency

MTCA – Model Toxics Control Act

PCB – polychlorinated biphenyl

PRG – preliminary remediation goal

RvAL– removal action level

SQS – sediment quality standards

3.3.1 Sediment

SLs for sediment were developed in consideration of both ecological and human health. ~~Sediment quality standards (~~SQS~~)~~ (173-204 WAC) were selected for ecological health. These standards are designed to protect benthic invertebrates in marine sediment. These standards are likely protective of other ecological users of the T-117 Sediment Study Area because of the small size of this area relative to the home ranges of fish, birds, and mammals within the LDW (Windward 2007a).

For human health, neither EPA nor Ecology have published risk-based SLs for direct contact with sediment. However, EPA has developed screening values for residential soil exposure, which can be used as an acceptable and health-protective surrogate for the purposes of screening for sediment exposure. The lower of the two values (i.e., SQS and EPA screening values for residential soil) for each chemical were used as SLs for sediment in this assessment (Table 3-2).

Table 3-2. Sediment screening levels

Chemical	SQS (original units)	SQS (mg/kg dw)[a]	EPA Screening Value (mg/kg dw)[b]	SL Used f~~F~~or EE/CA
Metals and Trace Elements				
Aluminum	na	na	**7,700**	7,700 mg/kg
Antimony	na	na	**3.1**	3.1 mg/kg
Arsenic	57 mg/kg	57	**0.39**	0.~~37mg~~39mg/kg
Barium	na	na	**1,500**	1,500 mg/kg
Cadmium	**5.1 mg/kg**	5.1	7.0	5.1 mg/kg
Chromium	260 mg/kg	260	**39**	39 mg/kg
Copper	390 mg/kg	390	**310**	310 mg/kg
Iron	na	na	**5,500**	5,500 mg/kg
Lead	450 mg/kg	450	**40**	40 mg/kg
Manganese	na	na	**180**	180 mg/kg
Mercury	**0.41 mg/kg**	0.41	2.3	0.41 mg/kg
Molybdenum	na	na	**39**	39 mg/kg
Silver	**6.1 mg/kg**	6.1	39	6.1 mg/kg
Thallium	na	na	**0.51**	0.51 mg/kg
Vanadium	na	na	**39**	39 mg/kg
Zinc	**410 mg/kg**	410	2,300	410 mg/kg
PAHs				
2-Methylnaphthalene	**38 mg/kg OC**	0.59	31	38 mg/kg OC
Acenaphthene	**16 mg/kg OC**	0.25	340	16 mg/kg OC

Chemical	SQS (original units)	SQS (mg/kg dw)[a]	EPA Screening Value (mg/kg dw)[b]	SL Used fFor EE/CA
Acenaphthylene	**66 mg/kg OC**	1.0	na	66 mg/kg OC
Anthracene	**220 mg/kg OC**	3.4	1,700	220 mg/kg OC
Benzo(a)anthracene	**110 mg/kg OC**	1.7	0.15	110 mg/kg OC[c]
Benzo(a)pyrene	**99 mg/kg OC**	1.5	0.02	99 mg/kg OC[c]
Benzo(g,h,i)perylene	**31 mg/kg OC**	0.48	na	31 mg/kg OC
Total benzofluoranthenes	**230 mg/kg OC**	3.6	0.15	230 mg/kg OC[c]
cPAH TEQ	na		**0.015**	0.015 mg/kg
Chrysene	**110 mg/kg OC**	1.7	15	110 mg/kg OC
Dibenzo(a,h)anthracene	**12 mg/kg OC**	0.19	0.02	12 mg/kg OC[c]
Dibenzofuran	**15 mg/kg OC**	0.23	na	15 mg/kg OC
Fluoranthene	**160 mg/kg OC**	2.5	230	160 mg/kg OC
Fluorene	**23 mg/kg OC**	0.36	230	23 mg/kg OC
Indeno(1,2,3-cd)pyrene	**34 mg/kg OC**	0.53	0.15	34 mg/kg OC[c]
Naphthalene	**99 mg/kg OC**	1.5	3.90	99 mg/kg OC
Phenanthrene	**100 mg/kg OC**	1.6	na	100 mg/kg OC
Pyrene	**1,000 mg/kg OC**	16	170	1,000 mg/kg OC
Total HPAH (calc'd)	**960 mg/kg OC**	15	na	960 mg/kg OC
Total LPAH (calc'd)	**370 mg/kg OC**	5.7	na	370 mg/kg OC
Phthalates				
BEHP	**47 mg/kg OC**	0.73	35	47 mg/kg OC
BBP	**4.9 mg/kg OC**	0.076	260	4.9 mg/kg OC
Diethyl phthalate	**61 mg/kg OC**	0.95	4,900	61 mg/kg OC
Dimethyl phthalate	**53 mg/kg OC**	0.82	na	53 mg/kg OC
Di-n-butyl phthalate	**220 mg/kg OC**	3.4	na	220 mg/kg OC
Di-n-octyl phthalate	**58 mg/kg OC**	0.90	na	58 mg/kg OC
Other SVOCs				
1,2,4-Trichlorobenzene	**0.81 mg/kg OC**	0.013	8.7	0.81 mg/kg OC
1,2-Dichlorobenzene	**2.3 mg/kg OC**	0.036	200	2.3 mg/kg OC
1,4-Dichlorobenzene	**3.1 mg/kg OC**	0.048	2.6	3.1 mg/kg OC
2,4-Dimethylphenol	**29 µg/kg**	0.029	120	0.029 mg/kg
4-Methylphenol	**670 µg/kg**	0.67	na	0.67 mg/kg
Benzoic acid	**650 µg/kg**	0.65	24,000	0.65 mg/kg
Benzyl alcohol	**57 µg/kg**	0.057	3,100	0.057 mg/kg
Hexachlorobenzene	**0.38 mg/kg OC**	0.0059	0.30	0.38 mg/kg OC

Chemical	SQS (original units)	SQS (mg/kg dw)[a]	EPA Screening Value (mg/kg dw)[b]	SL Used fFor EE/CA
n-Nitrosodiphenylamine	**11 mg/kg OC**	0.17	99	11 mg/kg OC
Pentachlorophenol	**360 µg/kg**	0.36	3.0	0.36 mg/kg
Phenol	**420 µg/kg**	0.42	1,800	0.42 mg/kg
Pesticides				
Dieldrin	na	na	**0.03**	0.03 mg/kg
Total DDTs	na	na	**1.4**	1.4 mg/kg
Toxaphene	na	na	**0.44**	0.44 mg/kg
PCBs				
Total PCBs	12 mg/kg OC	**0.19**[d]	0.22	12 mg/kg OC
Dioxins and Furans				
Dioxin/furan TEQ	na	na	**0.0000045**	4.5 ng/kg

a SQS values originally presented in units of mg/kg OC were converted to mg/kg dry weight to facilitate comparison with the EPA PRGs that are also in dry weight units. A TOC concentration of 1.55%, reflecting the average TOC concentration in the T-117 Sediment Study Area, was assumed.

b Values are from EPA's regional screening values for residential soil (EPA 2009f)(www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm). Values based on a non-carcinogenic endpoint were divided by 10 to be equivalent to a hazard quotientHQ of 0.1 per EPA Region 10 guidance (EPA 1996b).

c SL is based on ecological effects (i.e., SQS) even though human health SL is lower. This cPAH is evaluated as part of the cPAH TEQ parameter.

d If the SQS value of 12 mg/kg OC is not used because the TOC value in a sediment sample is either higher or lower than 0.5 to 3.5%, then a site-specific calculation, or "surrogate," can be applied, which results in a value of 0.19 mg/kg dw.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
cPAH – carcinogenic polycyclic aromatic hydrocarbon
DDT – dichlorodiphenyltrichloroethane
dw – dry weight
EE/CA – engineering evaluation/cost analysis
EPA – US Environmental Protection Agency
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
HQ – hazard quotient
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
MTCA – Model Toxics Control Act
na – not applicable
OC – organic carbon
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PRG – preliminary remediation goal
SL – screening level
SQS – sediment quality standards
SVOC – semivolatile organic compound
TEQ – toxic equivalent
TOC – total organic carbon

Bold identifies the concentrations used as the values were identified as SLs.

In the first step of the COPC and COC identification process, the SLs presented in Table 3-2 were compared to maximum concentrations in T-117 sediment. Screening was conducted for sediment (surface and subsurface) data collected since 1990. A complete description of all the data management rules used in this step is provided in

Appendix D.[8] As part of the second step, a 5% frequency of detection threshold was selected so that infrequently detected chemicals that may be artifacts in the data as a result of sampling, analytical, or other issues were excluded from further analysis, thereby focusing further evaluation on the contaminants most likely to pose the majority of site risk. This process is consistent with EPA risk assessment guidelines for focusing risk assessments when large numbers of chemicals are present at a site (EPA 1989). In addition, the possibility that these infrequently detected chemicals are from ~~of a~~ unique and localized sources was considered prior to the exclusion of those chemicals as COCs. The final step was included to provide additional refinement of the COC list by considering whether the CSM suggests that a COPC may be related to operations within the T-117 EAA.

Table 3-3 lists each sediment COPC and provides a rationale for the COC designation. COPCs were retained as COCs if there was a known or suspected T-117 Upland Study Area source of the chemicals and the concentrations of chemicals in sediment exceeded their respective SLs. The COPCs include total PCBs, several PAHs (including cPAHs), six metals, BEHP, BBP, hexachlorobenzene, dioxins and furans, and phenol. Approximately 50% of the total PCB concentrations in the T-117 Sediment Study Area was~~ere~~ greater than the SL, suggesting ~~widespread~~ the presence of PCB contamination in the area. Total PCB concentrations were as high as 2,600 mg/kg ~~-~~OC (51 mg/kg dw), which is more than 200 times the SL. The average total PCB concentration was greater than the SL by a factor of approximately 10. Concentrations of the other COPCs were greater than the applicable SLs much less frequently and by much smaller magnitudes (see Appendix E for all screening results).

---

[8] As part of the data aggregation necessary for screening, data management rules were established for the T-117 EAA; these rules were consistent with those used in the LDW RI/FS. Data management rules ensure consistency among the various datasets used in the screening. ~~Significant~~ D~~d~~ata management rules included summation rules for determining total PCBs or PAHs, carbon normalization of dry~~-~~weight values, ~~and~~ averaging of replicates, and the application of significant figures. These rules were also used to determine how TEQs for contaminants such as dioxins and furans and cPAHs were calculated.

Table 3-3. Sediment COPCs and COCs

COPC	Designated as a COC?	Rationale for COC Selection[a]
Metals		
Aluminum	no	risk estimates from LDW HHRA were well below thresholds of concern
Antimony	no	risk estimates from LDW HHRA were well below thresholds of concern
Arsenic	yes	upland source, one or more recent SL exceedances in sediment
Iron	no	risk estimates from LDW HHRA were well below thresholds of concern
Lead	no	risk estimates from LDW HHRA were well below thresholds of concern
Manganese	no	risk estimates from LDW HHRA were well below thresholds of concern
PAHs		
2-Methylnaphthalene	yes	upland source, one or more recent SL exceedances in sediment
Acenaphthene	yes	upland source, one or more recent SL exceedances in sediment
Anthracene	yes	upland source, one or more recent SL exceedances in sediment
Benzo(a)anthracene	yes	upland source, one or more recent SL exceedances in sediment
Benzo(a)pyrene	yes	upland source, one or more recent SL exceedances in sediment
Benzo(g,h,i)perylene	yes	upland source, one or more recent SL exceedances in sediment
Total benzofluoranthenes	yes	upland source, one or more recent SL exceedances in sediment
cPAH TEQ	yes	upland source, one or more recent SL exceedances in sediment
Chrysene	yes	upland source, one or more recent SL exceedances in sediment
Dibenzo(a,h)anthracene	yes	upland source, one or more recent SL exceedances in sediment
Dibenzofuran	yes	upland source, one or more recent SL exceedances in sediment
Fluoranthene	yes	upland source, one or more recent SL exceedances in sediment
Fluorene	yes	upland source, one or more recent SL exceedances in sediment
Indeno(1,2,3-cd)pyrene	yes	upland source, one or more recent SL exceedances in sediment
Phenanthrene	yes	upland source, one or more recent SL exceedances in sediment
Total HPAH (calc'd)	yes	upland source, one or more recent SL exceedances in sediment
Total LPAH (calc'd)	yes	upland source, one or more recent SL exceedances in sediment
Phthalates		
BEHP	no	single SL exceedance > 10 yrs old
BBP	no	no upland source, single SL exceedance > 10 yrs old
Other SVOCs		
Hexachlorobenzene	no	no upland source, single SL exceedance > 10 yrs old

COPC	Designated as a COC?	Rationale for COC Selection[a]
Phenol	yes	upland source, one or more recent SL exceedances in sediment
PCBs		
Total PCBs	yes	upland source, one or more recent SL exceedances in sediment
Dioxin and Ffurans		
Dioxin/furan TEQ	yes	upland source, assumed to be present at concentrations above the SL, although very few samples have been analyzed

[a] Upland source indicates there is a known or suspected source of the COPC in the T-117 Upland Study Area.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
COC – contaminant of concern
COPC – contaminant of potential concern
cPAH – carcinogenic polycyclic aromatic hydrocarbon
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SL – screening level
SVOC – semivolatile organic compound
T-117 – Terminal 117
TEQ – toxic equivalency quotient

Most of the COPCs were also designated COCs, except for phthalates, hexachlorobenzene, and five of the six metals (all but arsenic). The phthalates and hexachlorobenzene were not designated as COCs because only a single sample result for each contaminant exceeded SLs and the samples was collected more than 10 years ago. Concentrations from all of the more recently collected samples were less than the SLs for these chemicals. Concentrations for aluminum, antimony, iron, lead, and manganese in T-117 sediments were similar to concentrations evaluated in the LDW HHRA for which risk estimates were well below thresholds of concern (i.e., hazard quotient [HQ] of 1 or blood lead concentrations of 10 µg/dl). Consequently, these metals were not designated as COCs for the T-117 Sediment Study Area.

3.3.2 Soil

This section presents the soil SL development process and the identification of COPCs and COCs for soil for each relevant exposure pathway. As noted in Section 3.2, the terrestrial ecological exposure pathway is not complete. The soil-to-groundwater pathway was directly addressed by evaluating the groundwater concentrations versus relevant SLs in Appendix B (see Section 3.3.3). The soil SLs for direct human contact were based on the MTCA Method B standard formula values, with the exception of lead and TPH. For lead and TPH, the soil SLs were based on the MTCA Method A unrestricted land use CULs (Table 3-4). Method A provides the only applicable SLs for these chemicals. As noted in Table 3-1, SLs for the protection of sediment were not developed. There are no significant transport mechanisms to the T-117 Sediment Study Area for most of the soils present in the T-117 Upland Study Area and the Adjacent Streets and Residential Yards Study Area. Consequently, there is no need to address the protection of sediment quality for most of the soil areas. HoweverUnder present conditions, soil in some portion of the T-117 Upland Study Area, particularly on or near the bank, could be transported to the sediment, either now or after the NTCRA is completed through the erosion of bank soil to surface water and sediment via stormwater runoff. However, there are no bank surface soil data available to perform a risk-based screening. After completion of the NTCRA, Because all of these bank or near-bank soils will either be removed or completely isolated so that it cannot be transported to sediment, so as part of the NTCRA, there is no need to conduct additional risk-based screening for the protection of sediment quality. Any current soil areas in the T-117 Upland Study Area that would become part of a future LDW sediment area as the result of the post-NTCRA configuration will meet applicable sediment RvALs at the appropriate point of compliance as discussed in Section 4.

Table 3-4. Soil screening levels

Detected Chemicals	Concentration (mg/kg)		
	MTCA Method B		SL Used for EE/CA
	Carcinogen	Non-Carcinogen	
Metals			
Aluminum	nc	nc	nc
Arsenic	**0.67**	24	0.67
Barium	nc	**16,000**	16,000
Cadmium	nc	**80**	80
Chromium	nc	nc	nc
Chromium (III)	nc	120,000	240[a]
Chromium (VI)	nc	**240**	240
Copper	nc	**2,960**	3,000
Lead	nc	nc	250[b]
Mercury	nc	**24**	24
Nickel	nc	**1,600**	1,600
Silver	nc	**400**	400
Zinc	nc	**24,000**	24,000
SVOCs			
1-Methylnaphthalene	nc	nc	nc
2-Methylnaphthalene	nc	**320**	320
Acenaphthene	nc	**4,800**	4,800
Acenaphthylene	nc	nc	nc
Anthracene	nc	**24,000**	24,000
Benzo(a)anthracene	0.14	nc	nc[c]
Benzo(a)pyrene	0.14	nc	nc[c]
Benzo(b)fluoranthene	0.14	nc	nc[c]
Benzo(g,h,i)perylene	nc	nc	nc

Detected Chemicals	Concentration (mg/kg)		
	MTCA Method B		SL Used for EE/CA
	Carcinogen	Non-Carcinogen	
Benzo(k)fluoranthene	0.14	nc	nc[c]
Benzofluoranthenes	nc	nc	nc
Benzoic acid	nc	**320,000**	320,000
Benzyl alcohol	nc	**24,000**	24,000
BEHP	**71**	1,600	71
BBP	nc	**16,000**	16,000
Chrysene	0.14	nc	nc[c]
Dibenzo(a,h)anthracene	0.14	nc	nc[c]
Dibenzofuran	nc	**160**	160
Dimethyl phthalate	nc	**80,000**	80,000
Fluoranthene	nc	**3,200**	3,200
Fluorene	nc	**3,200**	3,200
Indeno(1,2,3-cd)pyrene	0.14	nc	nc[c]
Naphthalene	nc	**1,600**	1,600
Phenanthrene	nc	nc	nc
Pyrene	nc	**2,400**	2,400
cPAH TEQ	**0.14**	nc	0.14
PCBs			
Total PCBs	0.50	nc	0.50
TPH			
Total diesel-range hydrocarbons	nc	nc	2,000[b]
Gasoline-range hydrocarbons	nc	nc	100[b]
Dioxin and Furans			
Dioxin/furan TEQ	**0.000011**	nc	0.000011

[a] Hexavalent chromium criterion used because chromium speciation was not performed.

[b] Value from MTCA Method A for soil for unrestricted land use.

[c] Individual carcinogenic PAHs were evaluated only as part of the cPAH TEQ.

BBP – butyl benzyl phthalate
BEHP – bis(2-ethylhexyl) phthalate
cPAH – carcinogenic polycyclic aromatic hydrocarbon
EE/CA – engineering evaluation/cost analysis
MTCA – Model Toxics Control Act
nc – no criteria
PCB – polychlorinated biphenyl
SL – screening level
SVOC – semivolatile organic compound
TEQ – toxic equivalency quotient
TPH – total petroleum hydrocarbons
TSCA – Toxic Substances Control Act
VOC – volatile organic compound

Bold values were identified as SLs.

3.3.2.1 T-117 Upland Study Area

Similar to the approach used to evaluate the T-117 Sediment Study Area, the first step of the COPC and COC identification process was to compare the SLs presented in Table 3-4 with maximum concentrations in T-117 Upland Study Area soil samples. All available T-117 Upland Study Area soil data were evaluated in the screening process, except data associated with soil that has been removed as part of the 1999 and 2006 TCRAs. The screening process included a general statistical review of detected soil chemicals. Appendix E details and summarizes the T-117 Upland Study Area soil screening process.

For the second step, a 5% frequency of detection threshold was selected so that infrequently detected chemicals in the dataset were excluded from further analysis, thereby focusing further evaluation on the contaminants most likely to pose the majority of site risk. This process is consistent with EPA risk assessment guidelines for focusing risk assessments when large numbers of chemicals are present at a site (EPA 1989).

Table 3-5 summarizes the soil COPCs and COCs for the T-117 Upland Study Area, which include total PCBs, TPH, cPAH, dioxins/furans, and arsenic. Approximately 58% of the detected total PCB concentrations were greater than the SL, suggesting widespread PCB contamination in this area. The maximum detected total PCB concentration was over 8,000 times the SL. The average PCB concentration was greater than the SL by a factor of approximately 60.

Table 3-5. Soil COPCs and COCs in the T-117 Upland Study Area

COPC	Designated as a COC?	Rationale for COC Selection
Arsenic	yes	one or more recent SL exceedances in soil
Total PCBs	yes	one or more recent SL exceedances in soil
TPH (diesel range)	yes	one or more recent SL exceedances in soil
cPAH TEQ	yes	one or more recent SL exceedances in soil
Dioxin/furan TEQ	yes	one or more recent SL exceedances in soil

COC – contaminant of concern

COPC – contaminant of potential concern

cPAH – carcinogenic polycyclic aromatic hydrocarbons

PCB – polychlorinated biphenyl

SL – screening level

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

More than 50% of the detected concentrations of cPAHs, dioxins and furans, and arsenic exceeded the applicable SLs. Approximately 17% of detected TPH concentrations exceeded the applicable SL. These contaminants were thus retained as COCs because they were detected in more than 5% of the samples and exceeded applicable SLs.

3.3.2.2 Adjacent Streets and Residential Yards Study Area – Adjacent Streets

Soil investigations conducted in the Adjacent Streets since 2005 were described in Section 2.3.3. All available soil data, including both discrete samples (surface samples and borings) in streets and road shoulders and ~~multi-increment~~MIS samples collected along road shoulders in 2009, were included in the evaluation. Data were not included for catch basin solids[9] or for samples collected from areas removed during independent cleanup actions or from areas where more recent MIS was conducted.

Table 3-6 summarizes the soil COPCs and COCs ~~designations~~ for the Adjacent Streets, ~~.~~ ~~COPCs~~ which include total PCBs, TPH, cPAH, dioxins and furans, and arsenic.~~arsenic, total PCBs, TPH, cPAHs, and dioxins and furans.~~ Approximately 30% (51% for Adjacent Streets and 14% for Residential Yards) of the detected total PCB concentrations were greater than the SL, suggesting widespread PCB contamination in this area. The maximum detected total PCB concentration was over 960 times the SL. The average PCB concentration was greater than the SL by a factor of approximately 14. PCBs were thus retained as COCs because they were detected in more than 5% of the samples and exceeded applicable SLs.

Table 3-6. Soil COPCs and COCs for Adjacent Streets

COPC	Designated as a COC?	Rationale for COC Selection
Total PCBs	yes	upland source, SL exceedances
Dioxin/furan TEQ	yes, in locations where PCB concentrations exceeded the PCB RvAL[a]	potential upland source, SL exceedances
Arsenic	no	administrative decision by EPA based on lack of clear evidence that T-117 Upland Study Area was significant source of COPC to Adjacent Streets
TPH	no	administrative decision by EPA based on lack of clear evidence that T-117 Upland Study Area was significant source of COPC to Adjacent Streets
cPAH TEQ	no	administrative decision by EPA based on lack of clear evidence that T-117 Upland Study Area was significant source of COPC to Adjacent Streets

[a] Per EPA directive.

COC – contaminant of concern

COPC – contaminant of potential concern

SL – screening level

T-117 – Terminal 117

[9] Samples of catch basin solids were not considered to be soils for this streamlined risk assessment and were not screened. Catch basin data were presented in Section 2 and are discussed in Section 5 with respect to sediment recontamination potential.

cPAH – carcinogenic polycyclic aromatic hydrocarbons
EPA – US Environmental Protection Agency
PCB – polychlorinated biphenyl
TEQ – toxic equivalent
TPH – total petroleum hydrocarbons

Approximately 75% of dioxins and furans exceeded the applicable SLs (70% for Adjacent Streets and 79% for Residential Yards). Dioxins and furans were thus retained as COCs because they were detected in more than 5% of the samples and exceeded applicable SLs. However, they were only designated as COCs in areas where they were co-located with total PCB concentrations above the selected PCB RvAL, per administrative direction by EPA (2009a). This decision was based on an assumption that a minor portion of the dioxins and furans in the Adjacent Streets and Residential Yards Study Area may be associated with PCBs from asphalt manufacturing facility operations.

In Adjacent Streets, approximately 83% of cPAH, 14% of TPH, and 100% of arsenic detected values exceeded the applicable SLs. However these were not designated as COCs for the Adjacent Streets and Residential Yards Study Area, per administrative direction by EPA (2009a). EPA's decision was based on a lack of clear evidence that the T-117 Upland Study Area was a significant source of these contaminants to the Adjacent Streets. Although TPH and cPAH are expected to be associated with PCB-containing oil, they are also common urban contaminants (e.g., associated with asphalt paving). The limited arsenic concentration data available for the Adjacent Streets were within the range of background concentrations (Ecology 1994c) or were collected from areas identified for soil removal.

- ~~Based on the forensic work completed by the Dioxin Technical Workgroup and their 2008 and 2009 findings (Appendix M), EPA made the determination that the former asphalt manufacturing facility operations are likely not the source of the majority of the dioxins and furans detected in the Adjacent Streets and Yards Study Area, and that the source of the dioxins and furans is as yet undetermined. However, based on an assumption that a minor portion of the dioxins and furans in the Adjacent Streets and Residential Yards Study Area may be associated with PCBs from asphalt manufacturing facility operations, EPA directed dioxins and furans be designated as COCs where they are co-located with total PCBs above the action level in the Adjacent Streets and Residential Yards Study Area.~~
- ~~**TPH, cPAHs, and Arsenic** -TPH, cPAHs, and arsenic were not designated as COCs for the Adjacent Streets and Residential Yards Study Area, per administrative direction by EPA (2009a). EPA's decision was based on a lack of clear evidence the T-117 Upland Study Area was a significant source of these contaminants to the Adjacent Streets. While TPH and cPAH are expected to be associated with PCB-containing oil, they are also common urban contaminants (e.g., associated with asphalt paving). The limited arsenic concentration data~~

available for the Adjacent Streets were within the range of background concentrations (Ecology 1994c) or were collected in areas identified for soil removal.

3.3.2.3 Adjacent Streets and Residential Yards Study Area – Residential Yards

Following removal actions in 2004 and 2005, additional soil sampling was conducted in yards within the Adjacent Streets and Residential Yards Study Area in 2008 and 2009. Samples were analyzed for total PCBs and dioxins and furans (Ecology analyzed splits of a subset of the 2009 samples for dioxins and furans). Both total PCBs and dioxins and furans were selected as COPCs and COCs in this area (Table 3-7). The detailed screening results are provided in Appendix E.

Table 3-7. Soil COPCs and COCs for Residential Yards

COPC	Designated as a COC?	Rationale for COC Selection
Total PCBs	yes	upland source, SL exceedances
Dioxin/furan TEQ	yes	upland source, SL exceedances

COC – contaminant of concern

COPC – contaminant of potential concern

PCB – polychlorinated biphenyl

SL – screening level

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

As discussed in the previous section, EPA directed that dioxins and furans be designated as COCs where they are co-located with total PCB concentrations above the action level in the Adjacent Streets and Residential Yards Study Area (see Section 4.3.32.2).

3.3.3 Groundwater

As noted in the introduction to Section 3, groundwater was not explicitly addressed in the streamlined risk assessment. However, because protecting groundwater quality is an important goal of the NTCRA, technical analyses were conducted to address groundwater. Two of the analyses presented in Appendix B that pertain to groundwater potability and the identification of COCs for groundwater are summarized briefly below.

3.3.3.1 Groundwater potability

The potential for groundwater to be used as a drinking water source is important for the evaluation of site-specific potential groundwater exposure pathways. A full potability evaluation that details the regulatory basis for a non-potable designation for groundwater in the vicinity of the T-117 Upland Study Area is provided in

Appendix B. The area suggested for application of the non-potability designation is shown on Map 3-1. This area includes the T-117 Uplands Study Area and portions of the Adjacent Streets Study area near Basin Oil. Groundwater beneath other areas of the Adjacent Streets and Residential Yards Study Area was assumed to be potable. The non-potable designation for groundwater is reflected by the absence of the direct contact with groundwater exposure pathway in Section 3.2.2.

EPA's policy is to defer to a "State's determination of current and future groundwater uses" provided that the state's program is recognized in the Comprehensive State Ground Water Protection Program (CSGWPP) (EPA 2009d). The State of Washington's potability determination under MTCA is recognized by the CSGWPP; therefore, MTCA is the guiding regulation for this potability determination.

Based on MTCA, groundwater in the vicinity of the T-117 Upland Study Area is not potable as summarized below:

- EPA's policy is to defer to a "State's determination of current and future groundwater uses" provided that the state's program is recognized in the ~~Comprehensive State Ground Water Protection Program (~~CSGWPP~~)~~ (EPA 2009d). The State of Washington's potability determination under MTCA is recognized by the CSGWPP; therefore, MTCA is the guiding regulation for this potability determination.
- Based on MTCA, groundwater in the vicinity of the T-117 Upland Study Area is not potable as summarized below:
- Groundwater in the vicinity of the T-117 Upland Study Area does not flow into a source of drinking water. Groundwater flows directly into the adjacent portion of the LDW, which has been deemed by the State of Washington as being unsuitable for domestic use.
- Groundwater in the vicinity of the T-117 Upland Study Area could not become a source of drinking water and does not flow into a water body that could become a source of drinking water. Groundwater exceeds the state standard for specific conductance because of its location along the LDW and the upwelling of saline deep groundwater along a localized bedrock outcropping. As stated above, the LDW, as determined by the State of Washington, is not suitable for domestic use.
- In addition to the MTCA non-potability determination, local codes prohibit the construction of drinking water wells in the vicinity of the T-117 EAA:
- Based on the King County Board of Health (KCBOH) regulations and King County Code sections cited below, a drinking water well would be prohibited at the site.

- KCBOH Code § 12.32.010.D requires that lots created by subdivision, short subdivision, re-zone, or lot line adjustment that were created after 1972 and that are less than 5 acres must be connected to a public water supply.
- KCBOH Code § 12.32.010.A requires that property owners undertaking "new development" must connect to available public water supply. "Development" is defined broadly to include "land utilization" and according to County staff would itself include any proposal to install a groundwater extraction well, which effectively prohibits installation of such a well.
- King County Code § 13.24.140 (King County Water and Sewer Comprehensive Plan contained in Title 13 of the code) applies to properties outside the City and requires all new development within the Urban Growth Area to be served by the appropriate existing Group A water supplier, unless service cannot be timely and reasonably provided. Therefore, because all of the properties in the vicinity of the T-117 EAA are served by a public water supply, any new development at or near the T-117 EAA must also be connected to this supply.
- KCBOH Code § 12.24.010A states that the drinking water supply must come from the "highest quality source feasible." The highest quality source available at the T-117 EAA is the SPU water supply from the Cedar River Watershed.
- KCBOH Code § 12.24.010(C) specifies the minimum setbacks for drinking water wells, which are 100 ft from surface water, roads, utilities, and buildings. The T-‑117 Upland Study Area is a narrow piece of land (approximately 200 feet wide) situated between Dallas Avenue S and the LDW.

These KCBOH code sections reaffirm state regulations found at WAC 246-290-130(1) and WAC 246-290-135(2)(b).

3.3.3.2 Groundwater COCs

Similar to the process discussed above for sediment and soil COCs, SLs were developed for groundwater. With the exception of TPH, SLs were based on ambient water quality criteria to protect surface water beneficial uses. The TPH SL was based on MTCA Method A. These SLs are re-evaluated in Section 4 as part of the RvAL development to ensure the concentrations are also sufficiently low to prevent sediment recontamination.

There are no drinking water wells in the T-117 EAA, and as indicated in the previous section, future construction of drinking water wells is prohibited within the T-117 ~~EAA~~ Upland and Adjacent Streets and Residential Yards Study Areas. In addition, as discussed in Section 2.3.4.2 and Appendix B.4, the presence of groundwater contamination beneath the Adjacent Streets Study Area due to former T-117 operations is unlikely. As a result, groundwater COCs and RvALs have not been developed for the Adjacent Streets and Residential Yards Study Area.

Table 3-8B-1, of Appendix B, includes a summary of the selected groundwater SLs. Screening was conducted using groundwater chemistry results from monitoring wells sampled since 2003. The groundwater COPCs included arsenic, copper, silver, total PCBs, TPH, cPAH TEQ, and BEHP (Table 3-89). All but copper COPCs were designated as COCs. Under WAC 173-340-730(5)(c), copper was not retained as groundwater COC because concentrations in the vicinity of the T-117 Upland Study Area are not significantly different than the site specific background populations. Copper concentrations in upgradient wells (wells MW-01, and MW-09 through MW--13) were compared to concentrations in T-117 Upland Study Area wells (wells MW-02 through MW-08R). Copper concentrations between these two data-sets are not significantly different, and therefore, concentrations at the T-117 Upland Study Area wells are considered to be background values (Appendix B).

Table 3-8. Groundwater screening levels

~~All~~ Detected Chemicals	Concentration (µg/L)											
	Aquatic Life Criteria[a]								Human Health Criteria for Consumption of Organisms[f]	Surface Water Criteria MTCA Method B		SL Used for EE/CA
	Washington State WQC				National AWQC							
	Freshwater		Marine		Freshwater		Marine					
	Chronic[b]	Acute[c]	Chronic[b]	Acute[c]	CCC[d]	CMC[e]	CCC[d]	CMC[e]		Carcinogen	Non-Carcinogen	
Metals and Trace Elements		-	-	-	-	-	-	-	-	-	-	-
Arsenic	190	360	36	69	150	340	36	69	0.14[g, h]	0.098	18	0.14
Cadmium	**1.0**	**3.7**	9.3	42	**0.25**	2.0	8.8	40	nc	nc	20	0.25
Chromium (hexavalent)	10	15	50	1,100	11	16	50	1,100	nc	nc	486	10
Chromium (trivalent)	**180**	**550**	nc	nc	**74**	**570**	nc	nc	nc	nc	243,056	10[k]
Copper	**11**	**17**	3.1	4.8	**9**	**13**	3.1	4.8	nc	nc	2,665	3.1
Nickel	**160**	**1,400**	8.2	74	**52**	**470**	8.2	74	4,600	nc	1,103	8.2
Silver	nc	**3.4**	nc	1.9	nc	**3.2**	nc	1.9	nc	nc	25,926	1.9
Zinc	100	**110**	81	90	120	**120**	81	90	26,000	nc	16,548	81
TPH												
~~Total~~ TPH	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	500[j]
PCBs												
Total PCBs	0.014	2	0.03	10	0.014	nc	0.03	nc	0.000064[g]	0.00011	nc	0.000064
PAHs												
1-Methylnaphthalene	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
Acenaphthene	nc	nc	nc	nc	nc	nc	nc	nc	990	nc	643	990[i]
Anthracene	nc	nc	nc	nc	nc	nc	nc	nc	40,000	nc	25,926	40,000[i]
Benzo(a)anthracene	nc	nc	nc	nc	nc	nc	nc	nc	0.018[g]	0.030	nc	0.018
Benzo(a)pyrene	nc	nc	nc	nc	nc	nc	nc	nc	0.018[g]	0.030	nc	0.018

~~All~~ Detected Chemicals	Concentration (μg/L)											
	Aquatic Life Criteria[a]								Human Health Criteria for Consumption of Organisms[f]	Surface Water Criteria		SL Used for EE/CA
	Washington State WQC				National AWQC					MTCA Method B		
	Freshwater		Marine		Freshwater		Marine					
	Chronic[b]	Acute[c]	Chronic[b]	Acute[c]	CCC[d]	CMC[e]	CCC[d]	CMC[e]		Carcinogen	Non-Carcinogen	
Benzo(b)fluoranthene	nc	nc	nc	nc	nc	nc	nc	nc	0.018[g]	0.030	nc	0.018
Benzo(k)fluoranthene	nc	nc	nc	nc	nc	nc	nc	nc	0.018[g]	0.030	nc	0.018
Chrysene	nc	nc	nc	nc	nc	nc	nc	nc	0.018[g]	0.030	nc	0.018
Dibenzo(a,h)anthracene	nc	nc	nc	nc	nc	nc	nc	nc	0.018[g]	0.030	nc	0.018
Fluoranthene	nc	nc	nc	nc	nc	nc	nc	nc	140	nc	90	140[i]
Fluorene	nc	nc	nc	nc	nc	nc	nc	nc	5,300	nc	3,457	5,300[i]
Indeno(1,2,3-cd)pyrene	nc	nc	nc	nc	nc	nc	nc	nc	0.018[g]	0.030	nc	0.018
Naphthalene	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	4,938	4,938
Phenanthrene	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
Pyrene	nc	nc	nc	nc	nc	nc	nc	nc	4,000	nc	2,593	4,000[i]
cPAH TEQ	nc	nc	nc	nc	nc	nc	nc	nc	0.018[g]	0.030	nc	0.018
BTEX												
Xylene	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
Phthalates												
BEHP	nc	nc	nc	nc	nc	nc	nc	nc	2.2[g]	3.6	399	2.2
SVOCs												
Phenol	nc	nc	nc	nc	nc	nc	nc	nc	1,700,000	nc	1,111,111	1,700,000[i]
VOCs												
1,1,1-Trichloroethane	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	416,667	416,667
Acetone	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
Chlorobenzene	nc	nc	nc	nc	nc	nc	nc	nc	1,600	nc	5,034	1,600

All Detected Chemicals	Concentration (µg/L)											
	Aquatic Life Criteria[a]								Human Health Criteria for Consumption of Organisms[f]	Surface Water Criteria MTCA Method B		SL Used for EE/CA
	Washington State WQC				National AWQC							
	Freshwater		Marine		Freshwater		Marine					
	Chronic[b]	Acute[c]	Chronic[b]	Acute[c]	CCC[d]	CMC[e]	CCC[d]	CMC[e]		Carcinogen	Non-Carcinogen	
cis-1,2-Dichloroethene	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
Tetrachloroethene	nc	nc	nc	nc	nc	nc	nc	nc	3.3[g]	0.39	836	3.3[l]
Trichloroethene	nc	nc	nc	nc	nc	nc	nc	nc	30[g]	6.7	71	30[l]
Dioxin/Furans												
2,3,7,8-TCDD TEQ	nc	nc	nc	nc	nc	nc	nc	nc	5.0×10^{-9} [g]	nc	nc	5.0×10^{-9} [g]

a Aquatic life criteria are based on dissolved concentrations for metals (except mercury) and total concentrations for mercury and organic compounds.

b Chronic criteria are 4-day average concentrations not to be exceeded more than once every 3 years on the average, with the exception of pesticide and PCB concentrations, which are 24-hr average concentrations not to be exceeded at any time.

c Acute criteria are 1-hr average concentrations not to be exceeded more than once every 3 years on average, with the exception of silver and pesticide concentrations, which are instantaneous concentrations not to be exceeded at any time, or the PCB concentration, which is a 24-hr average concentration not to be exceeded at any time.

d The CCC is defined as an estimate of the highest concentration of a chemical in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.

e The CMC is defined as an estimate of the highest concentration of a chemical in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect.

f Washington State and national water quality criteria for the protection of human health are the same. Human health criteria are based on dissolved concentrations for all chemicals for marine water for ingestion of only organisms only (not water).

g Criteria are based on 10^{-6} excess cancer risk for carcinogenic chemicals.

h WQC represents the inorganic fraction of arsenic.

i The criteria for pentachlorophenol are pH-dependent; a pH of 7 was assumed.

j Criteria for MTCA Method A for groundwater.

k Hexavalent chromium criterion was used because chromium speciation was not performed.

l SL was selected based on MTCA Method B CUL site-specific calculated value is higher than MTCA Method B default value.

AWQC – ambient water quality criteria
BEHP – bis(2-ethylhexyl) phthalate
EE/CA – engineering evaluation/cost analysis
MTCA – Model Toxics Control Act
SVOC – semivolatile organic compound
TEQ – toxic equivalent

BTEX – benzene, toluene, ethylbenzene, and xylene
CCC – criteria continuous concentration
CMC – criteria maximum concentration
cPAH – carcinogenic polycyclic aromatic hydrocarbon
CUL – cleanup level
nc – no criteria
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SL – screening level
TCDD – tetrachlorodibenzo-*p*-dioxin
TPH – total petroleum hydrocarbons
VOC – volatile organic compound
WQC – water quality criteria

Bold identifies values calculated using a hardness value of 100 mg/L. In most cases, the Washington State WQC and national AWQC are the same. In cases where they are different, the lower of the two values is used.

Gray-shaded values were identified as SLs.

The site-specific background groundwater dissolved copper concentration was 5 µg/L based on the 90th percentile. This concentration is lower than, but consistent~~,~~ with, the background groundwater dissolved copper concentration (8 µg/L, as established by EPA) calculated for the Boeing Plant 2 site (Environmental Partners 2006).

Greater than 50% of the detected sample concentrations exceed the SLs for silver, total PCBs, TPH, and cPAH TEQ. Approximately 43% of the detected concentrations exceed the BEHP screening values. Approximately 19% of the detected sample concentrations exceed the SLs for arsenic. However, 43% of the concentrations reported below the laboratory reporting limits for arsenic also exceed the SL. All of these compounds have a detected frequency greater than 5%.

Table 3-9~~8~~. Groundwater COPCs and COCs

COPC	Designated as a COC?	Rationale for COC Selection
Arsenic	yes	one or more recent SL exceedance in groundwater
Copper	no	concentrations less than or equal to upgradient background concentration
Silver	yes	one or more recent SL exceedance in groundwater
Total PCBs	yes	one or more recent SL exceedance in groundwater
TPH	yes	one or more recent SL exceedance in groundwater
cPAH TEQ	yes	one or more recent SL exceedance in groundwater
BEHP	yes	one or more recent SL exceedance in groundwater

BEHP – bis(2-ethylhexyl) phthalate
COC – contaminant of concern
COPC – contaminant of potential concern
cPAH – carcinogenic polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SL – screening level
TPH – total petroleum hydrocarbons

3.3.4 RAA contaminants

According to the SOW (EPA 2007c), in addition to COCs selected for each of the T-117 EAA Study Areas discussed in Section 3.3.2 and summarized in Section 3.3.3, contaminants found on the Basin Oil property or Marina that pose a potential for post-~~-~~NTCRA sediment recontamination must be identified. This section presents the results of this identification analysis.

Basin Oil groundwater and soil data (Ecology 2009b) were screened using the SLs developed for the T-117 EAA in Appendix B and Section 3.3.2, respectively. Concentrations of arsenic, total PCBs, BEHP, copper, TPH, nickel, cPAHs, ethylbenzene, xylenes, and carbazole were greater than SLs in soil and groundwater upgradient of the T-117 Upland Study Area. Except for nickel, xylenes, carbazole, and ethylbenzene, these contaminants were already included as COCs for the T-117 EAA. Specific results were as follows:

- Monitoring wells downgradient of the Basin Oil property, and upgradient of the T-117 Upland Study Area, had SL exceedances for arsenic (MW-01 and MW-11), copper (MW-01 and MW-10), total PCBs (MW-01), BEHP (MW-01, MW-9, MW-10, and MW-11), and TPH (MW-10).
- Monitoring wells upgradient of Basin Oil property had arsenic concentrations greater than the SL (MW-12, MW-13).
- Concentrations of arsenic, TPH (lube oil and gas), cPAHs, total PCBs, ethylbenzene, and xylenes in surface soils were greater than SLs. Arsenic, cPAH, and carbazole concentrations in surface soil samples from upgradient monitoring wells were greater than their SLs.
- The total PCB concentration in one 12.5-ft-deep soil sample (BSB-3) was greater than the SL.

With respect to the Marina, as discussed in Section 2.4.2, metals, total PCBs (quantified as Aroclor 1254), pesticides, PAHs, TPH, and VOCs were detected above SLs in soil samples. Of the contaminants with concentrations greater than SLs in soil, only total PCBs (quantified as Aroclor 1260) had concentrations greater than the SQS in Marina sediment.

The chemicals identified in these RAAs at concentrations above SLs will be incorporated into the analysis presented in Section 5.2 of the recontamination potential from these two areas (Basin Oil property and the Marina).

3.3.5 Summary of streamlined risk assessment

This section provides an overview of the pathways, receptors, and COCs for each of the T-117 EAA Study Areas discussed in this section. A summary of the exposure pathways and receptors identified in the streamlined risk assessment is presented in Table 3-~~9~~10. A summary of the COCs identified in each T-117 study area is presented in Table 3-~~10~~11. Total PCBs and dioxins and furans were identified as COCs in all study areas. RvALs for COCs identified for sediment and soil are presented in Section 4.

Table 3-~~9~~10. Summary of exposure pathways and receptors identified in the streamlined risk assessment

Exposure Pathway~~s~~	Receptor~~s~~	Sediment	Soil			Groundwater
		T-117 Sediment Study Area	T-117 Upland Study Area	Adjacent Streets	Residential Yards	T-117 Upland Study Area
~~Aquatic~~ Organisms						
Ingestion, dermal contact	benthic invertebrates	X				X
	mammals	X				
	fish	X				X
	birds	X				
Inhalation	mammals	-				
	birds	-				
People						
Ingestion, dermal contact	kayakers	X				X
	fishermen	X				X
	clammers	X				X
	beachgoers	X				X
	residents			X	X	
	workers	X	X	X	X	X
Inhalation	kayakers					
	fishermen					
	clammers					
	beachgoers					
	residents		X	X	X	
	workers		X	X	X	
People and Animals						
Seafood c~~C~~onsumption	fish	X				
	birds	X				
	mammals	X				
	people	X				

T-117 – Terminal 117

Table 3-~~10~~11. Summary of COCs identified in the streamlined risk assessment

COCs	Sediment	Soil			Groundwater
	T-117 Sediment Study Area	T-117 Upland Study Area	Adjacent Streets	Residential Yards	T-117 Upland Study Area
Metals					
Arsenic	X	X			X
~~Copper~~					~~X~~
Silver					X
PAHs					
2-Methylnaphthalene	X				
Acenaphthene	X				
Anthracene	X				
Benzo(a)anthracene	X				
Benzo(a)pyrene	X				
Benzo(g,h,i)perylene	X				
Total benzofluoranthenes	X				
cPAH TEQ	X	X			X
Chrysene	X				
Dibenzo(a,h)anthracene	X				
Dibenzofuran	X				
Fluoranthene	X				
Fluorene	X				
Indeno(1,2,3-cd)pyrene	X				
Phenanthrene	X				
Total HPAH (calc'd)	X				
Total LPAH (calc'd)	X				
TPH					
Diesel- and lube oil-range hydrocarbons		X			X
Other SVOCs					
BEHP					X
Phenol	X				
PCBs					
Total PCBs	X	X	X	X	X
Dioxins and Furans					
Dioxin/furan TEQ	X	X	X	X	

BEHP – bis(2-ethylhexyl) phthalate
COC – contaminant of concern
cPAH – carcinogenic polycyclic aromatic hydrocarbon
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
OC – organic carbon
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SVOC – semivolatile organic compound
T-117 – Terminal 117
TEQ – toxic equivalent
TPH – total petroleum hydrocarbons

4 Identification of Removal Action Scope, Goals, and Objectives

This section presents the NTCRA scope, goals, and objectives for the T-117 EAA in accordance with EPA's *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (EPA 1993) and discusses the development of RvALs for the T-117 EAA. This section includes:

- A description of specific scope, goals, and objectives for the T-117 EAA
- Regulatory requirements and guidance, including applicable or relevant and appropriate requirements (ARARs)
- Definition Development of of RvALs, which are defined as site--specific removal action levels
- Presentation of the numerical RvALs for each medium, including sediment, soil, and groundwater, which wereRvALs selected to meet these goals, objectives, and ARARs
- Final removal boundaries for each study area, based on the RvALs for each mediumBoundaries for the removal actions in the study areas

4.1 NTCRA Scope, Goals, and Objectives

The scope of this NTCRA includes the removal (or removal and capping) of sediment and the removal of soil to meet RvALs at the appropriate points of compliance. This NTCRA is designed to address sediment COCs within the T-117 Sediment Study Area and soil COCs in the T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area.

The goal of the NTCRA for the T-117 EAA is to reduce the current and future exposure of ecological and human receptors to COCs. Reasonably anticipated future land uses include various non-industrial uses such as river and/or shoreline aquatic habitat and upland habitat, public access and recreation, residential and commercial uses, as well as industrial uses. Consistent with MTCA, unrestricted land use will be evaluated. These potential future site uses were considered in the selection of RvALs.

In summary, the removal action objectives (RAOs) for the T-117 EAA includeare:

Sediment

- **Human Health – seafood consumption**. Reduce human health risks associated with the consumption of resident LDW fish and shellfish by to reducing sediment concentrations of COCs to protective levels.
- **Human Health – direct contact**. Reduce human health risks associated with exposure to COCs through direct contact with sediments and incidental

sediment ingestion by reducing sediment concentrations of COCs to protective levels.

- **Ecological Health – benthic**. Reduce toxicity to benthic invertebrates by reducing sediment concentrations of COCs to comply with SMS.
- **Ecological Health – seafood consumption**. Reduce risks to crabs, fish, birds and mammals from exposure to COCs by reducing concentrations of COCs in sediment to protective levels.

Soil

- **Sediment Protection.** Reduce PCB concentrations in upland soils to ensure protection of sediments.

~~Sediment removal and/or capping to be protective of:~~

~~Biological resources~~

~~Human health~~

~~Direct contact – tribal clamming, netfishing, beach play~~

~~Indirect contact – fish consumption~~

~~Soil removal to be protective of:~~

~~Human health – direct contact, incidental ingestion~~

~~Ecological health~~

~~Sediment quality~~

~~Groundwater quality~~

Because of the residential land use within the T-117 EA~~E~~A, EPA has established that the RAOs for the T-117 EAA must consider RvALs associated with MTCA-defined unrestricted land use in the upland portions of the site (Appendix A).

Groundwater at the T-117 EAA has been evaluated and groundwater action levels have been developed to ensure that groundwater quality at the point of discharge to LDW surface water and sediment will not result in the recontamination of sediment (Section 5.2) or in the contamination of water at levels that could pose risks through seafood ingestion (Appendix B).

Specific removal actions for soil and sediment must meet the RAOs if they are to be considered and selected for implementation. The development and selection of specific removal actions must also consider reasonably anticipated future land uses. Selected RvALs must be sufficient to allow for the entire range of these potential uses. In addition, any future development projects must comply with land-use regulations (development, environmental, zoning) and the associated permitting procedures and requirements.

Selected RvALs for the T-117 Upland Study Area are also expected to be sufficiently protective to allow for possible future habitat ~~development~~, as well as other final site uses including commercial site uses (e.g., restroom facilities). The Port is examining habitat restoration opportunities within all or a portion of the T-117 Sediment Study Area and the T-117 Upland Study Area. As part of this potential site use, locations within the T-117 Upland Study Area may be converted to aquatic habitat; portions of the upland soil may become located within or beneath a portion of the intertidal sediment. In addition, any sediment removal action that includes excavation or dredging will expose new sediments within the aquatic area. To ~~address~~ ensure the protectiveness of sediment, ~~these potential future configurations,~~ the specific cleanup objective of any T-117 removal action that creates ~~generates~~ new sediment surfaces will be to achieve contaminant concentrations at or below the sediment RvALs to the prescribed depth of compliance. Furthermore, an additional cover or cap (e.g., clean, imported backfill material) may be placed over sediment areas at certain locations to meet the RvALs to the prescribed depth and/or to ensure the permanence of the removal action. If the removal action can seamlessly transition to habitat restoration, upland areas that would be converted into intertidal areas would be completed in accordance with the sediment NTCRA (i.e., meet the sediment RAOs).

Section 7 of this EE/CA describes removal action alternatives that are compatible with habitat restoration. It is expected that the existing aquatic sediment portion of the site will remain aquatic and will be subject to the RvALs defined for the Sediment Study Area. The future land use for the Adjacent Streets and Residential Yards Study Area is expected to retain a combination of residential and commercial uses. Current City zone designations for this study area include Commercial 1 (C1) and Neighborhood Commercial 3 (NC3) (City of Seattle 2007a). The City's Comprehensive Plan future land use map shows the Adjacent Streets and Residential Yards Study Area as commercial/mixed use and industrial (City of Seattle 2007b). Street improvements conducted in conjunction with this NTCRA will be consistent with current codes for street paving width and curb, gutter, and sidewalk installation.

4.2 REGULATORY REQUIREMENTS AND GUIDANCE

Potential ARARs and guidance for removal activities within the LDW Superfund Site were identified in the LDW Phase 1 RI (Windward 2003a).[10] Most of these regulations are relevant to the scope, goals, objectives, and development of RvALs for the NTCRA described in this EE/CA, as well as the detailed evaluation of removal action alternatives (Section 8.2.3 ~~and Table 8-1~~) and eventual NTCRA implementation. A listing and description these requirements and guidance, including CERCLA, TSCA, MTCA, SMS, and other requirements to be considered for the T-117 NTCRA, are provided in Appendix G.

[10] This information is being updated as part of the LDW FS.

Of particular importance to the cleanup and disposal of PCB contaminated waste at the T-117 EAA are the substantive requirements under TSCA (40 CFR 761.61) as an ARAR ~~requirements under 40CFR761.61.~~ Because of the complexity of the site, the removal of PCB contaminated soil and sediment is best suited for a risk-based disposal (40CFR761.61(c)), which is attained through application by providing the information outlined in 40CFR761.61(a)(3). The application information~~process~~ is intended to demonstrate that the removal action will not pose an unreasonable risk to human health or the environment. In order to meet this substantive requirement, t~~T~~his application will be prepared during the NTCRA design phase. Appendix H describes in further detail the information ~~required~~ to be provided for the risk-based disposal application.

4.3 Removal Action Levels

This section discusses the derivation of RvALs for the soil and sediment COCs identified in Section 3 and also considers practical quantitation limits (PQLs), background concentrations, and the total cancer risk per WAC 173-340-740(5)(a).

The development of sediment RvALs is discussed in Section 4.3.1, Section 4.3.2 discusses the development of the soil RvALs, Section 4.3.3 discusses the development of groundwater RvALs, and Section 4.3.4 provides a summary of the selected RvALs for the T-117 EAA. The RvALs are used in Section 4.4 to develop the sediment and soil removal boundaries. A detailed discussion of the development of groundwater RvALs is presented in Appendix B.

MTCA CULs are used as one basis for deriving RvALs, as MTCA is an ARAR for this site. Under MTCA, CULs for individual carcinogenic COCs for which other ARARs do not apply are typically calculated based on a risk level of 1×10^{-6}. The total cancer risk allowed for multiple chemicals under MTCA is 1×10^{-5} (WAC 173-340-740(5)(a)). EPA's range is 10^{-4} to 10^{-6}. Both MTCA and CERCLA equations and assumptions were used to calculate the total risks associated with the selected RvALs for soil.

As noted above, the T-117 Sediment Study Area is located within the LDW and sediment remedial action levels have not been finalized under the LDW-wide CERCLA and MTCA remedial program. Consequently, T-117 sediment action levels cannot be set as final until the LDW ROD is completed. EPA has therefore specified that the T-117 NTCRA use ~~a~~ site-specific RvALs. Sediment RvALs for the T-117 Sediment Study Area are based on SMS (except for arsenic, cPAHs, and dioxins and furans which are discussed in more detail in Section 4.3.1 below).

Similarly, EPA has also specified that the T-117 NTCRA use RvALs for soil in the Upland Study Area and the Adjacent Streets and Yards Study Area that have been developed based on the methodology set forth under MTCA for calculating soil CULs and defining appropriate points of compliance. Soil RvALs are thus protective of human health for exposure pathways present in the soil within the Adjacent Streets and Residential Yards Study Areas. Soil RvALs must also be protective of sediment and aquatic life where excavation occurs and these soils are converted from uplands to intertidal sediment

4.3.1 Development of sediment removal action levels

This section describes the development of sediment RvALs for the T-117 Sediment Study Area. As presented in Table 3-~~9~~10, the COCs for the T-117 Sediment Study Area are PAHs, total PCBs, phenol, dioxins and furans, and arsenic. RvALs for phenol (0.42 mg/kg) and individual PAHs were set equal to the SQS, consistent with the corresponding lowest SLs used for these contaminants (Table 3-2).

The SL for cPAHs was based on an EPA preliminary remediation goal (PRG) soil value protective of residential land use (0.015 mg/kg). cPAHs were also identified as a risk driver in the LDW HHRA (Windward 2007b) for seafood consumption and the direct sediment contact exposure pathways (i.e., beach play, netfishing, and clamming). Risk-based threshold concentrations (RBTCs) calculated from the LDW HHRA results were considered as RvALs for cPAHs because they are more relevant to exposure to sediment. The three RBTCs for cPAHs that were calculated in the LDW RI (Windward 2008), based on an assumed excess cancer risk of 1×10^{-6}, were 0.09 mg/kg (for beach play), 0.15 mg/kg (for clamming), and 0.38 mg/kg (for netfishing). The lowest of these RBTCs (0.09 mg/kg) was selected as the RvAL for cPAHs in sediment at the T-117 EAA. An RBTC was not calculated for cPAHs for seafood consumption because most of the risk was associated with the consumption of clams from throughout the LDW, and the relationship between cPAHs in tissue and sediment was highly uncertain (Windward 2008).

For total PCBs, RBTCs were calculated in the LDW RI (Windward 2008) for seafood consumption and the three direct sediment contact exposure scenarios. The RBTCs for the direct-contact scenarios were higher than the SL of 12 mg/kg OC (i.e., the SQS value); the RBTC for seafood consumption was lower than background concentrations (Windward 2008). Ultimately, total PCB sediment action levels for the LDW RI/FS may be influenced by background concentrations and other regulatory considerations. At the present time, EPA and Ecology have not made a final determination of action levels for the LDW project. Therefore, for the purposes of the T-117 EAA, the SQS (12 mg/kg OC-) was selected as the sediment RvAL for total PCBs. Because this RvAL is lower than all of the LDW RBTCs for the direct--contact scenarios, it is considered to be protective of human health under those scenarios. The RvAL is higher than the RBTC for seafood consumption, so it is not fully protective of human health for the seafood consumption pathway. Similarly, because the seafood consumption RBTC is below multiple potential background PCB concentrations and action levels will not be below background concentrations (WAC 173-340-700), the ultimate action level for the LDW project will be also be above the RBTC for seafood consumption. The removal of PCB-contaminated sediment~~,~~ with concentrations above the SQS from within the

T-117 Sediment Study Area will reduce the site-wide PCB concentration and the risks associated with seafood consumption in the LDW.

The SL for dioxins and furans was based on an EPA PRG for residential land use (4.5 ng/kg dioxin/furan TEQ). RBTCs were calculated in the LDW RI for the three direct sediment contact exposure scenarios. Although it was recognized that seafood consumption may also be an important exposure pathway for dioxins and furans, RBTCs were not derived for dioxins and furans because tissue data were not available at the time of the risk assessments (Windward 2008). The RBTCs for the three direct sediment contact exposure scenarios ranged from 13 to 37 ng/kg for a target risk of 1×10^{-6}; these RBTCs were higher than the SL. Because the sediment RBTCs were based on sediment exposure scenarios, they are more relevant to the establishment of a sediment RvAL than the SL, which was derived for the direct contact residential soil exposure. Accordingly, the lowest of the three RBTCs (13 ng/kg, based on a tribal clamming scenario) was selected as the sediment RvAL for dioxins and furans. Ultimately, background concentrations of dioxins and furans may influence the derivation of an action level for the LDW RI/FS. Action levels determined for the LDW will be tracked to ensure the NTCRA is consistent with those of the LDW.

The SL for arsenic was also based on an EPA PRG soil value for residential land use (0.39 mg/kg). Because arsenic was also a risk driver in the LDW HHRA, RBTCs were calculated in the LDW RI (Windward 2008) for the three direct sediment contact exposure scenarios discussed above.[11] The RBTCs ranged from 1.3 to 3.7 mg/kg for a target risk of 1×10^{-6}; these RBTCs were higher than the SL but were all lower than preliminary sediment background concentrations for arsenic that were reported in the LDW RI (Windward 2008). The action level for the LDW ~~RI/FS have~~ has yet to be determined~~, and~~ but ~~it~~ will be influenced by background concentrations. The arsenic RvAL to be used for the T-117 Sediment Study Area will also be influenced by background sediment concentrations when such a determination is~~can be~~ made ~~in~~for the LDW ~~RI/FS~~. Therefore, an RvAL for arsenic of 12 mg/kg is assumed for the purposes of this EE/CA, which is similar to the background concentrations being considered for arsenic. This assumption will be reviewed during the design of the T-117 NTCRA.

Risk estimates were made for the proposed sediment RvALs for the purposes of evaluating compliance with the MTCA requirements that cancer risks from individual contaminants not exceed 1×10^{-6} and that cumulative cancer ~~total~~ risks for all contaminants not exceed ~~a excess cancer risk of~~ 1×10^{-5} (Table 4-1). The cancer risk associated with the risk-based RvAL for each of the four carcinogenic COCs was at or

[11] An RBTC was not calculated for arsenic for seafood consumption because most of the risk was associated with the consumption of clams from throughout the LDW, and the relationship between arsenic in tissue and sediment was highly uncertain (Windward 2008).

below the threshold of 1 × 10-6. A background-based RvAL was also developed for arsenic. The excess cancer risk for the background-based RvAL for arsenic was 4 × 10-6. ~~T~~The ~~total~~ cumulative risk from the carcinogenic COCs, regardless of whether the risk-based or background-based RvAL for arsenic was used, was well below the ~~for the four carcinogenic COCs was 2~~1 × 10-~~6~~5, ~~below the~~ MTCA threshold. The sum of the HQs for the seven COCs with non-carcinogenic endpoints was 0.04, well below the MTCA threshold of 1. This evaluation indicates that the sediment RvALs are sufficiently protective.

Table 4-1. T-117 Sediment Study Area total risks for sediment removal action levels under the recreational scenario~~sediment removal action levels~~

COC	RvAL (~~dw~~dry ~~weight~~ equivalent, mg/kg)	Source of RvAL	Excess Cancer Risk	Hazard Quotient
~~Sediment – Recreational Scenario~~[a]				
Arsenic (risk-based)	2.8~~12~~[b, ~~c~~]	LDW RI	~~1~~5 × 10-~~6~~7	na
Arsenic (background-based)	12[~~b~~a]	LDW RI	4 × 10-6	na
2-Methylnaphthalene	0.59	SQS[b] ~~d~~	na	0.0005
Acenaphthene	0.25	SQS[~~d~~b]	na	0.00007
Anthracene	3.4	SQS[~~d~~b]	na	0.00005
cPAH TEQ[~~e~~c]	0.09	LDW RI	1 × 10-6	na
Dibenzofuran	0.23	SQS[~~d~~b]	na	na
Fluoranthene	2.5	SQS[~~d~~b]	na	0.0003
Fluorene	0.36	SQS[~~d~~b]	na	0.00004
Phenanthrene	1.6	SQS[~~d~~b]	na	na
Phenol	0.42	SQS	na	0.000004
Total PCBs	0.19[~~d~~d] ~~or~~ (12 mg/kg -OC)	SQS[b~~d~~]	2 × 10-7	0.04
Dioxin/furan TEQ	~~1.3 × 10-5~~0.000013[~~f~~e]	LDW RI	5 × 10-7	na
Total (risk-based)			**3 × 10-6**	**0.04**
Total (background-based)			**~~6~~2 × 10-6**	**0.04**

Note: ~~a~~ Recreational scenario equivalent to beach play scenario used in the LDW HHRA (Windward 2007b).

~~b~~a The RBTCs for arsenic are less than preliminary background concentrations (Windward 2008). For the purposes of this evaluation, a value of (12 mg/kg) was used for the RvAL, which is similar to the background concentrations being considered in the LDW RI/FS for arsenic.

b For the purposes of risk estimation, the SQS value originally given in units of mg/kg OC was converted to a dry weight concentration using the average TOC concentration in the T-117 Sediment Study Area (1.55%).

~~e~~c Other PAHs identified as sediment COCs are not explicitly evaluated for human health risk, including the individual components of the cPAH TEQ sum [benzo(a)pyrene, benzo(b)fluoranthene, benzo(a)anthracene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and chrysene]; benzo(g,h,i)perylene, for which human health toxicity benchmarks have not been established; and total LPAHs and HPAHs, which are not typically evaluated for human health risk.

[d] If the SQS of 12 mg/kg OC is not used because the TOC in a sediment sample is either higher or lower than 0.5 to 3.5%, then a site-specific calculation, or "surrogate," can be applied, which results in a value of 0.19 mg/kg dw.

[ee] This RvAL is derived from an RBTC (equivalent to 1 × 10-6) for tribal clamming. The excess cancer risk estimate given is for the beach play scenario, which has an RBTC approximately 2 times the RBTC for the tribal clamming scenario.

[d] For the purposes of risk estimation, the SQS value originally given in units of mg/kg OC was converted to a dry weight concentration using the average TOC concentration in the T-117 Sediment Study Area (1.55%). If the SQS of 12 mg/kg OC is not used because the in a sediment sample is either higher or lower than 0.5 to 3.5%, then a site specific calculation, or "surrogate" can be applied which results in a value of 0.19 mg/kg dw.

COC – contaminant of concern
cPAH – carcinogenic polycyclic aromatic hydrocarbon
dw – dry weight
FS – feasibility study
HHRA – human health risk assessment
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LDW – Lower Duwamish Waterway
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
OC – organic carbonRvAL – removal action level
PCB – polychlorinated biphenyl
PCB – polychlorinated biphenyl
RBTC – risk-based threshold concentration
RI – remedial investigation
RvAL – removal action level
SQS – sediment quality standard
T-117 – Terminal 117
TEQ – toxic equivalent
TOC – total organic carbon

As mentioned previously, portions of the T-117 Upland Study Area may be converted in the future to aquatic habitat as part of the restoration and redevelopment plans for the T-117 EAA. As described further in Section 7, the sediment removal and/or capping actions would be sufficient to result in clean sediment or cap material extending to a minimum depth of up to 45 cm (Figure 4-1), which and would provide protection for clammers and children playing within the intertidal areas (i.e., between approximately +13.8 ft and 0 ft mean lower low water [MLLW]). Clams, which have a maximum burrowing depth of 35 cm (1.1 ft), and clammers, who may dig up as deep asto 45 cm (1.5 ft), and have direct-contact exposure would be protected. Figure 4-1 presents a conceptual diagram of the anticipated post-NTCRA conditions for both upland and aquatic areas. This latter depth would also be sufficient to accommodate a maximum erosion potential of 6 cm (2.5 in.) during a 100-yr storm event; monitoring to assess the stability of the cap may be a part of the sediment monitoring program. Additional information regarding LDW sediment dynamics within the T-117 Sediment Study Area is provided in Section 5.

Because the final configuration of the sediment portion of the site is still being evaluated, a sediment cap design, if needed, would be based on US Army Corps of Engineers (USACE) guidance regarding the determination of cap thickness and the specific layers that are necessary for a cap that is dependent on the environment and the habitat in which it will be constructed. The cap design will be prepared during the NTCRA design phase and will take into account potential future habitat requirements. Section 6.1.2.2 presents additional details on the cap design.

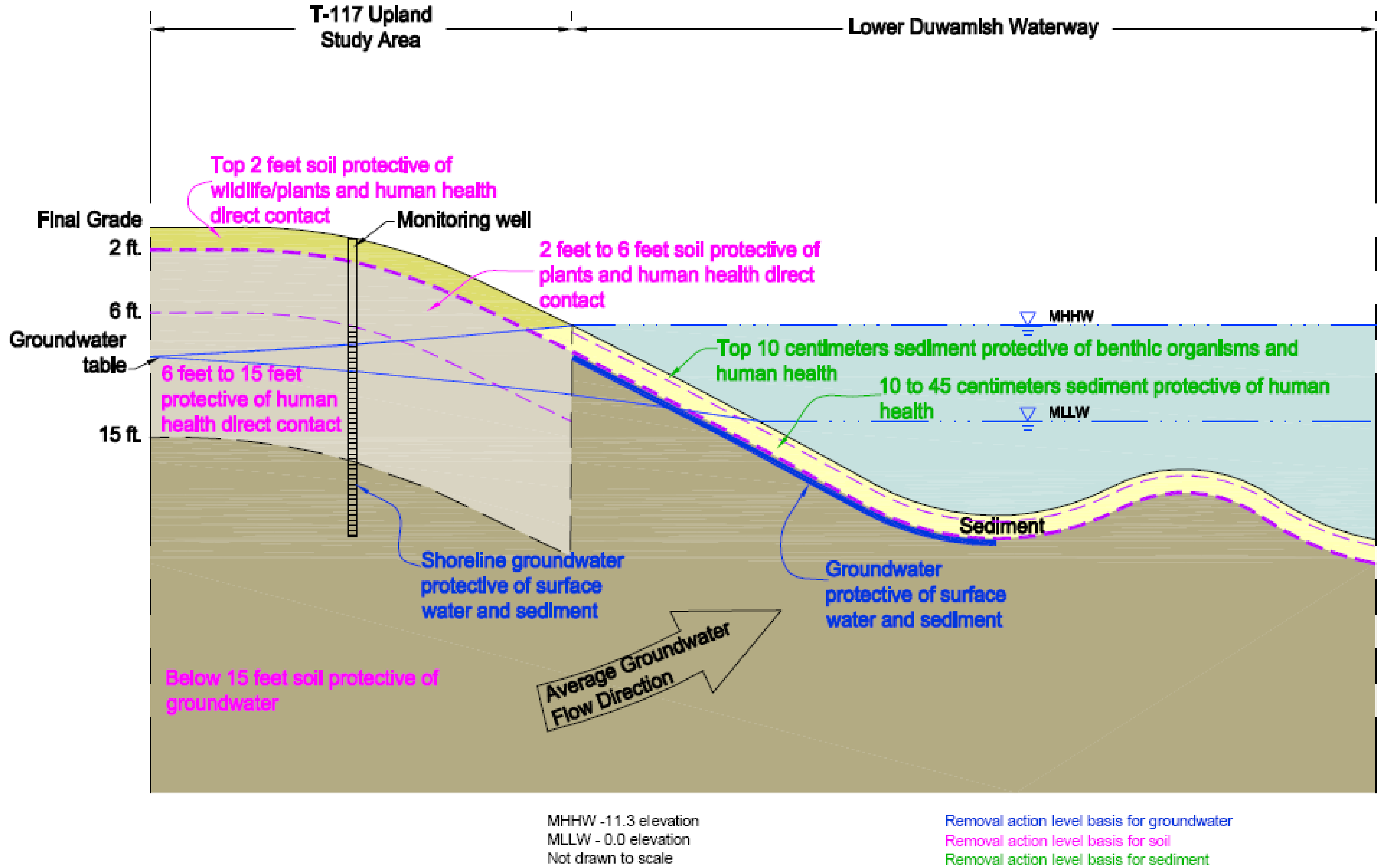


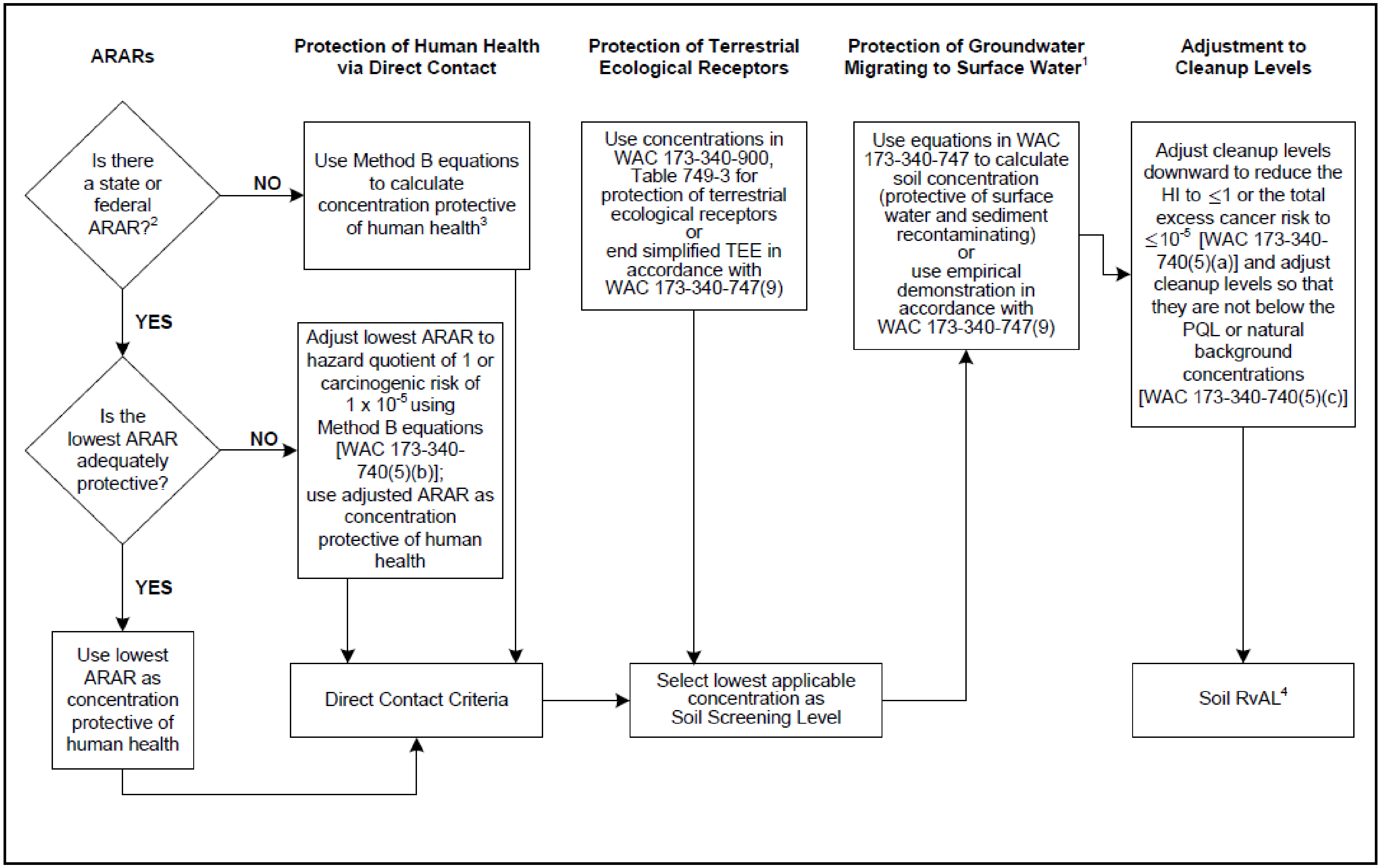
Figure 4-1. Conceptual diagram of points of compliance for upland soil and sediment cleanup

4.3.2 Development of soil removal action levels

This section describes the development of soil RvALs for the T-117 Upland Study Area and the Adjacent Streets and Residential Yards Study Area. As shown in Figure 4-2 and Table 4-2, the RvALs were calculated or developed using:

- MTCA Method B (Equations 740-1 and 740-2, WAC 173-340-740)
- ARARs
- CULs from MTCA based on potential exposure to applicable upland ecological receptors (TEE) (WAC 173-340-7490 through 7494)

Potential influences on other media (e.g., the soil-to-groundwater [WAC 173-340-747] and groundwater-to-sediment pathways) were also considered. In addition, residual risks associated with COCs remaining at concentrations at or below the candidate RvALs were examined to determine if additional modifications were warranted or if adjustments were needed for COC-specific exposure scenarios (e.g., early life-stage exposure to cPAHs). The potential for the erosion of soil to sediment will be addressed as part of the NTCRA design.



1. Only those compounds that exceeded groundwater SLs are evaluated for protection of groundwater
2. ARAR = Applicable or relevant and appropriate requirement. Based on state ARAR, groundwater is considered non-potable.
3. Use lower of carcinogenic and non-carcinogenic values if both are available; use Method A value for lead and TPH.
4. RvAL = Removal Action Level

Figure 4-2. Development of soil removal action levels

Table 4-2. T-117 Upland Study Area soil removal action levels

MTCA Regulation 173-340-	Basis	Unit	TPH	cPAH TEQ	Dioxin/Furan TEQ	Total PCBs	Metals	
			Heavy Oil-Range Organics[a]				Arsenic	Silver
~~Potential CULs~~								
740(3)(b)(i)	TSCA – 40 CFR 761.61(4)(i)(A)	mg/kg	nc	nc	nc	1.0	nc	nc
740(3)b)(ii)	TEE mammalian predator (shrew)	mg/kg	6,000	11.75	nc	0.65	7.1	nc
	TEE, avian predator (robin)	mg/kg	6,000	nc	nc	3.5	150.3	nc
	TEE, mammalian herbivore (vole)	mg/kg	6,000	82.35	nc	14.4	42.9	nc
	TEE, plants/soil biota	mg/kg	200	nc	2×10^{-6}	40	10	2.0
740(3)b)(iii)(B)(I)	direct contact, non-carcinogen	mg/kg	nc	nc	nc	nc	24	400
740(3)b)(iii)(B)II)	direct contact, carcinogen	mg/kg	nc	0.14	1.1×10^{-5}	0.50	0.67	nc
	preliminary human health CUL[b]	mg/kg	2,000	0.14	1.1×10^{-5}	1.0	0.67	400
700(6)(d)	PQLs	mg/kg	25/100[c]	0.008[d]	1.5×10^{-10}	0.01[e]	0.1	0.02
	background[f]	mg/kg	na	na	na	na	7.3	na
~~Summary of Applicable~~ CULs Used as a Basis for RvALs								
740	TEE wildlife/plants/soil biota, human health direct contact (< 2 ft)[g]	mg/kg	200	0.14~~0.008[h]~~	1.1×10^{-5} ~~2×10^{-6}~~	0.65	7.3	2.0
	TEE plants/soil biota, human health direct contact (2 to 6 ft)[g]	mg/kg	200	0.14~~0.008[h]~~	1.1×10^{-5}	1.0	7.3	2.0
	all other soil (6 to15 ft below grade)	mg/kg	2,000	0.14	1.1×10^{-5}	1.0	7.3	400

a NWTPH-Dx (diesel and lube oil ranges).

[b] Total cancer risk for all human health CULs is 5 × 10^{-6}; total hazard index is 1.

[c] 25 mg/kg is the diesel-range PQL; 100 mg/kg is the heavy oil-range PQL.

[d] PQL is based on site-specific PQLs for benzo(a)pyrene.

[e] PQL assumes a single Aroclor (1260) for PCBs.

[f] Background soil concentrations based on Puget Sound average from *Natural Background Soils Metals Concentrations in Washington State Toxics Cleanup Program* (Ecology 1994c).

[g] Soil CULs (used as a basis for selecting RvALs) for TPH, ~~dioxins and furans,~~ copper, and silver based on protection of plants or soil biota per the TEE requirements are subject to change based on further site-specific TEE evaluation.

~~[h] cPAH TEQ is adjusted for combined early life stage adjustments and soil exposure factors for residential and recreational PRG (Appendix I).~~

ARAR – Applicable or Relevant and Appropriate Requirement

BCF – bioconcentration factor

cPAH – carcinogenic polycyclic aromatic hydrocarbon

CPF – carcinogenic potency factor

CUL – cleanup level

CWA – Clean Water Act

na – not available~~applicable~~

nc – no criteria

~~nd~~ nc – not ~~data~~calculated

NWTPH – Northwest total petroleum hydrocarbons

PCB – polychlorinated biphenyl

PQL – practical quantitation limit

RfD – reference dose

RvAL – removal action level

T-117 – Terminal 117

TEE – terrestrial ecological evaluation

TEQ – toxic equivalent

TPH – total petroleum hydrocarbons

TPH-Dx – total petroleum hydrocarbons – diesel and oil extractable

TSCA – Toxic Substances Control Act

WAC – Washington Administrative Code

4.3.2.1 T-117 Upland Study Area

As presented in Table 3-110, the soil COCs for the T-117 Upland Study Area are total PCBs, TPH, cPAHs, dioxins and furans, silver, and arsenic. Table 4-2 lists the MTCA regulations that were used to determine the T-117 Upland Study Area soil RvALs for the identified COCs. The derivation of the RvALs for each COC is described below.

Total PCBs

An RvAL of 1.0 mg/kg was selected for total PCBs for most of the T-117 Upland Study Area based on the TSCA ARAR. According to MTCA, if it can be demonstrated that an ARAR is sufficiently protective, the ARAR may be used to establish a CUL under MTCA (WAC 173-340-740(3)(b)(iii)). An ARAR is considered sufficiently protective if it is associated with a cancer risk of 1×10^{-5} or less (WAC 173-340-740(5)(b)). The TSCA CUL of 1.0 mg/kg, proposed for use as an RvAL for the T-117 NTCRA, equates to an excess cancer risk[12] of 2×10^{-6}.

A different RvAL is applicable to areas within the T-117 Upland Study Area that may become upland habitat. For those areas, the RvAL is based on the MTCA-defined soil CUL for total PCBs of 0.65 mg/kg, which is relevant within limited soil depths based on a TEE for terrestrial receptor exposure (Table 4-2). The development of a TEE-based RvAL is appropriate inasmuch as the eventual size of the landscaped upland portion of a future T-117 habitat area may exceed the MTCA-defined 0.25-acre threshold for a TEE exclusion. Under the habitat restoration scenario, the T-117 Upland Study Area would be required to undergo a site-specific TEE rather than a simplified TEE. The most stringent default TEE CUL under MTCA is based on the protection of the mammalian predator (shrew) and is also protective of plants (the MTCA TEE CULs for the soil biota, avian predator, and mammalian herbivore are significantly greater and would not be a limiting factor). Burrowing mammalian predators, such as the shrew, and their primary food source of worms and insects are found in the top 1 to 2 ft of soil (Suter 1993). As a result, a conditional point of compliance of the upper 2 ft for the soil RvAL based on the MTCA TEE CUL is proposed, consistent with WAC 173-340-7490(4)(a). Plant roots would penetrate the full depth of the biologically active zone defined as the upper 6 ft in MTCA. Institutional controls, such as a property usedeed restrictions and a monitoring and maintenance plan, would be implemented at the developed habitat site to ensure that any disturbance of soil would be managed to protect ecological receptors. Institutional controls would also include the written notification of workers regarding maintenance-related limitations and signs stating the prohibition of unplanned digging within any habitat areas.

To address any potential concerns regarding exposure through the consumption of home-grown produce, the risk level associated with the PCB RvAL of 1.0 mg/kg was

[12] Calculated using MTCA Equation 740-2 and a carcinogenic potency factor of 2 per mg/kg-day.

compared to risks associated with this pathway to determine if adjustment was needed. Based on a review of the literature, including a risk assessment conducted by ~~the US Army Corps of Engineers (~~USACE~~)~~ and EPA (Weston Solutions 2005) for the Housatonic River,[13] exposures associated with the consumption of produce grown in soils that contain total PCBs and dioxins and furans at the T-117 RvALs would not increase the total risk to a level in excess of 1 x 10^{-5}. Though not reported in the referenced risk assessment, the risk corresponding to an exposure level of 1.0 mg/kg would be 1.5×10^{-6}, which is less than the risk of 2×10^{-6} posed by the ARAR based TSCA soil RvAL of 1.0 mg/kg.

TPH

To accommodate possible future use of the T-117 Upland Study Area for habitat, an RvAL of 200 mg/kg was selected for the upper 6 ft of soil. For depths below 6 ft, an RvAL of 2,000 mg/kg was selected for TPH based on MTCA Method A CULs (Table 4-2). The Method A CUL is based on preventing the accumulation of diesel-range TPH in groundwater in a coarse sand and gravel matrix and is lower than health-based TPH criteria for diesel. A TPH fraction analysis was not performed at T-117 to calculate a human health risk-based TPH value.

cPAH TEQ

Per EPA (2005e) guidance, the evaluation of early life-stage exposure to cPAHs was considered in the development of the RvAL for cPAHs because of the potential for the future exposure of children in areas of the T-117 Upland Study Area that may be made available for public access. cPAHs are the only COCs considered to be mutagenic, so they are the only COCs for which this adjustment may be necessary. ~~The adjusted RvAL was less than the PQL, thus an RvAL of 0.008 mg/kg TEQ was selected for cPAHs based on PQLs for individual PAHs. Nevertheless, the adjusted RvAL was~~ Early life-stage exposure parameters were used in the calculation~~s~~ of total risk to evaluate protectiveness under CERCLA for the recreational exposure scenario (Table 4-3). Additional details of this adjustment to account for early life-stage exposure are provided in Appendix I. The cPAH RvAL of 0.14 mg/kg TEQ was selected based on the MTCA Method B ARAR.

[13] The risk assessment estimated that the reasonable maximum exposure cancer risk associated with the consumption of produce grown in garden soil containing total PCBs at 2 mg/kg was 3×10^{-6}. The assessment used consumption rates for home-grown foods in three categories: exposed vegetables (11 kg/yr), root vegetables (10 kg/yr), and exposed fruit (12 kg/yr).

Table 4-3. T-117 Upland Study Area total risks for soil removal action levels

COC	RvAL (mg/kg)	Source of RvAL[a]	Excess Cancer Risk at RvAL			
			MTCA Unrestricted Land Use		CERCLA	
			MTCA Unrestricted Land Use Total Risk(unitless)[b]	MTCA Unrestricted Land Use Incremental Risk(unitless)[b, cd]	CERCLA Industrial Scenario (unitless)cd	CERCLA Recreational Scenario (unitless)[cd, e, f]
Arsenic[d]	0.677.3	MTCA Method B	1 × 10^{-56}	0	04 × 10^{-7}	2.6 x 10-602 × 10^{-7}
Silver	2400	MTCA Method B	nNc	nc	837 × 10^{-8}	2 × 10^{-78}
cPAH TEQ	0.14	MTCA Method B	1 6 × 10^{-6}	16 × 10^{-6}	6 × 10^{-7}	6 × 10^{-6}
Total PCBs	1.0	Method B/TSCA	2 × 10^{-6}	2 × 10^{-6}	1 × 10^{-6}	6 × 10^{-7}
Dioxin/furan TEQ	1.1 × 10^{-5}	MTCA Method B	1 × 10^{-6}	1 × 10^{-6}	6 × 10^{-7}	3 × 10^{-7}
Total			**1.52 × 10^{-56}**	**49 × 10^{-6}**	**23 × 10^{-6}**	**7 × 10^{-6}**

a For total PCBs, the RvAL was based on the TSCA ARAR using MTCA Method B CUL development procedures. For other COCs, the MTCA Method B standard equation value was used.

b Risk was calculated according to the standard MTCA Method B equation and assumptions with adjustments to the cPAH risk based on early life-stage exposure parameters (Appendix I).

dc The arsenic RvAL is based on natural background. The MTCA risk calculation was performed both using the natural background risk associated with arsenic and the incremental risk of the arsenic RvAL relative to natural background (which is zero). The second risk calculation demonstrates compliance with the MTCA total risk threshold of 1x10^{-5} (WAC 173-340-740(5)(a)).and corresponding risk used to calculate total risks is the MTCA Method B value, which is lower than the selected RvAL of 7.3 mg/kg, which is based on the soil background concentration.

c Risk was calculated according to CERCLA equations and assumptions appropriate to the scenario.

e The exposure frequency for the recreational scenario was 48 days/yr.

f The CERCLA recreational scenario risk calculation incorporates early life stage adjustments (Appendix I).

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act

COC – contaminant of concern

cPAH – carcinogenic polycyclic aromatic hydrocarbon

MTCA – Model Toxics Control Act

nc – non-carcinogens (not included in the MTCA total cancer risk analysis)

PCB – polychlorinated biphenyl

RvAL – removal action level

T-117 – Terminal 117

TSCA – Toxic Substances Control Act

Ecology is currently evaluating early life-stage exposure and is considering rule revisions to address this issue. On March 22, 2010, Ecology released a document with examples of updates to MTCA specifically related to cPAHs and early -life-stage exposure (Appendix I). The information and examples are currently under discussion among the MTCA /SMS Advisory Group members. Although early life-stage exposures are not currently incorporated into MTCA, the total risk calculation in Table 4-3 for the MTCA unrestricted-land-use scenario incorporates early life-stage exposure assumptions. Additional details on the adjustment to account for early life-stage exposures are provided in Appendix I. The cPAH soil RvAL may be below natural or anthropogenic background concentrations. Background concentrations have not been evaluated in this EE/CA but may be evaluated during remedial design. Ecology's document provided a mean background cPAH concentration of 1.8 mg/kg.

Dioxin/Furan TEQ

The RvAL of 11 ng/kg TEQ for dioxin/furan was selected for the T-117 Upland Study Area. This RvAL is equal to the MTCA Method B risk-based concentration that corresponds to a carcinogenic risk of 1×10^{-6}.

A recurring issue in risk assessment is the calculation of acceptable or safe levels of dioxins and furans in soil. EPA is currently undertaking a comprehensive review of this issue as part of its "dioxin reassessment." This work includes an examination of dioxin and furan soil action levels in use across the United States and internationally. On January 7, 2010, EPA's Office of Solid Waste and Emergency Response (OSWER) issued draft recommended interim PRGs for dioxin and furan soil at CERCLA and RCRA sites (EPA 2009b). The proposed draft recommended interim PRGs are 72 ng/kg TEQ for residential land uses and 950 ng/kg TEQ for commercial/industrial land uses. These draft recommended interim PRGs are lower than the previous value of 1,000 ng/kg TEQ for dioxin in residential soil and lower than the range of 5,000 to 20,000 ng/kg TEQ for dioxin in commercial/industrial soil. EPA expects to issue a final interim PRG by June 2010.

Currently, several soil criteria are being used by different government organizations, as listed below. These criteria are presented for informational uses only; none of these criteria are applicable under MTCA (i.e., they are not ARARs).

- EPA current residential soil cleanup standard: 1,000 ng/kg TEQ (EPA 1998). This standard forms the basis of the 1998 PRG and is the starting point for the derivation of CULs at CERCLA and RCRA sites. This value reflects an excess cancer risk of approximately 2.5×10^{-4} based on exposure and toxicity parameters used in 1998. This PRG is being reassessed as noted above, and may be lowered to 72 ng/kg TEQ. This draft PRG corresponds to an excess cancer risk of 1×10^{-5}.
- The EPA 2009 residential PRG (for Regions 3, 6, and 9) used for screening: 4.5 ng/kg TEQ (EPA 2009e). This PRG is based on an excess cancer risk of 1×10^{-6} and uses somewhat different exposure and toxicity parameters than those used in 1998 (listed above). This concentration is used for screening at CERCLA sites and is not necessarily used as a CUL.
- Agency for Toxic Substances and Disease Registry (ATSDR) direct-contact residential exposure SL is 50 ng/kg TEQ (73 FR 61133). This value is not a threshold for toxicity but is used as a SL by ATSDR health assessors to determine when to conduct health evaluations (i.e., when dioxins and furans are present above this level).
- Washington State Department of Health (WSDOH) site-specific health assessment: levels that trigger health assessment by WSDOH are site-specific.

Silver

To accommodate possible future use of the T-117 Upland Study Area for habitat, an RvAL of 2.0 mg/kg was selected for the upper 6 ft of soil based on the MTCA TEE. For depths below 6 ft, an RvAL of 400 mg/kg was selected for silver based on MTCA Method B (Table 4-2). The higher concentration was evaluated in conjunction with those of other non-carcinogenic COCs to ensure that the total hazard index for the site was less than 1.0.

Arsenic

A preliminary RvAL of 0.67 mg/kg was calculated for arsenic based on human health considerations. However, because this concentration was less than the preliminary natural background concentration in the Puget Sound region (7.3 mg/kg) (Ecology 1994c), an RvAL of 7.3 mg/kg was selected. This RvAL does not result in a total hazard index of greater than 1.0 when considered together with contributions from other non-carcinogenic COCs.

Assessment of Total Risk

The total excess cancer risk associated with each ~~for the selected~~ RvAL~~s~~ was assessed for the MTCA unrestricted-~~-~~land-~~-~~use scenario and for recreational and industrial scenarios under CERCLA.~~-~~ The MTCA unrestricted land use and CERCLA recreational scenarios incorporated early life-stage exposure parameters~~ risk calculations and RvALs based on MTCA-derived CULs, described above for individual contaminants, were assessed for total risk for both recreation and commercial exposure scenarios to ensure compliance~~. Detailed back-up for these risk calculations is presented in Appendix I. The total risks for the recreational and ~~co~~industrial~~mmercial land use~~ scenarios ~~(under CERCLA)~~ were ~~7~~ 6 × 10^{-6} and ~~3~~ 2 × 10^{-6}, respectively (Table 4-3), which were within the acceptable CERCLA 10^{-4} to 10^{-6} risk range. The total risk~~s~~ for the ~~recreational and commercial land use scenarios (under~~ MTCA unrestricted land use scenario~~)~~ w~~ere~~as ~~each~~ ~~1.55~~2 × 10^{-56} (Table 4-3). When the incremental arsenic risk was adjusted relative to natural background, the risk was reduced to 49 × 10^{-6},~~; risks estimates for both scenarios were~~ less than the 10^{-5} MTCA threshold.

4.3.2.2 Adjacent Streets and Residential Yards Study Area

As presented in Table 3-11~~0~~, the soil COCs for the Adjacent Streets and Residential Yards Study Area are total PCBs and dioxins and furans. An RvAL of 1 mg/kg was selected for total PCBs based on the TSCA ARAR, and an RvAL for dioxin/furan TEQ of 11 ng/kg was selected based on MTCA Method B.

Utility workers and residents may be exposed to soils within the Adjacent Streets and Residential Yards Study Area. MTCA does not have a CUL for utility workers, so the residential scenario was used to evaluate exposures under MTCA for both areas. CERCLA does have a utility worker scenario; risks were calculated for the worker scenario.[14] As shown in Table 4-4, these total risk estimates were less than 10^{-5} (MTCA) and were within the CERCLA range of 10^{-4} to 10^{-6}.

Table 4-4. T-117 Adjacent Streets and Residential Yards Study Area total risks for soil removal action levels

COC	RvAL (mg/kg)	Source of RvAL	Excess Cancer Risk at RvAL: MTCA Unrestricted Land Use (unitless)[a]	CERCLA: CERCLA Utility Worker Scenario for Adjacent Streets (unitless)[b]	CERCLA: CERCLA Residential Scenario for Adjacent Streets and Residential Yards (unitless)[b]	CERCLA: CERCLA Recreational Scenario (unitless)[c, d, e]
Adjacent Streets – Utility Worker Scenario						
Total PCBs	1.0	TSCA	2×10^{-6}	2×10^{-8}	5×10^{-6}	4.5×10^{-6}
Dioxin/furan TEQ	1.1×10^{-5}	Method B	1×10^{-6}	1×10^{-8}	2×10^{-6}	2.4×10^{-6}
Total			$\mathbf{3 \times 10^{-6}}$	$\mathbf{3 \times 10^{-8}}$	$\mathbf{7 \times 10^{-6}}$	$\mathbf{6.9 \times 10^{-6}}$

a Risk was calculated according to the standard MTCA Method B equation and assumptions.

b Risk was calculated according to CERCLA equations and assumptions appropriate to the scenario. For the residential scenario, these are standard default assumptions used by EPA Regions 3, 6, and 9.

c Risk was calculated according to CERCLA equations and assumptions appropriate to the scenario.

d The exposure frequency for the recreational scenario was 48 days/yr.

e The CERCLA recreational scenario risk calculation incorporates early life--stage adjustments (Appendix I).

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act

EPA – US Environmental Protection Agency

MTCA – Model Toxics Control Act

PCB – polychlorinated biphenyl

RvAL – removal action level

TEQ – toxic equivalent

4.3.3 Development of groundwater removal action levels

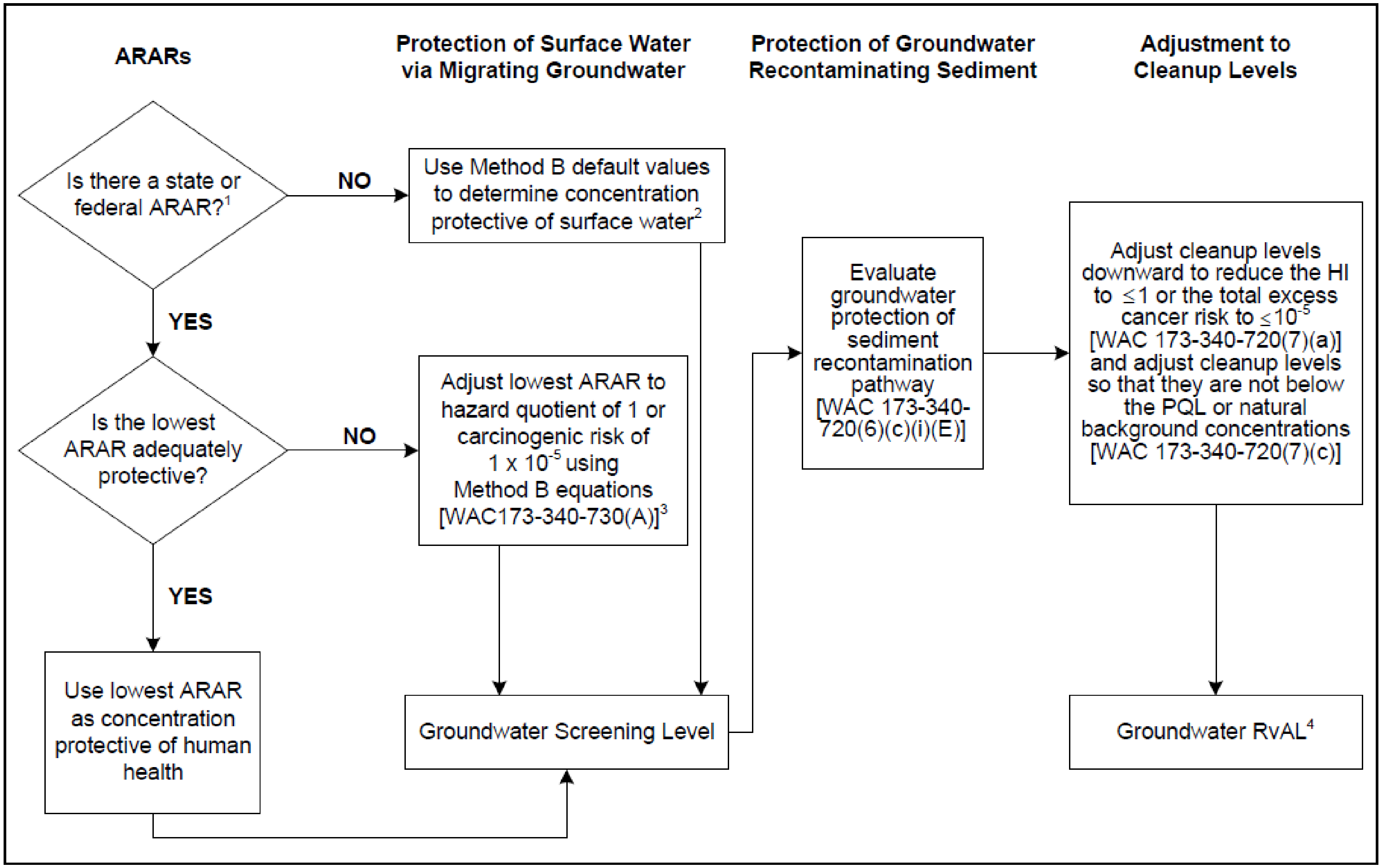
This section describes the development of groundwater RvALs for the T-117 Upland Study Area and the Adjacent Streets. As shown in Figure 4-3 and Table 4-5, the RvALs were calculated or developed using:

- MTCA Method B (Equations 7240-1 and 7240-2, WAC 173-340-7240)
- ARARs (
- Ssurface water protection criteria using MTCA Equation 730-2 with a site-specific fish consumption rate of 57 g/day and a fish diet fraction of 1 for the Duwamish

[14] Risks for the utility worker scenario were calculated using the following equation: risk = 1 x 10^{-6} x MTCA CUL/utility worker PRG, where risk is unitless and the MTCA CUL and the utility worker PRG are both expressed as mg/kg. The utility worker PRGs for PCBs and dioxins and furans were derived by adjusting the industrial PRGs as follows: the exposure frequency was adjusted down from 250 days/yr to 30 days/yr; the exposure duration was adjusted down from 25 yr to 1 yr; and the soil ingestion rate was adjusted up from 100 mg/day to 330 mg/day.

corridor and Elliott Bay based on the King County Asian Pacific Islander seafood consumption survey) (EPA 1999)

- CULs from MTCA based on background concentrations (e.g., Method A for arsenic)
- CULs from based on site site-specific background concentrations



1. ARAR = Applicable or relevant and appropriate requirement. Based on state ARAR, groundwater is considered non-potable.
2. MTCA Method A value used if no Method B value is available (for TPH), or if background level is above Method B value (for arsenic). Levels are also adjusted for the practical quantitation limit, or natural background, per WAC 173-340-720(7)(c).
3. Use lower of carcinogenic and non-carcinogenic values.
4. RvAL = Removal Action Level

Figure 4-3. Development of groundwater cleanup levels

Table 4-5. T-117 Upland Study Area groundwater removal action levels

MTCA Regulation (WAC 173-340)-	Basis	Unit	TPH (Heavy Oil -Range Organics)[a]	Total cPAH TEQ	BEHP	Total PCBs	Silver	Arsenic	Total Risk
Surface Water									
730(3)(b)(i)(A)	WAC 173-201A, marine[b]	µg/L	nc	nc	nc	3.00E-02	1.9	36	
730(3)(b)(i)(B)	Sec. 304, CWA, marine, chronic[c]	µg/L	nc	nc	nc	3.00E-02	1.9	36	
730(3)(b)(i)(B)	Sec. 304, CWA, organism only[c]	µg/L	nc	1.80E-02	2.2	0.000064	nc	0.14	
730(3)(b)(i)(C)	40CFR131, NTR, marine, chronic[d]	µg/L	nc	nc	nc	0.03	1.9	36	
730(3)(b)(i)(C)	40CFR131, NTR, organism only[d]	µg/L	nc	3.10E-02	5.9	0.00017	nc	0.14	
730(3)(b)(ii)	environmental effects	µg/L	nc	nc	nc	nc	nc	nc	
	appropriate ARAR	µg/L	nc	0.0180	2.2	0.000064	1.9	5	
	CPF (kg-day/mg)		na	7.3	0.014	2	na	1.5	
	oral RfD (mg/kg-day)		na	na	0.02	na	0.005	0.0003	
	BCF		na	30	130	31000	0.5	44	
	cancer risk		na	6.01.38E-076	1.3E-66.18E-07	066.12E-071.3E-6	na	1.43E1E-0604	1.1E-04
	hazard quotient		na	na	0.0120.0055157	na	1.5E-047.3E-05	0.5970.00792	0.609
730(3)(b)(iii)(A)	human health, fish consumption, non-carcinogen	µg/L	nc	nc	399	nc	25,926	17.7	
730(3)(b)(iii)(B)	human health, fish consumption, carcinogen	µg/L	nc	0.0296014	3.61.7	0.000100005	nc	0.0982047	

MTCA Regulation (WAC 173-340)-	Basis	Unit	TPH (Heavy Oil -Range Organics)[a]	Total cPAH TEQ	BEHP	Total PCBs	Silver	Arsenic	Total Risk
730(3)(b)(iii)(C)	human health, fish consumption, petroleum mixture	µg/L	500	na	na	na	na	na	
	preliminary CUL	µg/L	500	0.0180014	2.21.7	0.00006400005	1.9	0.0982047	
	cancer risk		na	6.11.0E-0706	1.0E-066.2E-07	1.0E-066.1E-07	na	1.0E-061.43E-06	4.0E-063.3E-06
	hazard quotient		na	na	0.006009	na	7.33E-050.0002	0.008006	0.015
700(6)(d)	PQLs[e]	µg/L	250/500	0.15	1.0	0.01	0.02	0.02	
	background[f]	µg/L		0.00022ntc not calculated	1.37not calculatednte	0.00033not calculatednte	nanot calculatednte	0.71not calculatednte	
730	CUL	µg/L	500	0.15	2.21.7	0.01	1.9	0.710.05	
Groundwater									
720(4)(b)(i)	MCL, SDWA	µg/L	nc	nc	6.0	0.5	nc	10	
	MCLG for non-carcinogens, SDWA	µg/L	nc	nc	nc	nc	100	10	
	MCL, WSDOH	µg/L	nc	nc	nc	nc	nc	nc	
720(4)(b)(ii)	protect surface water (from above)	µg/L	500	0.0180014	2.21.7	0.00006400005	1.9	0.7105	
	preliminary CUL	µg/L	500	0.018014	2.21.7	0.00006400005	1.9	0.09805	
	cancer risk		na	6.11.0E-0706	1.0E-066.2E-07	6.11.0E-0706	na	1.4E0E-06	3.34.0E-06
	hazard quotient		na	na	0.006009	na	7.3E-050.00002	0.0068	0.014015
700(6)(d)	PQLs[e]	µg/L	250/500[g]	0.15	1.0	0.01	0.02	0.5	
	background[h]	µg/L	na	na	na	na	na	5	

MTCA Regulation (WAC 173-340)-	Basis	Unit	TPH (Heavy Oil -Range ~~Organics)~~[a]	Total cPAH TEQ	BEHP	Total PCBs	Silver	Arsenic	Total Risk
720	CUL	µg/L	500	0.15	~~2.2~~1.7	0.01	1.9	5	
720(8)(e)	shoreline compliance level		12,500	0.15	~~55~~42.5	0.01	47.5	~~17.8~~5	

a NWTPH-Dx (diesel- plus lube oil-ranges).

b Table 240(3) WAC 173-201A.

c National recommended water quality criteria (EPA 2002).

d 40CFR131.35, revised July 1, 2003.

e PQL assumes a single Aroclor (1260) for PCBs and incorporates the TEF calculation for cPAH.

f Background surface water concentrations are based on water quality upgradient of the LDW as indicated in the draft feasibility study (ENSR|AECOM 2009).

g 250 µg/L is the diesel-range PQL; 500 µg/L is the lube oil-range PQL.

h Background groundwater concentration for arsenic is based on MTCA Method A~~, and concentration for copper is based on site-specific statistical data analysis.~~.

i CULs are MTCA-defined CULs. These serve as a basis for the RvALs throughout the EE/CA. Human health surface water quality criteria based on bioaccumulation have been conservatively assumed to apply to groundwater discharges even though the applicability of these criteria is uncertain.

j Equation 730-2 in MTCA was modified to include the site-specific Asian Pacific Islander fish consumption rate of 57 g/day and fish diet fraction of 1 for the Duwamish corridor and Elliott Bay. The EPA consumption rate for the LDW of 97 g/day is not appropriate for the computation of MTCA surface water CULs.

ARAR – applicable or relevant and appropriate requirement
BCF – bioconcentration factor
BEHP – bis(2-ethylhexyl) phthalate
CFR – Code of Federal Regulations
cPAH – carcinogenic polycyclic aromatic hydrocarbon
CPF – carcinogenic potency factor
CUL – cleanup level
CWA – Clean Water Act
EE/CA – engineering evaluation/cost analysis
EPA – US Environmental Protection Agency
~~EPA – US Environmental Protection Agency~~
LDW – Lower Duwamish Waterway
MCL – maximum contaminant level
MCLG – maximum contaminant level goal
MTCA – Model Toxics Control Act
na – not applicable
nc – no criteria
NTR – National Toxics Rule
NWTPH-Dx – Northwest total petroleum hydrocarbons – diesel and lube oil
PCB – polychlorinated biphenyl
PQL – practical quantitation limit
RfD – reference dose
RvAL – removal action levels
SDWA – Safe Drinking Water Act
TEF – toxic equivalency factor
TPH – total petroleum hydrocarbons
WAC – Washington Administrative Code
WSDOH – Washington State Department of Health

Because groundwater in the vicinity of the T-117 Upland Study Area is not potable, as described in Appendix B, MTCA cancer risks for groundwater ingestion were not calculated. The total cancer risk was calculated (Table 3-B-348) based on surface water protection using MTCA Equation 730-2, as modified. The total cancer risk for groundwater protective of surface water was less than 44.0 × 10^{-6}, below the acceptable total risk range threshold of 10^{-5}. The HQ, calculated using MTCA Equation -730-1, was 0.015, well below the acceptable total HQ of 1. CERCLA risks were not calculated for groundwater, inasmuch as it is not suitable for domestic use.

As presented in Table 3-98, the groundwater COCs for the T-117 Upland Study Area include arsenic, copper, silver, PCBs, TPH, cPAH TEQ, and BEHP. Table 4-5 lists the regulations that were used to determine the T-117 Upland Study Area groundwater RvALs for the identified COCs. The derivation of the RvALs for each COC is summarized below. and described in detail in Appendix B.

Arsenic

Arsenic background values were determined based on MTCA Method A. A site-specific background value was not calculated because of the small sample set and elevated reporting limits. Reporting limits for select sampling events were significantly greater than the MTCA Method A value. The arsenic RvAL was 5 µg/L.

Silver and BEHP

Silver and BEHP RvALs are based on the protection of surface water. RvALs were derived from published standards defined in the Clean Water Act. The silver RvAL is 1.9 µg/L, and the BEHP RvAL is 2.21.7 µg/L.

TPH

The TPH RvAL is based on the MTCA Method A value because no surface water quality criterion is available. The TPH RvAL is 500 µg/L.

Total PCBs and cPAH TEQ

The total PCBs and cPAH TEQ RvALs are based on practical qualitative limits, which represent the practical level that analytical laboratories can sample and report results. The RvAL for total PCBs is 0.01 µg/L, and the RvAL for cPAH TEQ is 0.15 µg/L.

4.3.4 Summary of T-117 EAA removal action levels

Sediment, soil, and groundwater RvALs derived in Section 4 for T-117 EAA COCs are summarized in Table 4-6.

Table 4-6. T-117 EAA sediment, ~~and~~ soil, and groundwater removal action levels

COCs	Sediment[a]	Soil[b]			Groundwater
	T-117 Sediment Study Area	T-117 Upland Study Area	Adjacent Streets	Residential Yards	T-117 Upland Study Area[ic]
Metals					
Arsenic	12 mg/kg[ed]	7.3 mg/kg	na	na	5 µg/L
~~Copper~~	~~na~~	~~na~~	~~na~~	~~na~~	~~3.4 µg/L~~
Silver	na	2.0/400 mg/kg[de]	na	na	1.9 µg/L
PAHs					
2-Methylnaphthalene	0.59 mg/kg[ef]	na	na	na	na
Acenaphthene	0.25 mg/kg[ef]	na	na	na	na
Anthracene	3.4 mg/kg[ef]	na	na	na	na
Benzo(a)anthracene	1.7 mg/kg[ef]	na	na	na	na
Benzo(a)pyrene	1.5 mg/kg[ef]	na	na	na	na
Benzo(g,h,i)perylene	0.48 mg/kg[ef]	na	na	na	na
Total benzofluoranthenes	3.6 mg/kg[ef]	na	na	na	na
cPAH TEQ	0.09 mg/kg[fg]	0.~~008~~14 mg/kg[fg]	na	na	0.15 µg/L
Chrysene	1.7 mg/kg[ef]	na	na	na	na
Dibenzo(a,h)anthracene	0.19 mg/kg[ef]	na	na	na	na
Dibenzofuran	0.23 mg/kg[ef]	na	na	na	na
Fluoranthene	2.5 mg/kg[ef]	na	na	na	na
Fluorene	0.36 mg/kg[ef]	na	na	na	na
Indeno(1,2,3-cd)pyrene	0.53 mg/kg[ef]	na	na	na	na
Phenanthrene	1.6 mg/kg[ef]	na	na	na	na
Total HPAH (calc'd)	15 mg/kg[ef]	na	na	na	na
Total LPAH (calc'd)	5.7 mg/kg[ef]	na	na	na	na
TPH					
Diesel- and lube oil-range hydrocarbons	na	200/2,000 mg/kg[gh]	na	na	500 µg/L
Other SVOCs					
BEHP	na	nc	na	na	~~2.2~~1.7 µg/L
Phenol	0.420 mg/kg	na	na	na	na
PCBs					
Total PCBs	0.19 mg/kg dw[ef, ij] or 12 mg/kg -	0.65/1.0 mg/kg[hi]	1.0 mg/kg	1.0 mg/kg	0.01 µg/L

COCs	Sediment[a] T-117 Sediment Study Area	Soil[b] T-117 Upland Study Area	Adjacent Streets	Residential Yards	Groundwater T-117 Upland Study Area[jc]
	OC				
Dioxins and Furans					
Dioxin/furan TEQ	13 ng/kg	11 ng/kg	11 ng/kg	11 ng/kg	na

a Sediment point of compliance for the intertidal area is the top 10 cm for protection of benthic organisms and human health; the subtidal point of compliance is the top 45 cm for protection of human health.

b Upland soil point of compliance is the depth at which the RvAL is reached, not to exceed 15 ft.

jc If the SQS value of 12 mg/kg OC is not used because the TOC in a sediment sample is either higher or lower than 0.5 to 3.5%, then a site-specific calculation, or "surrogate," can be applied, which results in a value of 0.19 mg/kg dw.

cd This RvAL is lower than preliminary background concentration (Windward 2008) and has been adjusted upward. The background concentration forlowest LDW RBTC for arsenic is 1.3 mg/kg; however, the RvAL is 12 -mg/kg, which is similar to background concentrations being considered for arsenic.

de The TEE-based RvAL is 2.0 mg/kg in the upper 02 to 6 ft of soil for areas to be protective for terrestrial ecological exposures defined under MTCA and as determined by the type of biota to be present. The RvAL is 400 mg/kg for soils deeper than 6 ft.

ef These RvALs were established based on SQS values, which were originally presented in units of mg/kg OC. The OC-normalized units were converted to mg/kg dry weight using a TOC concentration of 1.55%, reflecting the average TOC concentration in the T-117 Sediment Study Area based on both surface and subsurface sample results. For PCBs, If the SQS value of 12 mg/kg OC is not used because the TOC value in a sediment sample is either higher or lower than 0.5 to 3.5%, then a site-specific calculation, or "surrogate," can be applied, which results in a value of 0.19 mg/kg dw.

fg These RvALs are likely to be lower than applicable background concentrations and may need to be adjusted upward.

gh TEE-based RvAL is 200 mg/kg in the upper 02 to 6 ft of soil for areas to be protective for terrestrial ecological exposures defined under MTCA and as determined by the type of biota to be present. The RvAL is 2,000 mg/kg for soils deeper than 6 ft.

hi TEE-based RvAL is 0.65 mg/kg in the upper 2 ft of soil for areas to be protective for terrestrial ecological exposures defined under MTCA. The RvAL is 1.0 mg/kg for soils deeper than 2 ft.

ij The point of compliance for the groundwater RvALs is the point of exposure or the location where groundwater discharges to surface water (see Figure 4-1).

BEHP – bis(2-ethylhexyl) phthalate

cPAH – carcinogenic polycyclic aromatic hydrocarbon

COC – contaminant of concern

dw – dry weight

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

LDW – Lower Duwamish Waterway

LPAH – low-molecular-weight polycyclic aromatic hydrocarbon

MTCA – Model Toxics Control Act

na – not applicable

nc – no criteria

nc – no criteria

OC – organic carbon

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RBTC – risk-based threshold concentration

RvAL – removal action level

SQS – sediment quality standards

SVOC – semivolatile organic compound

TEE – terrestrial ecological evaluation

TEQ – -toxic equivalent

TOC – total organic carbon

TPH – total petroleum hydrocarbons

4.4 REMOVAL BOUNDARY DETERMINATION

This section discusses the process for identifying the removal boundaries for each of the T-117 EAA study areas and presents the boundaries. Removal boundaries were determined based on RvALs for the identified T-117 COCs. The lateral extent of the removal boundary boundaries for each portion of T-117 EAA study areas is presented on Map 4-1. The area within the removal boundary is referred to as the removal area.

4.4.1 T-117 Sediment Study Area

A sediment removal boundary was developed in the 2005 EE/CA (Windward et al. 2005c) using a weight-of-evidence approach that included a comparison of site sediment chemistry data to SMS and consideration of COCs identified in the LDW HHRA (Windward 2007b) and ERA (Windward 2007a). Since that time, RBTCs were developed and preliminary background data were compiled for the LDW RI (Windward 2008). Although the LDW RI does not specify sediment action levels, a preliminary comparison presented in the RI showed that many of the RBTCs were less than background concentrations.

EPA's stated intention for the T-117 EAA is to sufficiently clean up the EAA so that future T-117 cleanup actions are not necessary under the LDW Record of Decision (ROD) (EPA 2007b). EPA therefore is requiring that the T-117 sediment cleanup boundary be based on a point-by-point RvAL rather than based on the previously approved weight-of-evidence approach that was used to derive the 2005 sediment removal boundary.

The sediment removal boundary shown on Map 4-1 has been delineated to encompass all sampling locations with PCB concentrations greater than the RvAL. Total PCBs was the most prevalent COC, and the PCB RvAL is primarily responsible for determining the delineation of the removal boundary. All other COCs with concentrations greater than their RvALs are also contained within the removal boundary. As discussed in Section 4.3.1, the depth of compliance is 45 cm.

4.4.2 T-117 Upland Study Area

The removal boundary for the T-117 Upland Study Area is presented on Map 4-1 and is discussed relative to each applicable upland COC in this section. PCBs, dioxins and furans, cPAH, arsenic and TPH were identified as COCs for the T-117 Upland Study Area. This boundary encompasses all of the areas where soil will be removed to meet the RvALs for the COCs both spatially and by depth (i.e., up to 15 ft deep) to allow for the broadest possible range of land uses in the future.

As required per SOW Amendment 1, a spatial analysis of the distribution of PCB and TPH concentrations (Maps 4-2 through Map 4-7) was used to verify that the proposed removal prisms (i.e., the three-dimensional removal boundaries) will be located and sized to ensure the removal of all soil that exceeds the RvAL. These maps were created using statistical interpolation to estimate PCB and TPH concentrations at locations other than those that were actually sampled, and thus introduce some uncertainty.

4.4.3 Adjacent Streets and Residential Yards Study Area

Two different types of soil samples have been collected from the Adjacent Streets and Residential Yards Study Area: point samples (i.e., single point surface and subsurface samples, including soil and monitoring well borings) and MIS samples. Both point and MIS samples are used to delineate Adjacent Street ROW cleanup boundaries, whereas MIS samples alone are used to delineate Residential Yards cleanup boundaries. Soils represented by point samples will be removed from areas with concentrations greater than 1 mg/kg PCBs.

Based on EPA's statistical evaluation of MIS sample triplicate data (Appendix L), EPA has directed that variability (as the upper confidence limit on the mean [UCL]) be incorporated into the establishment of CULs. Accordingly, soils represented by MIS samples will be removed from areas where the UCL is greater than 1 mg/kg. As described in Section 9.3.3.2, final soil excavation depths will be based on confirmation sampling to ensure that RvALs have been attained.

As discussed in Section 3, dioxins and furans are designated as COCs in areas where they are co-located with PCBs above the PCB RvAL, per administrative direction by EPA (2009a). Based on the forensic work completed by the Dioxin Technical Workgroup and their 2008 and 2009 findings (Appendix M). Measurable concentrations of dioxins are always present in urban soils because of the contributions from various typical combustion and chemical sources. Elevated dioxin concentrations on the T-117 Upland Study Area have been documented. Potential T-117 sources that contribute contaminants to nearby streets and yards include the track-out of PCB- or dioxin-contaminated soil, air emissions from the burning of PCB-contaminated waste oils, and typical oil-fired furnace air emissions. Data from numerous studies assembled and evaluated by the Dioxin/Furan Technical Workgroup indicate that levels of dioxins in the neighborhood are higher than would be expected from typical urban sources, such as vehicle or residential emissions. Given the PCB concentrations measured in the Adjacent Streets and Residential Yards Study Area and the results of chemical pattern analyses for samples with concentrations of dioxins and furans, the contribution of direct PCB track-out to total dioxin concentrations appears to be small. The overall apportionment between T-117 and non-T-117 contributions, primarily related to potential air emission pathways, remains uncertain. Given this current uncertainty, dioxins and furans are not being used independently to define removal boundaries at this time. However, in areas where removal actions are required for PCBs, dioxins and furans will remain a COC and will be included as part of confirmation sampling for the Adjacent Streets and Residential Yards Study Area. This will eliminate the potential that any given street or yard area will have to be re-excavated, should the uncertainty about total T-117 contributions be resolved in the future.

~~As discussed in Section 3, dioxins and furans are designated as COCs in areas where they are co-located with PCBs above the PCB RvAL, per administrative direction by EPA (2009a). Based on the forensic work completed by the Dioxin Technical Workgroup and their 2008 and 2009 findings (Appendix M), EPA has made the determination that the asphalt manufacturing facility operations were likely not the source of the majority of the dioxins and furans detected in the Adjacent Streets and Yards Study Area, and that the source of the dioxins and furans is as yet undetermined. However, based on an assumption that a minor portion of the dioxins and furans in the Adjacent Streets and Residential Yards Study Area may be associated with PCBs from asphalt manufacturing facility operations, EPA has directed that dioxins and furans be designated as COCs where co-located with PCBs above the PCB RvAL in the Adjacent Streets and Residential Yards Study Area (Appendix M).~~

In summary, cleanup in the Adjacent Streets and Yards Study Area will be guided by the following assumptions:

- PCBs ~~will be~~are the driver for streets and yards cleanup.
- Wherever PCB cleanup occurs, co-located dioxins will also be removed.
- Where PCB concentrations are below the PCB RvAL but dioxin/furan TEQs exceed the dioxin/furan TEQ RvAL, no cleanup will occur as part of this removal action.
- Post NTCRA PCB sampling will include analysis of dioxins and furans.

Additional dioxin and furan data are expected to be generated as a result of additional sampling in the LDW, at adjacent upland sites, and in stormwater conveyance systems. These data will provide information to better identify dioxin and furan sources and upland soils concentrations in the area and will help put the dioxin and furan concentrations in the Adjacent Streets and Residential Yards Study Area into broader perspective with respect to sources and possible future removal actions. Removal areas for Adjacent Streets and Residential Yards, based on the distribution of PCBs, are shown on Figure 4-1.

5 Recontamination Assessment

The long-term effectiveness of the planned NTCRA at the T-117 EAA relies on the identification, characterization, and control of potential recontamination sources and pathways as they may exist after completion of the removal action. To assess this future recontamination potential, this section:

- Provides an overview of the source control strategy
- Establishes the baseline condition for a post-NTCRA T-117 EAA and discusses potential recontamination sources and pathways
- Critically evaluates the potential for these sources/pathways to contribute to the recontamination of post-NTCRA sediments
- Provides recommendations for multi-media monitoring to ensure long-term protectiveness of the remedy

The recontamination assessment in this EE/CA is necessary to ensure that the potential for recontamination is addressed as part of the NTCRA design and through future source control actions by the responsible site owners, in coordination with the ongoing LDW-wide source control activities for the LDW Superfund Site. The potential for recontamination will also be considered in the design of post-NTCRA monitoring programs to help ensure the long-term effectiveness of the removal action.

This assessment builds upon the initial evaluation presented in the draft EE/CA (Windward et al. 2008) and takes into consideration newly obtained site data for soil, catch basin solids, and groundwater. Also considered are the results of Ecology's recent sediment recontamination assessment for the Marina (SAIC 2009)~~,~~ and the investigation of soil and groundwater at the Basin Oil property (Ecology 2009b)~~, and the findings of the sediment transport analysis presented in the LDW RI (Windward 2008) as it relates to the T-117 EAA~~.

5.1 Overall Source Control Strategy

Source control for the T-117 EAA is governed by the strategy outlined for the LDW (Ecology 2004a). The goal of the LDW strategy is to minimize the potential for chemicals in sediments to exceed the LDW sediment cleanup goals and the SMS (WAC 173-204). Ecology is the lead agency implementing source control; Ecology works in cooperation with local jurisdictions and EPA, together forming the LDW Source Control Work Group (SCWG), to pursue this goal. The member agencies of the SCWG rely upon a variety of tools and strategies to encourage, implement, and monitor source control activities within the LDW and adjoining drainage basins, including public education, implementation of source-tracing programs, evaluation of potential upland and in-water contaminant sources, and enforcement of requirements for the cleanup of contaminated sites and drainage systems that may have an ongoing or future potential to contaminate LDW sediment.

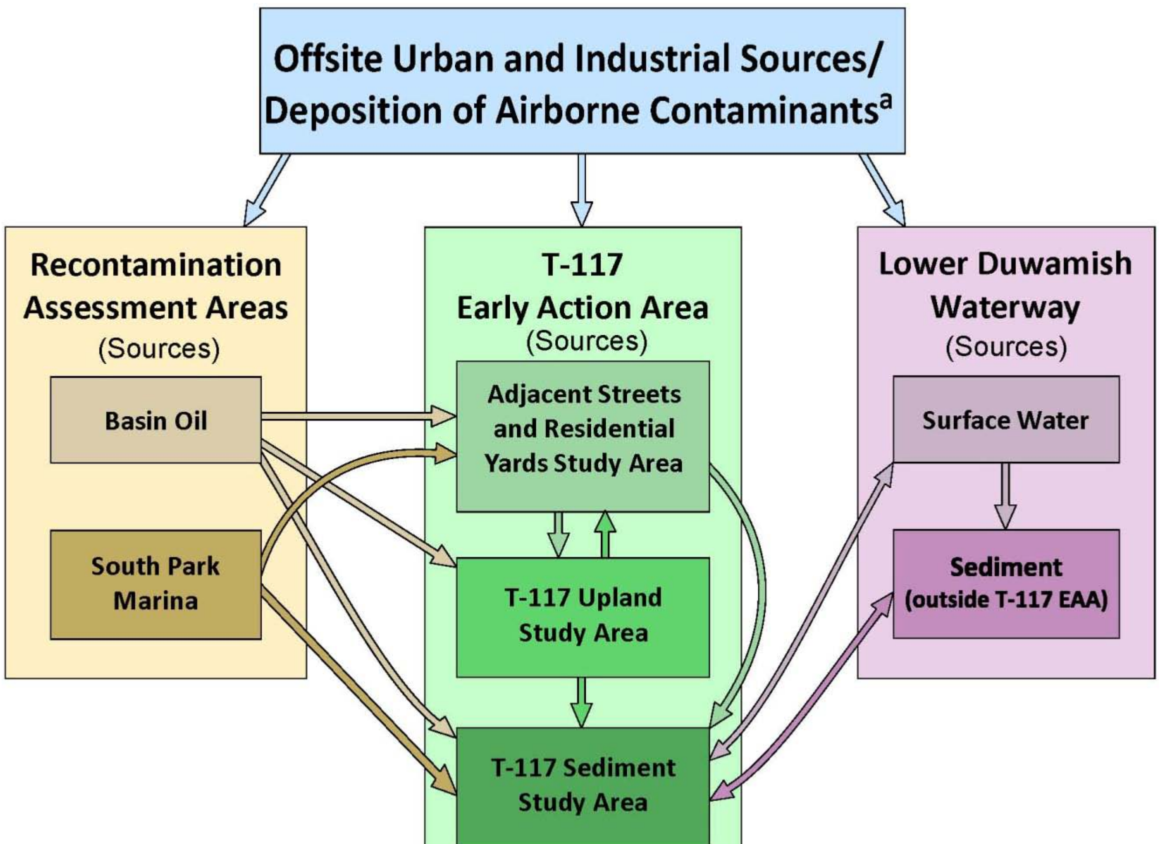
Ecology's source control investigation findings and plans for implementing source control activities at the LDW Superfund Site are documented in various data gaps reports and source control action plans (SCAPs) (Ecology and SAIC 2008). The original SCAP for the T-117 EAA (Ecology 2005a) was published relatively early in the LDW source control process and, thus, did not include the results of later investigations and evaluations of groundwater and potential contaminant sources and pathways associated with the expanded T-117 EAA and adjacent properties (i.e., the Marina and Basin Oil property). Nonetheless, the T-117 EAA has continued to be a high priority for Ecology and the SCWG. The T-117 EAA SCAP identified storm drain outfalls and soil from Basin Oil, the former A&B Barrel, the T-117 Upland Study Area, and the Adjacent Streets as potential sources of recontamination to the sediment. Ecology recently completed a sediment recontamination assessment for the Marina (SAIC 2009) and site investigations at the inactive Basin Oil property (Ecology 2009b). Ecology also performed a facility review of Boeing South Park and determined that the likelihood of recontamination from stormwater discharges from parking lot runoff and non-contact cooling water from air conditioners to the LDW is low (Ecology 2004c). The City and the Port have also conducted source control-related activities, including the implementation of drainage controls, independent cleanup actions, catch basin monitoring, and bank stabilization of the T-117 shoreline. Subsequent~~Ongoing~~ source evaluation work by the Port and other SCWG members includes ongoing groundwater monitoring and the evaluation of the stormwater drainage system design and monitoring at the Marina. ~~All of these post-SCAP activities and results are discussed in Section 2. SCAP activities identified but not yet completed include the verification of compliance with the NPDES permit requirements and the verification of catch basin drainages and discharge locations, connections to the sanitary sewer, and the presence of any septic systems.~~ Ecology recently identified the ongoing EE/CA process as the principal vehicle for advancing source control for the T-117 EAA (Ecology and SAIC 2008).

5.2 Potential Post-NTCRA Recontamination Sources and Pathways

The interrelationships between the potential pathways and associated source areas that may affect the post-NTCRA T-117 EAA are complex. Since the cessation of asphalt manufacturing operations in the mid-1990s, the potential for recontamination of soils has largely been restricted to the redistribution of existing contaminants. The ~~NTCRA~~ removal action described in this EE/CA~~s~~ is~~are~~ expected to remove the potential for recontamination to upland, street, and yard soils from this historical source. Thus, this section focuses on the potential for recontamination of post-NTCRA sediment.

Figure 5-1 provides an overview of the potential sediment recontamination routes relevant to the T-117 sediment area after completion of the removal action. The T-117

Upland Study Area and the Adjacent Streets and Residential Yards Study Area are either adjacent to or upgradient of the T-117 Sediment Study Area, which is located between RM 3.5 and RM 3.7 on the west side of the waterway within the LDW Superfund Site. The neighboring Marina and Basin Oil property are not geographically within the T-117 EAA but are considered to be potential upland source areas (referred to as RAAs). Although the NTCRA will not include the cleanup of these areas, they are evaluated in this EE/CA relative to their potential to contribute to the recontamination of the T-117 Sediment Study Area. ~~and are thus included in this analysis inasmuch as they may serve as potential sources of recontamination to the EAA.~~ The scope of work for the NTCRA (EPA 2007c) ~~also~~ stipulates that the RAAs must be considered in view of their recontamination potential.



[a] Deposition of airborne contaminants has been theorized for the T-117 EAA. King County (2008) has measured airborne deposition at various locations within the Duwamish corridor. However, no data are currently available to determine if urban and industrial sources not within the T-117 EAA are impacting the T-117 EAA and the rate at which airborne contaminants may be deposited at the site.

Figure 5-1. Overview of post-NTCRA potential sediment recontamination source areas and routes at the T-117 EAA

Potential sources of COCs and pathways to the post-NTCRA T-117 EAA sediment discussed in this section include:

- Erosion and transport of onsite surface soil not isolated after the completion of the removal action
- Erosion and transport of surface or subsurface soil from adjacent properties
- Transport of contaminants via stormwater (including entrained soil/sediment and airborne contaminants)
- Migration and discharge of onsite and offsite contaminated groundwater from the T-117 EAA and RAAs to LDW sediiment
- Transport and deposition of LDW sediment (upstream contributions and impacts from other removal actions)Transport and deposition of LDW sediment, including upstream contributions, and potential impacts from other nearby in--water actions that may occur prior to the implementation of the LDW remedy (e.g., a RCRA action or interim measure that addresses sediment adjacent to Boeing Plant -2)
- Sorption from LDW surface water
- Atmospheric deposition to the water surface and to surfaces in contact with stormwater discharging to the river

The section is organized to first present the more localized potential sources and pathways (e.g., soil, groundwater) followed by larger-scale potential sources and pathways (e.g., upstream sediment, atmospheric deposition). The order in which the information is presented does not necessarily imply the relative importance of the pathway. Figure 5-2 presents a conceptual view of the potential pathways that are discussed further in this section.

Slipsheet for (11x17)

Figure 5-2. T-117 EAA possible post-NTCRA recontamination routes

5.2.1 Erosion and transport of surface soil

This section provides a discussion of the potential for sediment recontamination via surface soil erosion from each of the upland source areas, including the T-117 Upland Study Area, Adjacent Streets and Residential Yards Study Area, the Marina, and Basin Oil property. Post-NTCRA T-117 EAA sediment could potentially be recontaminated through bank erosion and stormwater transport of contaminated surface soils ~~from upland source areas~~not otherwise addressed through the removal action or post-removal action monitoring and controls.

5.2.1.1 T-117 Upland Study Area soil

As part of the T-117 EAA NTCRA, contaminated surface, shallow subsurface, and bank soils will be removed and disposed of offsite, and the removal areas will be backfilled with clean soil or covered with clean fill or capped if they are located within the intertidal area. Therefore, upon completion of the NTCRA, the potential for any remaining soils from the T-117 Upland Study Area to impact LDW sediment quality will be significantly reduced if not eliminated.

Residual contaminants, if present, would be located at depth and are expected to be at concentrations below their respective RvALs or will be capped. Measures will be taken to isolate any remaining subsurface contaminants that might be exposed through modified site topography. This isolation will be achieved through soil excavation and, where necessary, through the placement of clean, imported backfill materials to establish the post-NTCRA topography. This removal and isolation action is particularly important in areas where the final site use may include enhanced aquatic habitat and where the upland topography will be lowered to increase the intertidal surface area. In summary~~Thus~~, the NTCRA will~~is~~ be~~ing~~ designed to ensure the effective long-term isolation of any remaining contaminants in soils in the T-117 Upland Study Area.

5.2.1.2 Adjacent Streets and Residential Yards Study Area soil

The adjacent streets and residential yards that have been cleaned up are expected to be minor~~imal~~ sources of PCB contribution to the T-117 Sediment Study Area. Soil from some yards with elevated dioxin/furan concentrations will not be removed as part of this cleanup action. PCB and dioxin/furan concentrations are elevated around two of the T-117 Upland Study Area catch basins (CB-3 and CB-5). To date, the source of these contaminants has not been identified, and further investigation~~s~~ is being conducted. The possibility that the contaminants may have come from the Adjacent Streets and Residential Yards Study Area has not been ruled out. When the removal action in the Adjacent Streets and Residential Yards Study Area is complete, the concentrations of contaminants in stormwater that discharges~~ing~~ to the T-117 Sediment Study Area may resemble those in stormwater from similar LDW stormwater sub-basins. This possibility will be confirmed through ~~subject to empirical~~

sampling verification. The erosion of surface soils from yards and unpaved street shoulders in the Adjacent Streets and Residential Yards Study Area, with subsequent transport to the T-117 Sediment Study Area or CSS, has also been identified as a potential post-NTCRA recontamination pathway. Although soils entrained in stormwater flows could reach the LDW through various storm drain systems that discharge to the waterway (see Section 5.2.2.2), this post-NTCRA pathway is expected to be minimal because of street pavement and vegetative cover in the yards.

Recent independent cleanup actions for the Adjacent Streets (Integral 2006b) have included the paving of streets and either the paving of the gravel shoulder areas or removal of contaminated material in the unpaved road shoulders and replacement with clean gravel. NTCRA cleanup actions for the Adjacent Streets will include the removal and offsite disposal of remaining contaminated soil. Where soil is removed, these areas will be backfilled with clean soil resulting in the attainment of RvALs in the remaining surface or near-surface soil. Upon completion of the NTRCA, the majority of the Adjacent Streets will be repaved and curbed to meet current City design standards, greatly minimizing the potential for the transport of residual low-level surface soil contaminants from this area. In addition, these actions should greatly limit the potential for wind-erosion of surface soils.

5.2.1.3 South Park Marina soil

In 2007 and 2008, Ecology collected soil, sediment, and groundwater samples at the Marina. As described in the subsequent recontamination assessment report (SAIC 2009), the sampling focused on the location of a former disposal pond associated with the former A&B Barrel recycling facility on the Marina property. Work included the advancement of 16 soil borings to depths that rangeding from 2.5 -to 20 ft. Ecology reported a number of exceedances of MTCA CULs as well as draft soil-to-sediment and groundwater-to-sediment SLs developed by Ecology for COCs at the Marina. Subsequent to this data collection work and initial screening, Ecology concluded that the potential for these COCs to reach the LDW was not clearly established. For example, groundwater showed only limited exceedances of Ecology's CULs and draft SLs. As stated in the recontamination assessment report (SAIC 2009), river bank soil samples also had a number of exceedances, but the link between these COCs and those in the intertidal sediment was uncertain. In order to evaluate and resolve these uncertainties, a sediment recontamination assessment was conducted (SAIC 2009). completed a sediment recontamination assessment for the Marina (SAIC 2009) based on the results of soil, groundwater, and sediment sampling activities conducted in 2007 and 2008. The investigation identified a number of contaminants with concentrations in soil that exceeded MTCA CULs and draft soil-to-sediment and groundwater-to-sediment SLs used by Ecology and described in the investigation report (SAIC 2009). The sampling focused on the location of a former disposal pond in the vicinity of the Marina and included the advancement of 16 soil borings to depths ranging from 2.5 to 20 ft. Although the presence of elevated contaminant

~~concentrations in upland soil was documented, it was unknown whether these soils could migrate to the LDW. Therefore, a quantitative recontamination assessment was undertaken using a conservative fate and transport analytical model (SAIC 2009).~~ Results showed that any potential erosion and transport of COCs in soils from the Marina would have little effect on COC concentrations in the post-NTCRA T-117 EAA sediment. Table 5-1 presents the soil and groundwater COCs identified and evaluated by Ecology in their source control study of the Marina.

Table 5-1. Concentrations of ~~Contaminants of concern~~ COCs identified ~~by Ecology for~~ at the Marina compared with T-117 Upland Study Area removal action levels

COC~~s~~	Maximum Concentration in Groundwater (~~µ~~µg/L)[a]		T-117 Upland Study Area Groundwater RvALs (~~µ~~µg/L)[b]	Maximum Concentration in Soil (mg/kg)[a]		T-117 Upland Study Area Soil RvALs (mg/kg)[b]
	Min	Max		Min	Max	
Metals						
Arsenic	1.56	8.07	5	1.0	~~9.4~~10.8	7.3
Cadmium	0.022	0.091	~~NS~~ns	0.021	31.4	ns
Chromium	1.31	40.4	~~NS~~ns	6.04	465	ns
Copper	2.83	9.83	~~3.4~~ns	5.43	198	ns
Lead	0.192	0.519	ns	1.18	3180	ns
Mercury	0.00115	0.0~~0~~156~~9~~	ns	0.004	29.5	ns
Silver	0.01 U	0.005	1.9	0.038	0.299	2.0/400[c~~b~~]
Zinc	2.93	5.2	ns	14.8	1,510	ns
PCBs						
Total PCBs	0.2 U	0.21 U	0.01	0.0059	36	0.65/1.0[d]
PAHs						
cPAH TEQ	nc	~~U~~nc	0.15	0.0017	1.01	0.14~~008~~
TPH						
~~Gasoline-range organics~~		~~U~~	~~ns~~		~~U~~	~~ns~~
Diesel-range organics	0.2 U	0.21 U~~U~~	500	1.8 U	~~23~~12,000 J	200/2,000[e]
Residual-range organics	0.2 U	0.21 U~~U~~	500	6.5 U	~~21~~27,000 J	200/2,000[e]

[a] ~~-~~Source: SAIC (2008).

[b] Soil RvALs as defined in Section 4.

[c] The TEE-based RvAL is 2.0 mg/kg in the upper 0 to 6 ft of soil for areas where the terrestrial ecological exposure scenario defined under MTCA is applicable. The RvAL is 400 mg/kg for soils deeper than 6 ft.

[d] TEE-based RvAL is 0.65 mg/kg in the upper 2 ft of soil for areas where the terrestrial ecological exposure scenario~~s~~ defined under MTCA is applicable. The RvAL is 1.0 mg/kg for soils deeper than 2 ft.

[e] TEE-based RvAL is 200 mg/kg in the upper 0 to 6 ft of soil for areas where the terrestrial ecological exposure scenario defined under MTCA is applicable. The RvAL is 2,000 mg/kg for soils deeper than 6 ft.

COC – contaminant of concern RvAL – removal action level

DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
MTCA – Model Toxics Control Act
nc – not calculated
ns – not specified
PCB – polychlorinated biphenyl
SAIC – Science Applications International Corporation
SVOC – semivolatile organic compound
TEE – terrestrial ecological evaluation
TPH – total petroleum hydrocarbons
U – not detected at given concentration
VOC – volatile organic compound

Ecology's recontamination assessment (SAIC 2009) considered the erosion of bank contaminants and the migration of COCs in groundwater to LDW sediment. The recontamination assessment concluded that COCs associated with soil at the Marina might cause recontamination of the LDW if soil particles were to erode~~d~~ and be transported to the LDW by stormwater. The owners of the Marina recently provided a map of the storm drain system at the Marina (Crow 2010). The quality of storm solids in the facility's catch basins that could eventually be transported to the T-117 Sediment Study Area will be assessed during the removal action design phase (See Section 9.4). If the stormwater pathway is determined to pose~~s~~ a risk of sediment recontamination, additional soil erosion and/or stormwater controls or monitoring will be required. These will be developed in cooperation with the Marina owner and in consultation with Ecology.

5.2.1.4 Basin Oil property soil

Ecology initiated an investigation of surface and subsurface soil and groundwater conditions at the Basin Oil property in 2009 through the collection of 10 soil borings to depths of 14 to 16 ft at various locations throughout the property (see discussion of Basin Oil investigation sampling locations and results in Section 2.4.1). Soil samples from the 0-to-6-in. depth were analyzed, and many of the COCs identified for the T-117 Sediment Study Area (PCBs, TPH, PAHs, phenol) were detected. Boring logs from the investigation indicated the presence of slight to moderate sheens at some borehole locations in shallow soils (1 to 2 ft) and again at the 7-to-8-ft depth range. These sheens were likely associated with the detectable organic vapors recorded using field instrumentation, as noted on the boring logs. Soil samples from the near-surface interval (0-to-6-in. depth) and the deepest interval from each boring were submitted for analysis; the remaining samples were archived.

Petroleum hydrocarbons (i.e., diesel, lube oil, and gasoline-range organics) were detected in the near-surface soil samples, particularly at boreholes BSB-6 through BSB-10. PAHs were also detected in the shallow soil from borehole BSB-1. Gasoline-range organic compounds and LPAHs were detected in shallow soil samples from BSB-7 and BSB-10. Other contaminants detected at the Basin Oil property included PCB Aroclor 1260, BEHP, arsenic, and dioxins and furans. As described in Section 3.3.4, Basin Oil groundwater and soil data (Ecology 2009b) were screened using the SLs developed for the T-117 EAA in Section 3.3.2. Concentrations of arsenic, total PCBs, TPH, nickel, cPAHs, ethylbenzene, xylenes, and carbazole were greater than their respective SLs in

Basin Oil soil. However, the concentrations of these contaminants were below soil RvALs (Section 4.3.3), and thus, the contaminants from this RAA do not pose a potential for recontamination of T-117 soil. No PCB concentrations were detected in surface soil, and the highest dioxin/furan TEQ was 1.59 ng/kg; thus, the contaminants from this RAA do not pose a potential for recontamination of T-117 sediment.

5.2.1.5 Soil pathway summary and post-NTCRA monitoring recommendations

The activities to be completed as part of the NTCRA as well as those planned for the Adjacent Streets and Yards are expected to eliminate the potential for surface soils to recontaminate post-NTCRA T-117 EAA sediment at concentrations above the proposed RvALs. In addition, evaluations of recontamination potential from soils from the Marina and Basin Oil property indicated a low potential for LDW PCB recontamination of T-117 sediment recontamination from these sources. A plan for monitoring stormwater solids and sediment quality after the removal action will be developed and implemented. The plan will include adaptive management response measures to be implemented in the event monitoring data indicate the potential for sediment recontamination.

5.2.2 Stormwater transport

As discussed in Section 5.2.1, one pathway for contaminants to reach the T-117 Sediment Study Area is via stormwater runoff. Urban runoff carries contaminants from various sources, including soil, fertilizers and pesticides from yards and gardens, spills, drips from automobiles, tire wear, road surface wear, and atmospheric deposition. Available information regarding stormwater runoff from the T-117 Upland Study Area, Adjacent Streets and Residential Yards Study Area, the Marina, and Basin Oil property is discussed below.

5.2.2.1 T-117 Upland Study Area stormwater

Historically, contaminated surface soils within the T-117 Upland Study Area likely served as a source of contamination to the LDW via several pathways, including the stormwater pathway (Ecology 2005a). More recently, much of the T-117 Upland Study Area, except the upper bank area immediately east of the edge of the T-117 Upland Study Area pavement, has been paved, isolating most of the underlying contaminated soils from stormwater. In the future, and as discussed above in Section 5.2.1.1, planned NTCRA actions will include the removal of upland soils with COC concentrations greater than the RvALs followed by backfilling or capping with clean materials. Nevertheless, stormwater runoff will continue to originate on the surface of the T-117 Upland Study Area. This runoff will discharge to the LDW through existing or newly constructed conveyances, swales, and outfalls; via sheet flow or infiltration through permeable surfaces (e.g., vegetated or gravel-covered shoreline areas). Stormwater could become contaminated through the deposition of regional airborne contaminants (as discussed in Section 5.2.6) or as a result of future onsite activities.

PCBs, PAHs, dioxins and furans, and some metals were detected in recent (2009) solids samples collected within and adjacent to catch basins CB-3 and CB-5 (Map 2-1). Some of the contaminants (i.e., PCBs and PAHs) in the~~The contaminated~~ solids adjacent to the catch basin could have potentially originated from atmospheric deposition because these same contaminants have been observed in atmospheric deposition samples elsewhere in the Duwamish corridor (King County 2008) or from surface soil at the top of ~~within~~ the ~~T-117~~ unpaved bank at the east side of the T-117 Upland Study Area. The NTCRA will remove any T-117 Upland Study Area sources through the remediation of contaminated surface soils. In addition, new drainage systems for the T-117 Upland Study Area will be designed to include BMPs for retaining solids (e.g., sumps, swales, or filters) and will be required to meet the City code as described below for the Adjacent Streets and Residential Yards Study Area. Solids that accumulate in these new drainage systems will also be monitored for COCs as described further in Section 9.4

5.2.2.2 Adjacent Streets and Residential Yards Study Area stormwater

Following cleanup of the Adjacent Streets and Residential Yards, a permanent drainage system will be constructed to collect and treat runoff from the approximately 1.7-ac area that is currently served by the temporary system that was installed by SPU as part of the interim cleanup that occurred in December 2004 (Map 2-2). This area includes approximately 1.1 acres of public ROW in the triangle-shaped area formed by the intersections of 17th Avenue S, Dallas Avenue S, and S Donovan Street, as well as about 0.6 acres of private property (Basin Oil and the hillside adjacent to S Donovan Street). Treated runoff from this area will be discharged to the T-117 Upland Study Area as it was prior to the 2004 interim cleanup. Runoff from the Residential Yards outside this area that will be affected by the cleanup will continue to be discharged to the combined sewer system (Map 2-2).

Samples collected to date from streets and catch basins adjacent to T-117 indicate that except for PCBs, the concentrations of other LDW contaminants of concern are comparable to those found in urban streets and storm drains sampled throughout the LDW. As described in Section 2.3.3.1, elevated concentrations of PCBs were found in ROW soils in 2004, which led SPU to conduct an interim action to protect residents in the area from being exposed to PCBs by removing and/or capping the PCB-contaminated soil. Recent samples collected from the temporary drainage system indicate that the 2004 interim cleanup has been effective in containing PCBs. Table 5-2 compares the results for sediment samples collected from catch basins in roadways adjacent to T-117 with the results from 124 to 133 ROW catch basins throughout the LDW (number of samples varies depending on the parameter analyzed). These LDW ROW catch basin samples are considered to be representative of the stormwater solids that will originate from the roadways in the vicinity of the T-117 EAA following the NTCRA. As shown in Table 5-2, concentrations in samples from the temporary storm drains generally fall within the lower range of concentrations detected in other roadway samples. The samples collected from the Dallas Avenue S storage tanks contain higher levels of metals, but because these samples contained a large amount of rust from weathering of the tanks, they are probably not representative of metals concentrations in the roadway solids.

Table 5-2. Stormwater sampling results

Contaminant	Unit	SQS/ LAET	CSL/ 2LAET	T-117 Temporary Storm Drain System Sampling Locations and Dates								Lower Duwamish ROW Catch Basins[c]				
				Concentrations									Concentrations			
				CB1-DAL (CB) 03/22/05[b]	CB2-DAL (CB) 03/22/05[b]	CB2-DAL (CB) 03/10/10	CB3-DAL (CB) 03/22/~~05~~[b] 05[a]	SW1/ Tanks (Tank) 02/25/08	SW1/ Tanks (Tank) 03/10/10	RCB 101 (CB) 03/14/07[b]	CB4-DAL (CB) 03/10/10	n	Min	Max	Median	Mean
Arsenic	mg/kg dw	57	93	na	na	10 U	na	**20**	30 U	7 U	**8**	129	3	750	9	18
Copper	mg/kg dw	390	390	na	na	**147**	na	**472**	**284**	**50.6**	**143**	128	9.1	4,520	99	168
Lead	mg/kg dw	450	530	na	na	**237 J**	na	**450**	**250 J**	**22**	**67J**	129	4	3,690	89	168
Mercury	mg/kg dw	0.41	0.59	na	na	**0.08**	na	0.08 U	**0.33**	0.05 U	**0.04**	129	0.02	2.2	0.07	0.17
Zinc	mg/kg dw	410	960	na	na	**571**	na	**1,890**	**1,040**	**237**	**588**	128	58	3,650	333	464
TPH – diesel	mg/kg dw	2,000[d]	nc	na	na	**530**	na	na	**900**	730 U	75U	124	35	6,800	370	917
TPH – oil	mg/kg dw	2,000[d]	nc	na	na	**2,300**	na	na	**3,500**	**4,100**	**550**	124	110	20,000	2,350	3,669
Total LPAH	µg/kg dw	5,200	13,000	na	na	**3,270 J**	na	**120**	**1,100 J**	**180 J**	**110**	133	14	8,900	310	895
Total HPAH	µg/kg dw	12,000	17,000	na	na	**8,060 J**	na	**1,272**	**7,480 J**	**1,160**	**1,226 J**	133	42	36,520	1,603	3,768
BEHP	µg/kg dw	1,300	1,900	na	na	**21,000**	na	**6,200**	**18,000**	**2,500**	**1,600 J**	126	24	36,520	1,957	3,977
Total PCBs	µg/kg dw	130	1,000	**23,000**	**14,000**	**420 NJ**	**3,900**	**350**	**620NJ**	**310**	**560 NJ**	133	10	23,000	64	670

[a] Catch basins cleaned after sampling.

[b] Same as CB4-DAL.

[c] Samples collected from catch basins located in the right-of-way throughout the Lower Duwamish Waterway study area. Non-detected values are included in the summary statistics at their detection limits.

[d] MTCA Method A soil CUL for unrestricted use.

BEHP – bis(2-ethylhexyl) phthalate
CB – catch basin
CSL – cleanup screening level
CUL – cleanup level
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
J – estimated concentration
LAET – lowest apparent effects threshold
2LAET – second lowest apparent effects threshold
Bold identifies detected concentrations.

LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
N – tentative identification (presence or identity of the analyte is in doubt and the reported concentration is estimated)
na – not analyzed
nc – no criteria
PCB – polychlorinated biphenyl
ROW – right-of-way
SQS – sediment quality standards
U – not detected at given concentration

~~As discussed in Section 2, runoff from the portion of the Adjacent Streets and Residential Yards Study Area located just east of 17th Avenue S (approximately 1.7 acres) is a potential post-NTCRA recontamination pathway to the T-117 Sediment Study Area (Figure 5-2). Runoff from this area is currently collected and conveyed by a temporary stormwater system to storage tanks, where it is subsequently released at a controlled rate to the CSS at 17th Avenue S and S Donovan Street (Section 2.2). The City obtained discharge authorization from the King County Industrial Waste Program for this discharge; as part of the authorization, SPU tests the quality of water discharged to the CSS every month in which discharges occur. Since 2005, PCBs have been detected once (in January 2008) in the runoff collected by the temporary system at a concentration of 0.12 µg/L (Appendix C). This detection does not represent a recontamination concern to the LDW because it is an isolated detection and the reported concentration was only slightly above the method detection limit. The majority of the stormwater represented by this sample was discharged to the CSS, which is conveyed to the County's wastewater treatment plant.~~

~~After the NTCRA, the temporary stormwater system will be replaced with a permanent collection and treatment system, and runoff from the entire area currently served by the temporary system will be discharged to the LDW in the vicinity of the T-117 EAA. The new system will be designed in accordance with the SMC 22.800 and the Seattle Department of Planning and Development Director's Rules (City of Seattle 2009a), which establish specific requirements and procedures for designing and constructing facilities that treat stormwater prior to release to adjacent surface waters. The potential for runoff from the Adjacent Streets and Residential Yards Study Area to be a significant source of recontamination to post-NTCRA T-117 EAA sediment is therefore considered to be limited by the above-described controls. In addition, previous remediation efforts at residential yards and planned paving upgrades will greatly limit the potential for stormwater contamination from this area, thus controlling contaminants that might otherwise reach post-NTCRA T-117 EAA sediment at concentrations above selected RvALs. Runoff from the remainder of the Adjacent Streets and Residential Yards Study Area (generally west of 17th Avenue S) is directed to the CSS, which occasionally overflows to the LDW. The nearest CSO (operated by the County) is located at 8th Avenue S and discharges to the LDW approximately 3,800 ft downriver of the T-117 EAA. County records show that this CSO has not overflowed in the past 10 years.~~

~~Contaminants from this area (primarily from the road shoulders on 16th Avenue S and S Donovan Street) could become entrained in stormwater that discharges to the CSS. Although the cleanup is expected to significantly reduce or eliminate PCB discharges to the CSS, it is likely that TPH, PAHs, and metals, which are commonly found in urban runoff in the Study Area and other urban areas in the vicinity, will remain at concentrations typical of urbanized environments.~~

After the cleanup and removal of PCB-contaminated soil in the ROW, runoff from the Adjacent Streets is expected to be similar in quality to runoff from other urban areas and as such can be managed in accordance with existing City stormwater management program/policies and the City's NPDES municipal stormwater permit. In 2009, the City updated its stormwater code (SMC 22.800) and associated technical manuals (City of Seattle 2009a) to comply with its NPDES permit. Ecology has reviewed and approved both as being equivalent to the *Stormwater Management Manual for Western Washington* (Ecology 2005b).

The method of treating runoff from the Adjacent Streets will be determined during design. Options include biofiltration swales, filter strips, bioretention cells, wet vaults, and media filtration. These treatment technologies have all been approved by Ecology for urban stormwater treatment and are considered to be effective in removing 80% or more of the total suspended solids present in stormwater (Ecology 2005b). Because many of the pollutants typically found in urban runoff (e.g., metals, petroleum hydrocarbons and other organic compounds) are hydrophobic and tend to adsorb to particulates, these treatment systems are also effective in removing other pollutants. Considering that treatment will be applied and given the relatively small drainage area (1.7 ac), the post--project stormwater pollutant loadings to the T-117 Sediment Study Area from the Adjacent Streets will be low. Therefore, the potential for T-117 sediments to recontaminate after cleanup is expected to be low.

Post-remedial monitoring of the T-117 Sediment Study Areas and stormwater solids will provide an indication of how effective upland actions in the Adjacent Streets and Residential Yards Study Area have been. For all contaminants, not just PCBs, stormwater monitoring results will be compared with a range of regulatory and guidance values to evaluate the presence and relative scale of this line of evidence and the potential for recontamination. Decisions regarding the need for additional source control, such as increased BMPs or additional treatment, will be made in consideration of needed load reduction estimates.

5.2.2.3 South Park Marina stormwater

Ecology's sediment recontamination assessment of the Marina (SAIC 2009) evaluated the potential for post-NTCRA T-117 EAA sediment to be recontaminated by COCs identified at the Marina through erosion and groundwater ~~the stormwater~~ discharge ~~pathway~~. The quantitative assessment used an analytical model, which generally concluded that the ~~stormwater~~ transport of COCs from the Marina has had and will continue to have little effect on COC concentrations in T-117 EAA sediment. Although the assessment did not specifically include the sampling of solids from the Marina catch basins,~~Thus,~~ COC loading from the Marina is expected to be minimal, in part because the southern-most catch basin at the Marina discharges through a general stormwater NPDES-permitted shoreline outfall fitted with an oil/water separator and a sand filter (StormwateRx®) (see Section -2). Required monitoring of this outfall by the

Marina owner will provide limited information to support the assessment of this potential pathway~~e long-term effectiveness of the NTCRA~~. I~~ However, i~~t is generally recognized that NPDES monitoring may not always address all COCs that may need to be considered to protect LDW sediment. Post-~~-~~NTCRA monitoring of the T-117 sediment removal area should detect recontamination that may originate from this potential source.

~~The stormwater system at the Marina has not been completely mapped, and this is currently a data gap relative to the complete evaluation of this RAA. Additional work will be performed prior to the NTCRA to characterize the stormwater conveyance system at the Marina and to verify stormwater drainage areas and points of discharge (i.e., to the LDW or the CSS).~~

5.2.2.4 Basin Oil property stormwater

~~Information regarding the quality of surface soil at the Basin Oil property is provided in Section 2.4.1. As discussed in Section 5.2.1.4, petroleum hydrocarbons and other contaminants were detected in surface and near-surface soil samples collected by Ecology.~~ Currently, runoff from the property is largely contained onsite because of excavation activities that have prevented most runoff from exiting the property. Only the driveway entrances currently drain offsite. In the future, unconfined contaminated surface soil, contaminants associated with future activities at this site, or airborne deposited materials at the Basin Oil property will have the potential to reach the post-NTCRA T-117 EAA sediment via the storm drain infrastructure planned for portions of the Adjacent Streets and Residential Yards Study Area. This new stormwater conveyance will eventually discharge to the LDW in the vicinity of the T-117 Sediment Study Area. ~~In order t~~To prevent potential sediment recontamination, contaminated surface and subsurface Basin Oil soil~~s at the Basin Oil property must be addressed by~~will be cleaned up (e.g., by removal or capping) before the NTCRA. If this is not feasible and soil can only be addressed post-NTCRA, additional care and source control measures will be needed. Once~~ the site owner (e.g., through removal, capping) in consultation with Ecology before the NTCRA occurs. When~~ these soils have been addressed, it is expected that the property will be a minimal source of contamination to sediments.

5.2.2.5 Stormwater pathway summary and monitoring recommendations

~~T~~The preceding discussions indicate that it is unlikely that post-NTCRA T-117 EAA sediment will be contaminated at concentrations above the RvALs as a result of stormwater discharge. New stormwater systems installed at the site will be required to meet the treatment requirements of SMC 22.800 and the SPU Director's Rule 20-005 (SPU), 17-2009 (DPD) (City of Seattle 2009a) that sets forth specific source control measures under the code.

Storm drain solids in the new stormwater system will also be monitored to verify that site-related contaminants are not present at elevated concentrations. The potential for the enrichment of contaminants in the finer-fraction soils and the increased potential for the transport of fine-grained materials will be considered in the selection of monitoring and analytical approaches. Planning for this monitoring will be included in the long-term post-NTCRA monitoring plan for the T-117 EAA. Monitoring in the Adjacent Streets and Residential Yards Study Area may be supplemented by ~~accomplished as part of~~ the City's source-~~-~~tracing program, which ~~that~~ is conducted in collaboration with the LDW SCWG. Details of the monitoring program for the T-117 EAA will be tailored to the specific design of the stormwater conveyances. In addition, T-117 EAA sediments in the vicinity of stormwater discharges ~~may~~ will be monitored as part of the long-term sediment monitoring plan.

5.2.3 Groundwater discharge

After completion of the NTCRA, groundwater will continue to discharge to the T-117 Sediment Study Area and could potentially be a pathway for recontamination of post-NTCRA T-117 EAA sediment. The potential for this pathway to recontaminate post-NTCRA sediment is discussed in detail in Appendix B and summarized in the following subsections.

5.2.3.1 T-117 Upland Study Area groundwater

As part of the NTCRA, contaminated surface and subsurface soil will be removed from the T-117 Upland Study Area to meet the RvALs at the specified compliance depths detailed in Section 4. This removal will greatly reduce the potential for residual soil contaminants to partition to groundwater. Even under current conditions at the T-117 Upland Study Area, the potential for contamination of sediment via groundwater discharge is low (see Appendix B), and this will be verified through groundwater monitoring (see Section 5.2.3.5). These empirical data and lines of evidence demonstrate that groundwater is not causing sediment recontamination under current conditions. It can therefore be inferred that groundwater will not result in sediment recontamination after contaminated soils have been removed from the upland site.

5.2.3.2 Adjacent Streets and Residential Yards Study Area groundwater

Information on the concentrations of contaminants in groundwater beneath this area is limited. However, given the nature and extent of the contamination within the Adjacent Streets and Residential Yards Study Area (i.e., shallow soils contaminated primarily with PCBs and dioxins and furans) and the planned removal of contaminated soil as part of the NTRCA, it is unlikely that water infiltrating through any exposed soils (i.e., lawns or street ROW soils) will leach contamination to groundwater (Appendix B). Thus, it is unlikely that contamination transported via the groundwater pathway from the Adjacent Streets and Residential Yards Study Area will impact the post-NTCRA T-117 EAA sediment above the RvALs. ~~The need for~~ The number and placement of additional wells in Adjacent Streets will be evaluated during the NTCRA design phase.

5.2.3.3 South Park Marina groundwater

As discussed above, Ecology recently completed a sediment recontamination assessment of the Marina as part of its lead role for implementing source control in the LDW (SAIC 2009). The assessment concluded that groundwater transport from the Marina is predicted to have little effect on sediment. Sediment sampling in 2008 verified that elevated Marina groundwater contaminants (i.e., arsenic, dieldrin, tetrachloroethylene [PCE], and mercury) were not elevated in the adjacent Marina sediment (SAIC 2008); only PCB concentrations in the Marina sediment were elevated above the RvALs.

In addition, a net groundwater flow map (Map 2-75) was prepared for the T-117 Upland Study Area based on the March 2008 tidal study. This assessment indicated that groundwater generally travels in an east-northeast direction. Based on groundwater flow direction and the contaminant distribution at the Marina, it is unlikely that groundwater is migrating from the Marina to the T-117 Upland Study Area. Thus, any COC loading in groundwater from the Marina is not expected to contaminate T-117 EAA groundwater or recontaminate post-NTCRA sediment at concentrations above the RvALs.

5.2.3.4 Basin Oil property groundwater

Groundwater samples were collected by Ecology from monitoring wells MW-12 and MW-13, which were installed next to the Basin Oil property on the 17th Avenue S and S Donovan Street ROWs, respectively (see Map 2-4039, Section 2.4.1). Dissolved arsenic was detected in all samples at concentrations that ranged from 9.4 to 20.4 µg/L. Similar groundwater monitoring results have been reported for downgradient monitoring wells MW-01, MW-09, MW-10 and MW-11. Arsenic, copper, and BEHP were detected in one or more wells, and low concentrations of PCBs and TPH-D were detected in monitoring wells MW-1 and MW-10, respectively, based on recent groundwater monitoring of these wells by the Port and the City. However, tThese concentrations of detected contaminants are not indicative of a concentrated upgradient source and thus indicate a low likelihood of recontamination of post-NTCRA sediment.

5.2.3.5 Groundwater pathway summary and monitoring recommendations

Based on available sampling, and monitoring data evaluated in Appendix B, and the results of independent recontamination analyses for areas upgradient of the T-117 Sediment Study Area, it is unlikely that post-NTCRA T-117 EAA sediment will be contaminated at levels above the established RvALs via groundwater transport. Nevertheless, the potential for groundwater transport of COCs to the T-117 Sediment Study Area will be considered evaluated during the development of the NTCRA design and the long-term effectiveness monitoring program. Post-NTCRA groundwater monitoring and long-term performance monitoring of the T-117 Sediment Study Area is discussed further in Section -9.5.

As part of the program, long-term groundwater and sediment monitoring will be implemented following the NTCRA to ensure that the groundwater flowing to and through the T-117 Upland Study Area is not a source of recontamination. The post-NTCRA long-term monitoring program will likely include a monitoring well network upgradient of the restored T-117 shoreline to monitor groundwater quality prior to discharge to the LDW.

5.2.4 In-waterway sediment transport and deposition

~~As discussed in Section 5.2, o~~One pathway for contaminants to reach the T-117 Sediment Study Area is via transport and deposition of LDW sediment. Sediment may be transported from upstream areas and/or nearby areas subject to sediment removal actions.

The T-117 Sediment Study Area is located in the LDW, an estuarine system that is influenced by the Upper Duwamish/Green River. A great deal of sediment from this river is being deposited within the LDW. To estimate the influence of this transport and deposition on an LDW-wide scale, sediment transport dynamics within the LDW ~~(including the T-117 Sediment Study Area)~~ have been modeled as part of the LDW RI to estimate area-specific net erosion rates and maximum scour depths during high-flow events, net sedimentation rates, and bed replacement dynamics (Windward 2008; QEA 2008). This modeling is currently being used in the LDW FS (ENSR|AECOM 2009) to predict changes in chemical concentrations in sediment over time and can also be used to estimate the future influence of the Upper Duwamish/Green River on sediment composition in the river segment (RM 3.5 and RM 3.6) that includes the -T--117 Sediment Study Area. At the end of the 30-year modeling period, 75 to 100% of the sediment within this segment and the channel-side half of the area between RM 3.6 and RM 3.7 was estimated to be replaced with sediment from the Upper Duwamish/Green River. Thus, this general area is predicted to take on the characteristics of the sediment being depositing from the river over ~~However~~time. However, an assessment of sediment deposition or erosion within the spatial scale of the T-117 Sediment Study Area based on LDW-wide or reach-specific model predictions has~~may have~~ a high level of uncertainty, ~~and~~ can only ~~should be only~~ be considered~~used~~ as one line of evidence to assess future conditions, and is not a substitute for post--removal action sediment monitoring.

~~As shown in Figure 5-3, greater than 99% of the sediment load to Reach 2b, where the T-117 EAA is located, was estimated to come from the Upper Duwamish/Green River system (QEA 2008). Mean contaminant concentrations in sediment in this upstream~~

area (1.7 mg/kg OC total PCBs, 6.8 mg/kg dw arsenic, 51 µg/kg dw cPAH TEQ)[15] are much lower than sediment RvALs. Thus, post-NTCRA sediment deposition from upstream should not result in recontamination of the T-117 EAA to levels that exceed the selected RvALs.

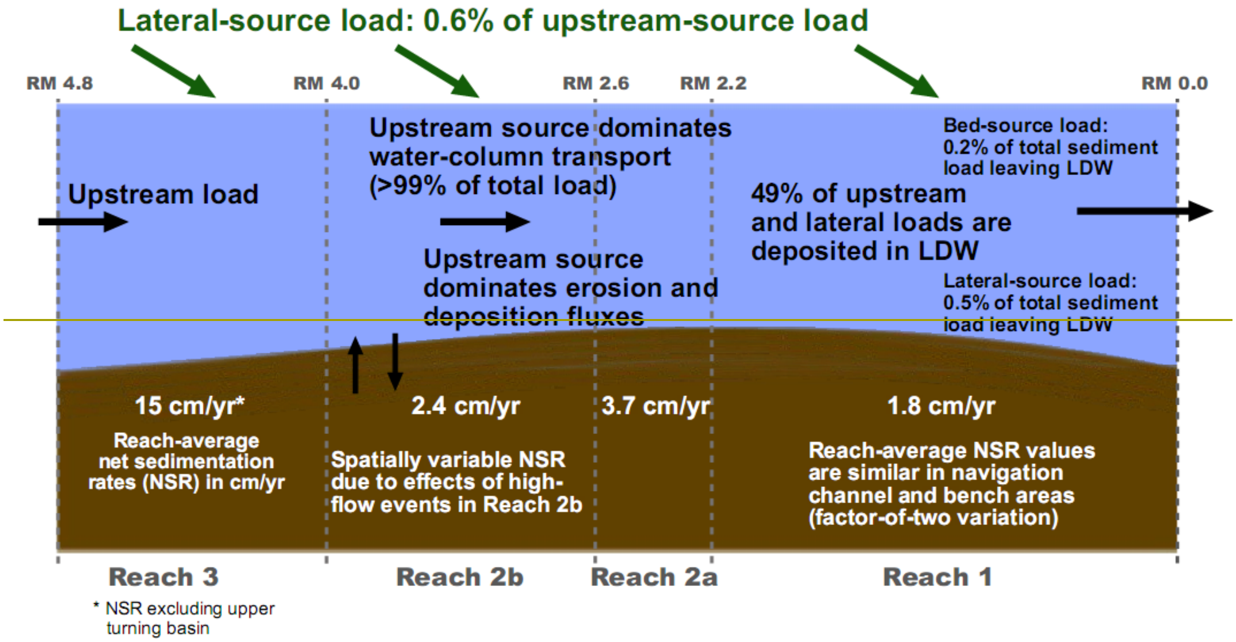


Figure 5-3. Schematic of the net LDW sediment transport processes over a 30-yr period

Based on the sediment transport modeling, the T-117 Sediment Study Area was identified in the LDW RI (Windward 2008) as having the following conditions and characteristics:

Between RM 3.5 and RM 3.6, the sediment area was characterized as a net depositional environment with a net sedimentation rate > 3 cm/year. From RM 3.6 to RM 3.7 in the nearshore, the sedimentation rate was estimated to be much lower (0 to 0.5 cm/year).

The net erosion rate during high-flow events (2- to 100-year flood events) was estimated to range from 0 to 6 cm/year in the area between RM 3.6 and RM 3.7, with maximum scour depths up to 6 cm.

Less than 1% of sediment deposited within the T-117 Sediment Study Area was estimated to originate from lateral sources.

At the end of the 30-year modeling period, 75 to 100% of the sediment between RM 3.5 and RM 3.6 and the channel-side half of the area between RM 3.6 and RM 3.7 was estimated to be replaced with sediment from the Upper Duwamish/Green River.

[15] Note that these concentrations are based on data presented in the RI (Windward 2008); additional data have been collected since that time and are being evaluated.

Thus, this area is predicted to take on the characteristics of the sediment being depositing from the river over time.

In contrast, only 0 to 25% of the nearshore sediment between RM 3.6 and RM 3.7 was estimated to be replaced with sediment from the Upper Duwamish/Green River, indicating little bed replacement.

Contaminated areas in the LDW will be addressed through sediment remediation and source control actions (which could involve actions such as bank remediation) following the issuance of the ROD for the LDW. However, the relative sequencing of other actions and the T-117 EAA NTCRA has not yet been established. If areas near or upstream of the T-117 EAA are addressed after the NTCRA, these actions could potentially recontaminate T-117 EAA sediment, particularly if these areas are dredged. Dredging tends to re-suspend sediment, some of which may be transported outside of the dredging footprint. Sediment transport modeling to specifically assess the potential for contamination of the T-117 EAA during or following the remediation of nearby areas has not been conducted. However, it is expected that any remedial actions carried out at nearby areas will include measures to minimize the potential for contaminants to spread during remedial actions. Sediment and water quality monitoring will also likely be required during all remedial activities, and post-remediation monitoring programs willshould be designed to not only assess the effectiveness of the remedial actions carried out at nearby areas but also ensure that post-cleanup residuals from those projects do not affect neighboring areas (e.g., the T--117 Sediment Study Area).

5.2.5 Surface water transport within the LDW

Sources of COCs to surface waters of the LDW include maritime activities, which can occasionally result in releases of fuel and other hazardous materials, and a variety of other upland/lateral sources, including regional stormwater discharges and CSOs. Depending on the location and nature of these releases, they could potentially provide a source of recontamination to T-117 EAA sediment after the completion of the NTCRA.

However, present-day maritime practices, rapid spill response resources, regulatory requirements, and municipal/industrial wastewater discharge limits have been established to control and/or eliminate these types of releases to the LDW. Thus, it is unlikely that they would contaminate post-NTCRA T-117 EAA sediment at levels above the selected RvALs. This would be verified through a post-NTCRA sediment monitoring program.

5.2.6 Atmospheric deposition

Atmospheric sources of contaminants are generally widespread (EPA 2001); contaminants are emitted to the air from both point sources (e.g., industrial facilities) and non-point sources (e.g., motor vehicles, marine vessels, trains) and may be transported over long distances, generally in the direction of the prevailing winds. Contaminants in the atmosphere are deposited to both land and water surfaces through wet deposition (i.e., precipitation) and dry deposition (i.e., as particles). The deposition of contaminants from the air directly to a water body (e.g., the LDW) through either wet deposition or dry deposition is called direct atmospheric deposition. Although emission sources associated with oil combustion and other activities were present historically at the asphalt manufacturing facility, no site-specific emission sources are currently active within the T-117 EAA.

Indirect atmospheric deposition of contaminants occurs when contaminants deposited on upland areas are conveyed to water bodies via stormwater flow. Although not the only potential source of COCs in stormwater conveyances, contributions from atmospheric deposition can be detected through the sampling of storm solids and mitigated through the cleaning of conveyance systems and the application of other stormwater BMPs.

In the LDW, the The potential contribution of contaminants via direct atmospheric deposition on the T-117 Sediment Study Area (approximately 2 ac) is relatively small compared with the potential contribution via indirect atmospheric deposition on the upland drainage areas (estimated to be approximately 12 ac, including portions of the Marina). For the most part, contaminants deposited on the T-117 upland areas become entrained in storm solids and are monitored and controlled. because of the relatively small surface areas of the T-117 Sediment Study Area (approximately 2 acres) and surrounding LDW study area (441 acres between RM 0 and RM 5) (ENSR|AECOM 2009) compared to the surface area of the Green/Duwamish Watershed (294,600 acres).

Direct aAtmospheric deposition information hasdata have been collected in the vicinity of the T-117 EAA by the County (2008) and can be used to evaluate the potential contribution of contaminants to the T-117 Sediment Study Area from direct atmospheric deposition. Sixteen rounds of deposition data were collected at the South Park Community Center (SPCC) atmospheric deposition monitoring station between 2005 and 2007. The SPCC station is the closest monitoring station to the T-117 EAA and was one of five monitoring stations used by the County in their study of atmospheric deposition near the LDW. Samples collected at the SPCC station were analyzed for a number of contaminants, including phthalates, selected PAHs , and PCB Aroclors, both identified as sediment COCs for the T-117 EAA., and Data from the SPCC station were converted to atmospheric deposition flux values by the County (see Table 5-32). Fluxes calculated for other area monitoring stations were similar.[16]

[16] Together, the SPCC, Duwamish, and Georgetown monitoring stations represent the commercial/industrial neighborhood conditions in the Duwamish Valley. For comparison, the average atmospheric deposition flux values (based only on detected results) were: 2.94 µg/m²/day BEHP, 0.95 µg/m²/day BBP, and 0.042 to 0.241 µg/m²/day for PAHs. In all samples from these three

Table 5-3~~2~~. Hypothetical contribution of COCs to T-117 Sediment Study Area based on average atmospheric deposition flux rates ~~contribution to sediment concentrations based on atmospheric deposition flux at the SPCC station~~

COC	Average Atmospheric Deposition Flux (µg/m²/day)[a]	Hypothetical Contribution of Direct Atmospheric Deposition to Sediment Concentrations over a 1-Year Period by Sedimentation Rate (mg/kg dw)~~:~~ [b]			Sediment RvAL (mg/kg dw)[c]
		0.1 cm/yr	0.5 cm/yr	1 cm/yr	
PAHs					
Benzo(a)anthracene	0.048	0.015	0.003	0.001	1.7
Benzo(a)pyrene	0.074	0.023	0.005	0.002	1.5
Benzo(g,h,i)perylene	0.086	0.026	0.005	0.003	0.48
Total benzofluoranthenes	0.174	0.053	0.011	0.005	3.6
Chrysene	0.112	0.034	0.007	0.003	1.7
Dibenzo(a,h)anthracene	0.028	0.009	0.002	0.001	0.19
Indeno(1,2,3-cd)pyrene	0.051	0.002	0.003	0.002	0.53
PCBs					
Total PCBs	0.011[d]	0.003	0.00066	0.0003	0.19

a Averages were calculated using detected concentrations from only the SPCC station.

b Based on calculations made using the deposition flux values provided in Column 2 and the following assumptions: sediment ~~transport~~ deposition rate of 1 cm/yr; sediment density of 1.2 g/cm³, or 6g/5cm³ (from LDW STAR); ~~TOC content of sediment: 2%.~~ Sample calculation for Total PCBs at a sedimentation rate of 0.5 cm/yr ~~BEHP~~ follows.

Calculation:

(0.011~~2.4~~ µg PCBs~~BEHP~~/m²/day) x (365 day/yr) = 4.015~~876~~ µg PCB~~BEHP~~/m²/yr

(4.015~~876~~ µg PCB~~BEHP~~/[m² x yr]) x (1yr/0.5~~1~~cm) x (100 cm/1 m) = 803~~87,600~~ µg PCB~~BEHP~~/m³

(803~~87,600~~ µg PCB~~BEHP~~/m³) x (5 cm³/6g) x (1m³/1,000,000 cm³) = 0.000669~~173~~ µg/g PCB~~BEHP~~

0.00066~~973~~ µg/g PCB~~BEHP~~ = 0.00066~~973~~ ppm = 0.0006~~673~~ mg/kg PCB~~BEHP~~ (dw concentration)

~~OC normalization: (0.073 mg/kg)/(0.02 TOC) = 3.65 mg/kg OC~~

c Sediment RvALs i~~a~~s defined in Section 4.

d~~c~~ Represents single detected concentration of Aroclor 1254 at the SPCC station; no other samples from this station had detected concentrations of any PCB Aroclors.

---

stations, only two PCB Aroclors were detected: Aroclor 1254 was detected in five samples at a range of 0.011 µg/m²/day (detected at the SPCC station) to 0.044 µg/m²/day (detected at the Georgetown station). The Beacon Hill station represents urban residential neighborhood conditions. Average atmospheric deposition flux values (based only on detected results) at this station were~~: 1.64 µg/m²/day BEHP, 0.498 µg/m²/day BBP, and~~ 0.012 to 0.090 µg/m²/day for PAHs. No PCB Aroclors were detected in any of the samples from the Beacon Hill station.

BBP – butyl benzyl phthalate

BEHP – bis(2-ethylhexyl) phthalate

COC – contaminant of concern

dw – dry weight

CSL – cleanup screening level

OC – organic carbonLDW – Lower Duwamish Waterway

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RvAL – removal action level

SPCC – South Park Community Center

SQS – sediment quality standard

STAR – sediment transport analysis report

T-117 – Terminal 117

COC	Average Atmospheric Deposition Flux (µg/m^2/day)[a]	Hypothetical Direct Atmospheric Deposition Contribution to Sediment Concentration Over 1-Year Period (mg/kg OC)[B]	SQS (mg/kg OC)	CSL (mg/kg OC)
PAHs				
Benzo(a)anthracene	0.048	0.073	110	270
Benzo(a)pyrene	0.074	0.113	99	210
Benzo(g,h,i)perylene	0.086	0.131	31	78
Total benzofluoranthenes	0.174	0.265	230	450
Chrysene	0.112	0.170	110	460
Dibenzo(a,h)anthracene	0.028	0.043	12	33
Indeno(1,2,3-cd)pyrene	0.051	0.078	34	88
Phthalates				
BEHP	2.4	3.65	47	78
BBP	1.5	2.28	4.9	64
PCBs				
Total PCBs	0.011[c]	0.017	12	65

Using conservative assumptions,[17] estimated sediment concentrations for the T-117 COCs based on the average SPCC atmospheric deposition flux values were calculated

[17] Conservative assumptions used to estimate sediment concentrations associated with direct atmospheric deposition: 1) all airborne contaminant mass that falls onto the LDW is sorbed to sediment, 2) sediment deposition rate of clean sediment is between 0.1 and 1 cm-/yr (calculations were based on three assumed deposition rates of 0.1, 0.5, and 1 cm/year for comparison, and 3) sediment density is 1.2 g/cm^3 (the lower end of the wet sediment density range reported in the LDW sediment transport analysis report (Windward and QEA 2008)). The calculation used to derive the hypothetical contributions from direct atmospheric deposition to sediment is considered to be conservative because it assumes that 100% of contaminants deposited to the LDW surface accumulate in the sediment. Atmospheric particulate matter is divided into two size classes: fine particulate matter (less than 2.5 µm in diameter [PM2.5]) and coarse particulate matter (between 2.5 and 10 µm in diameter [PM10]). The LDW sediment transport model showed that only 10% of sediment particles less than 10 µm in size (clay or fine silt) are expected to be deposited to LDW sediment. The other 90% is transported downstream. Particulate matter deposited to the LDW via atmospheric deposition

(see Table 5-32). The hypothetical contributions from direct atmospheric deposition to sediment concentrations are all well below the SQS criteria for these chemicals and thus were less than the RvALs. These results indicate that contributions of contaminants to sediment from direct atmospheric deposition alone would not be expected to result in sediment concentrations above the RvALs.

This type of conservative calculation is acceptable as a screening exercise because it places the direct atmospheric deposition pathway in context with other potential pathways and allows an estimation of the importance of this pathway relative to other pathways and relevant to source control. This type of analysis would not be used to make decisions about implementing source control measures other than to help prioritize pathways and sources for additional assessment. Based on available atmospheric deposition data and the hypothetical deposition contribution from direct atmospheric deposition, it appears that other pathways are more important for source control. The potential for recontamination through indirect atmospheric deposition is more uncertain; periodic sampling of storm solids within the T-117 conveyance systems will be conducted to assess the importance of this pathway.

The calculation used to derive the hypothetical contributions from direct atmospheric deposition to sediment is considered to be conservative because it assumes that 100% of contaminants deposited to the LDW surface accumulate in the sediment. Atmospheric particulate matter is divided into two size classes: fine particulate matter (less than 2.5 µm in diameter [PM2.5]) and coarse particulate matter (between 2.5 and 10 µm in diameter [PM10]). The LDW sediment transport model showed that only 10% of sediment particles less than 10 µm in size (clay or fine silt) are expected to be deposited to LDW sediment. The other 90% is transported downstream. Particulate matter deposited to the LDW via atmospheric deposition would be expected to have deposition rates similar to those of clay or fine silt; therefore, the use of a 100% deposition rate in the calculation is highly conservative. In addition, a sediment deposition rate of 1 cm/year is considered to be conservative because the sediment deposition rate over much of the T-117 EAA is higher than 1 cm/yr. The sediment density used in the calculations is 1.2 g/cm^3, which is considered to be conservative because it at the lower end of the wet sediment density range reported in the LDW sediment transport analysis report (Windward and QEA 2008). A higher sediment density used in the calculations would generate a lower hypothetical contaminant

would be expected to have deposition rates similar to those of clay or fine silt; therefore, the use of a 100% deposition rate in the calculation is highly conservative. In addition, a sediment deposition rate of 1 cm/yr is considered to be conservative because the sediment deposition rate over much of the T-117 EAA is higher than 1 cm/yr. The sediment density used in the calculations is 1.2 g/cm^3, which is considered to be conservative because it at the lower end of the wet sediment density range reported in the LDW sediment transport analysis report (Windward and QEA 2008). A higher sediment density used in the calculations would generate a lower hypothetical contaminant contribution from direct atmospheric deposition.

contribution from direct atmospheric deposition.Because of the relatively small quantities of contaminants present in atmospheric deposition samples and the relatively small contribution of contaminants via direct atmospheric deposition, the potential for the direct atmospheric deposition pathway to recontaminate post-NTCRA T-117 EAA sediment is low. The potential for recontamination through indirect atmospheric deposition is more uncertain; periodic sampling of storm solids within the T-117 conveyance systems will be conducted to assess the importance of this pathway.

5.3 Overall Summary and Monitoring Recommendations

All of the potential individual recontamination pathways that originate at the T--117 EAA and the RAAs (Basin Oil and Marina) have a relatively low likelihood of increasing contaminant concentrations in the post-NTCRA T-117 Sediment Study Area to concentrations above sediment RvALs. The estimated potential for recontamination is summarized in Table 5-4, and is based on the following factors:

- Potential contribution of contaminants to T-117 Sediment Study Area after cleanup from each ongoing source
- Degree of confidence in information regarding the chemical characteristics/loading from each source or the likely occurrence of an event that will impact the sediment offshore of T-117, such as a spill

Table 5-4. Evaluation of post-removal recontamination risk from ongoing sources in the T-117 vicinity

Source/Pathway	Description	Potential Post-Rremoval Action Impact to T-117 Sediment Study Area	Uncertainty/ Probability[a]	PotentialLikelihood -to Cause Exceedances of Sediment RvALs
Stormwater	Runoff from 1.1 ac of road and+ 0.6 ac of private property (Basin Oil). Contaminated soil in ROW to be removed during the NTCRA. After cleanup, runoff will be treated per City stormwater code (SMC 22.800) using conventional stormwater treatment technologies.	low	medium	low
Groundwater	Groundwater discharge to sediment.	low	medium	low
Spills/over-water activities	Spills that occur in the vicinity of T-117 or from adjacent areas.	high	low	low
Soil erosion[ab]	Contaminated soil in T-117 upland, banks and ROW to be removed as part of NTCRA. RAAs with known soil contamination (i.e., Marina and Basin Oil) are either paved or will be remediated by others.	low	medium	low

Source/Pathway	Description	Potential Post-Rremoval Action Impact to T-117 Sediment Study Area	Uncertainty/ Probability[a]	PotentialLikelihood -to Cause Exceedances of Sediment RvALs
Direct atmospheric deposition[cb]	Deposition from local and regional airshed onto the immediate area offshore of T-117.	low	highlow	low
In-waterway sediment transport[de]	Deposition of contaminated sediment from sediment cleanup activities elsewhere in the waterway.	high	low	medium-low
Cumulative effects		**low**	**medium**	**low**

[a] Uncertainty/probability represents the confidence level in the available data. For event-driven sources (e.g., spills and in-waterway sediment), it represents the likelihood of occurrence.

[b] Soils within the upland areas that drain to the T-117 Sediment Study Area.

[cb] Atmospheric deposition that falls elsewhere on the drainage basin is included under stormwater.

[de] Cleanup activities elsewhere in the LDW will be tightly controlled to reduce the potential for contaminated materials to migrate downriver.

NTCRA – non-time-critical removal action

RAA – recontamination assessment area

ROW – right-of-way

SMC – Seattle Municipal Code

T-117 – Terminal 117

Each of these factors is qualitatively rated high, medium, or low. -These two factors are then combined to evaluate the overall potential for an individual source to cause recontamination. -Spills and the transport of contaminated sediment from cleanup activities elsewhere in the LDW have an overall rating of low and medium-low, respectively, because of the high potential for impacts, but both have a low probability of occurrence. For example, the likelihood of a major spill occurring immediately adjacent to T-117 is fairly low; similarly, the chance of recontamination from upriver cleanup activities is not expected to be highlow because these cleanups will be tightly controlled to minimize the potential for offsite migration of contaminants.

Groundwater discharges and atmospheric deposition also received medium and low rankings, respectively. Information regarding atmospheric loading (Section 5.2.6) as well as groundwater in the proximity of the shoreline is available.

The quality of groundwater that discharges from the T-117 Uupland Study Area and Aadjacent Sstreets is expected to improve, primarily as a result of the removal of contaminated soil located above or in contact with the shallow aquifer. Although little is currently known regarding groundwater beneath the Adjacent Streets, additional pre-design groundwater monitoring will be conducted (Section 9.5) to verify that this groundwater will not be a future source of recontamination to the post-NTCRA T-117 EAA.

Additional groundwater monitoring is also planned to further assess the potential for groundwater from the Marina and Basin Oil properties to contribute to recontamination.- It is recognized that the data necessary to assess some of the pathways (e.g., dioxin and furan groundwater data) are limited. These additional information needs will be addressed through the implementation of measures set forth in Section 9.4.

Stormwater discharges and soil erosion are rated low because stormwater will be treated prior to discharge, which will remove the majority of the solids; and most of the contaminated soil within the area that drain to T-117 will be removed as part of the NTCRA. -Contaminated soil that remains at the Marina and the Basin Oil properties are also not expected to pose a risk for sediment recontamination.

The Marina was evaluated by Ecology (SAIC 2009), and results of the quantitative recontamination assessment showed that eroded soil from the Marina would be unlikely to impact the adjacent T-117 Sediment Study Area. Contaminants in Basin Oil soil will be addressed through actions by others and overseen by Ecology, ensuring that any remaining soil is not subject to erosion and transport at this site.-

Potential recontamination from transport and deposition of contaminated sediment from other portions of the LDW has not been addressed. As discussed in Section 5.2.4, it is inappropriate to apply the LDW STM to the T-117 Sediment Study Area.

The design phase of the NTCRA will include the design of post-NTCRA stormwater, groundwater, and sediment monitoring programs to verify that recontamination of post-NTCRA T-117 Sediment Study Area does not occur. If it appears that post-NTCRA contaminant concentrations are increasing, a variety of potential recontamination sources and pathways will be evaluated, such as, but not limited to:

- Ongoing source control actions in the Adjacent Streets and Residential Yards Study Area
- Further evaluation of sources and source pathways from the RAAs (the Marina and Basin Oil)
- Review of groundwater monitoring results for indications of increased COC concentrations
- Investigation of atmospheric deposition and entrainment in stormwater

SPU will sample solids in the storm drain system and stormwater in the portion of the Adjacent Streets and Residential Yards that will discharge at or in the vicinity of T--117 as required by EPA to evaluate whether the removal action and proposed stormwater treatment system are effective in controlling PCBs and other LDW COCs in the runoff from this area. An adaptive management strategy will be developed and will phase in increasingly more aggressive source investigations and, if necessary, an evaluation of additional treatment until the source(s) of any future contamination is identified and controlled.

Further analysis of airborne particulate loads within the vicinity of the T-117 EAA may also be necessary in order to further assess inputs from the atmosphere if elevated COCs are noted in stormwater solids following the implementation of the NTCRA. Additional source control measures in the vicinity of the T-117 EAA, such as the completion of the soil cleanup at Basin Oil, are advised to further minimize the potential for recontamination. Other ongoing LDW-wide source control actions and information collected by the LDW SCWG member agencies (e.g., SPU stormwater solids data) will be regularly reviewed as a means of evaluating potential sources in the T-117 EAA vicinity. This review will occur annually or whenever the LDW Source Control Work Group publishes an updated source control status report. The post-NTCRA groundwater monitoring will also be a key element in the evaluation of the potential for post-NTCRA recontamination of the T-117 sediment. Finally, the timing and sequencing of in-water LDW cleanups projects (e.g., Boeing Plant 2, Slip 4, South Park Bridge removal, and the LDW) should be considered.

6 Identification, Evaluation, and Screening of Technologies

This section of the EE/CA considers removal, treatment and disposal technologies that are suited for implementing the removal action at the T-117 EAA. The cleanup activities described in this EE/CA focus on sediment and soil removal, so emphasis is placed upon those technologies that are applicable to those media, are readily available, and can be implemented within the anticipated NTCRA timeframe. This section:

- Identifies and provides an evaluation and screening of soil removal technologies (i.e., excavation)
- Identifies and provides an evaluation and screening of sediment dredging and capping technologies
- Identifies, discusses, and evaluates treatment and disposal options

The identification and evaluation of technologies (USACE 2003) takes into account a broad range of methods, such as the use of multi-user disposal sites that have been identified by LDWG in *Identification of Candidate Technologies for the Lower Duwamish Waterway* (RETEC 2005), hereafter referred to as the Candidate Technologies Report. This report was designed to help ensure compatibility with remedial technologies that may eventually be applied within the LDW as a whole.

The technologies identified in this section of the EE/CA are used to develop the removal action alternatives presented in Section 7. These alternatives must be applicable to all the removal areas within the T-117 EAA as identified in Section 4, including the T-117 Sediment Study Area, T-117 Upland Study Area, and the Adjacent Streets and Residential Yards Study Area. Thus, technologies that address submerged and intertidal sediment as well as upland soil must be included. Removal actions to address the shoreline and sediment will use a variety of technologies. Figure 6-1 presents the various shoreline and sediment zones that are described throughout the rest of this document.

In addition to the primary removal technology, all alternatives must include supporting methods needed to prepare the site for the selected removal action and support the removal activities (e.g., aboveground structural demolition, asphalt removal, well abandonment, and implementation of site security measures). Soil/sediment staging areas and water management systems (for surface water and groundwater) and other support facilities will also be necessary. A discussion of these supporting methods is included in the description of each alternative (Section 7).

Slipsheet for 8.5 x 11

Figure 6-1. Locations of zones within the shoreline and sediment

The evaluation and selection of technologies in this EE/CA emphasizes those technologies demonstrated to be proven and readily implemented at full scale (rather than research or pilot-scale). An additional key selection criterion includes the appropriateness of the technology for the size and site-specific conditions of the T-117 EAA, as well as the time frame of the NTCRA. Sediment remediation technologies that were screened and eliminated in the Candidate Technologies Report (RETEC 2005) for application in the LDW were not included in this screening.

General technologies discussed in this section for the T-117 NTCRA include those associated with:

- Removal and containment
- Treatment or disposal

Monitored natural recovery and enhanced natural recovery are not considered to be applicable strategies for the T-117 EAA because of the elevated concentrations and persistent nature of contaminants located in the T-117 EAA Upland and the Adjacent Streets and Residential Yards Study Areas and the uncertainty regarding low sedimentation rates estimated for portions of the T-117 Sediment Study Area (Windward and QEA 2005) within the T-117 Sediment Study Area.

Some types of institutional controls may be implemented, as necessary, to help ensure the long-term maintenance and integrity of remediated upland areas and sediment caps, but institutional controls are not considered to be a substitute for active removal measures and are not appropriate or sufficiently protective for use at the T-117 EAA if used as the sole measure for preventing exposure to contaminants. Institutional controls were not considered for areas where their use would preclude achieving RAOs. Restrictive covenants may be appropriate in areas where sediment capping is used to meet sediment RAOs as part of a removal alternative or as a component of future redevelopment (i.e., construction of upland or intertidal habitat) in order to prohibit activities that would compromise a cap and potentially release contaminated materials that remain beneath the cap. However, such controls may be limited and cannot be used where they might be infeasible (e.g., where they would interfere with tribal use of the area or could not be effectively implemented or enforced).

6.1 Soil and Sediment Removal and Containment Technologies

A comprehensive list of potential removal technologies was compiled, reviewed, and screened against specific criteria (Appendix K); a summary of this evaluation is presented as Table 6-1. Applicable technologies for the T-117 EAA include those well-known, proven technologies that can be used for soil and sediment removal (i.e., excavation and dredging). Land-based removal technologies are used as a means of excavating contaminated soil and nearshore intertidal sediment using equipment positioned on land. Over-water removal technologies include dredging as a means for removing offshore subtidal sediment. These technologies are effective when used in conjunction with procedures and safeguards to limit uncontrolled release of soils and sediment or excessive turbidity in the LDW during the removal action.

6.1.1 Land-based technologies

The primary land-based removal technology under consideration for the T-117 EAA is excavation. Excavation has already been used as the principal means of removing soil in the T-117 Upland Study Area (RETEC 2007b) and the Adjacent Streets (Integral 2006a) and is also a viable method for addressing the cleanup of nearshore sediment. Excavation is typically conducted using backhoes, front-end loaders, and dump trucks. Supporting methods include shoring (for excavations that are deep or close to structures), soil stockpiling and containment, dust control, groundwater extraction (for dewatering deeper excavations), and storing and treating extracted groundwater. Contaminated soil or sediment can be excavated, placed in lined trucks, and transported to appropriate treatment or disposal facilities. Truck wheel washing and inspection are necessary to control soil track-out during excavation work. Excavation and its supporting methods have been successfully implemented during previous removal actions and are proven removal methods for this site; they have thus been retained for inclusion in removal action alternatives.

Land-based containment technologies (e.g., capping) that require institutional controls have not been retained for application in the T-117 Upland or Adjacent Streets and Residential Yards Study Areas ~~have not been retained~~ because they are inconsistent with the RAO (Section 4.4) of allowing for a range of possible land uses in these study areas. One exception is the use of clean cover (soil) that would be placed onto cleaned upland areas as needed for the construction of habitat. As specified in WAC-173-340-7492(3), an institutional control may be required to ensure that site conditions within developed habitat areas are maintained and the exposure of species to unacceptable soil contaminants is prevented.

6.1.2 Over-water technologies

This section discusses over-water technologies for addressing contaminated sediment at the T-117 Sediment Study Area, which are dredging and capping. Both technologies have been applied elsewhere within the LDW and have been proven to be feasible methods for removing or containing contaminated sediment.

6.1.2.1 Sediment dredging

As mentioned previously, land-based excavation may also be used as a means for removing contaminated sediment from the intertidal mudflat. This approach could be implemented without generating excessive turbidity in the water column because excavation would be conducted "in the dry" during low tides (this process is discussed in more detail in Section 7.1.1.4). Only the remaining less-contaminated subtidal sediment would need to be removed using conventional over-water dredging methods.

For subtidal sediment, both mechanical and hydraulic dredging are candidate technologies. Mechanical dredging involves lowering a bucket or clamshell to the bottom of the river, excavating the target material, and then lifting the bucket to the surface. The dredged material is placed onto a barge for transport to an offloading site. Environmental bucket dredges are equipped with specially designed buckets to reduce the outflow of contaminated solids during the dredging process.

The hydraulic dredging process involves using agitation equipment to loosen the target material from the river bed and then mixing the loosened material with water to form slurry. A centrifugal pump is used to convey the slurry through a hose or pipeline to a handling site. Hydraulic dredges for low-volume environmental remediation can range from small (4-to-6-in.-diameter discharge) diver-guided suction dredges used for working in and around confined areas to floating cutterhead hydraulic dredges (8-to-16-in.-diameter discharge) for working in less ~~un~~restricted areas. Hydraulic dredging would require the development of a large handling site nearby to dewater the dredge spoils. The resulting solids would then need to be transported to a disposal facility.

For the T-117 site, several factors would limit the effectiveness of hydraulic dredging for sediment remediation, such as:

- **Spillage** – The cutterhead or auger action associated with hydraulic dredging would leave a spillage layer of sediment not captured by the dredge. Spillage layers are composed of a mixture of sediment from the cut face of the dredged area that is not captured by the hydraulic dredge, with chemical concentrations similar to the average concentration of the chemical in the dredged material. As a rule of thumb, the thickness of spillage layer is on the order of half of the discharge pipe diameter (Palermo et al. 2008). So a 12-in. dredge (12-in.-diameter discharge pipe) would leave a spillage layer of approximately 6 in. thick.
- **Slurry** – Hydraulic dredging generates a slurry that is on the order of 10 parts water to 1 part sediment. Small hydraulic dredges can generate larger volumes of water because of the constraints of small working areas. Consequently, hydraulic dredging requires the mobilization, construction, and operation of a handling site to manage the slurry generated by a hydraulic dredge, which is typically only cost effective for long-duration projects or for work that can only be completed by hydraulic dredging, such as diver dredging around constrained areas. For example, the remediation of the Thea Foss Waterway in Commencement Bay used hydraulic dredging because the slurry could be pumped into a 10-~~-~~ac placement site (former St. Paul Waterway), which was large enough to clarify the slurry before discharge to Commencement Bay.

- **Debris** – The type of debris commonly found in the T-117 intertidal mudflat, such as riprap and rock from the shoreline and small wood debris from the river, ~~area~~ would likely plug and damage the smaller-sized dredges ~~(6- to 14-in. diameter discharge pipe)~~ typically used for environmental remediation of this scope.

Because of these factors (i.e., spillage, slurry, debris) and the relatively small volume of material to be dredged, hydraulic dredging was not considered practical for this removal action.

Mechanical dredging is therefore the preferred technology for subtidal sediment removal. The specific type of dredging bucket will be selected based on water quality performance criteria established during the design phase of the NTCRA.

6.1.2.2 Sediment capping

Sediment capping could be completed using either land-based earth-moving equipment (e.g., backhoes or other types of excavators, front-end loaders, dump trucks, conveyor systems) or conventional offshore floating equipment. Clean capping material could be imported to the site in dump trucks or on barges and then placed as engineered fill. The cap would be designed to resist disturbance and the re-exposure of materials contained beneath the cap. The three primary functions of capping are (Palermo et al. 1998):

- Physical isolation of the contaminated sediment from human and ecological receptors
- Stabilization of contaminated sediment and the prevention of resuspension and transport to other sites
- Reduction of the flux of dissolved contaminants into the water column~~.~~

The cap would be specifically designed to provide these functions in a manner that is compatible with the site conditions along the T-117 shoreline, including sediment grain size, bathymetry, surface water flow, and ship traffic. Capping designs prepared in accordance with USACE guidance for PCB-~~-~~contaminated sediments in river settings can have caps that range from 12 to 36 in. thick. The caps are often multi-layered to provide chemical isolation immediately over the impacted sediment and include a sand and gravel/cobbles layer to prevent erosion from waves and prop wash and a surficial habitat layer of sand and gravel. A robust 3-ft-~~-~~thick cap configuration is being assumed for the EE/CA (portions of the cap could be even thicker, if needed, to accommodate clamming). It consists of~~A typical cap design includes~~ three layers: a sandy material to provide primary physical and chemical containment of the underlying sediment, an armored layer (cobbles) to protect against erosion, and a surface layer of natural sand and gravel.

Sediment capping could also be completed using floating equipment similar to that used for mechanical dredging. The dredge bucket would be used to collect capping material from a haul barge and place the material on the bed of the waterway. A typical cap design includes three layers: a sandy material to provide primary physical and chemical containment of the underlying sediment, an armored layer to protect against erosion, and a surface layer of natural sand and gravel. If necessary, Tthe specific cap design and structural components will would be further evaluated and incorporated during the design phase of the NTCRA. Cap thicknesses and composition will would be based on guidance published by EPA and USACE guidance (Palermo et al. 1998; EPA 2005d). Sediment capping has been retained as a technology for inclusion in one or more of the removal action alternatives to be presented in Section 7.

6.2 Material Treatment and Disposal

This section describes the broad range of soil and sediment treatment and disposal technologies identified and evaluated for the T-117 EAA. A comprehensive list of potential treatment and disposal technologies was compiled, reviewed, and screened against specific criteria (Appendix K). The Candidate Technologies Report (RETEC 2005) prepared for the LDW FS serves as a basis for identifying applicable technologies. However, because the Candidate Technologies Report focused on sediment treatment technologies, this EE/CA also includes consideration of a full range of soil treatment technologies. Additional sources of information on technologies included:

- Federal Remediation Technologies Roundtable. Treatment technologies screening matrix for SVOCs (Platinum International 2002, Sections 4.1 through 4.8)
- *Superfund Guidance on Remedial Actions for Superfund Sites with PCB Contamination* (EPA 1990)
- *Engineering Issue: Technology Alternatives for the Remediation of PCB-Contaminated Soil and Sediment* (Davila et al. 1993), prepared for EPA
- *Application, Performance, and Costs of Biotreatment Technologies for Contaminated Soils* (Battelle 2002), prepared for EPA
- Commercially permitted PCB disposal facilities (EPA 2008a)

Table 6-1 includes a list of the identified treatment and disposal technologies and information regarding the technology evaluation and screening process. Each technology was evaluated for its applicability to the T-117 NTCRA. The evaluation addressed expected soil and sediment quantities and physical characteristics, estimated COC concentrations, processing costs, and the availability of suitable staging and transfer areas for storing, treating, and loading excavated or dredged materials. Technologies were evaluated and selected based on their estimated implementability, effectiveness, and cost.

Table 6-1. ~~Review of can~~Review of candidate removal action technologies for the T-117 NTCRA

Process Option	Description	Contaminants of Concern Typically Treated	Screening Decision
***In Situ* Treatment**			
Biological			
Aerobic biodegradation	Degradation of organic contaminants in the soil using microbes in the presence of oxygen. Enhanced bioremediation includes the injection of nutrients, oxygen or other amendments.	Effective principally to PAHs, other non-halogenated SVOCs, and BTEX. Biodegradation of PCBs not feasible.	Not applicable: not feasible for PCB-contaminated soils, site hydrologic characteristics of the fill (potential preferential flow pathways) not conducive to treatment. Too much treatment time would be required.
Anaerobic biodegradation	The injection of a methanogenic culture, anaerobic mineral medium and routine supplements of glucose to maintain methanogenic activity. Nutrients and pH are controlled to enhance degradation.	Effective principally on chlorinated VOCs. Bio-degradation of PCBs is not proven.	Not applicable: not effective for PCB contaminated soils, site hydrologic characteristics of the fill (potential preferential flow pathways) not conducive to treatment; treatment time constraints.
Phyto-remediation	A process that uses plants to remove, transfer, stabilize, and destroy contaminants in soil.	Used to address metals, pesticides, solvents, explosives, crude oil, PAHs, and landfill leachate. Effective at up-taking PCBs in shallow soils (surface to 3 ft depths) and low concentrations, but not proven to meet RvALs for higher concentrations of PCBs.	Not applicable: not proven to clean up PCBs to site RvALs, unable to remediate to necessary depth.
Chemical			
Chemical oxidation	Delivery of oxidizers into soils using injection wells in contaminated soils. Oxidation of organics using oxidizing agents such as ozone, peroxide, permanganate, or Fenton's reagent.	Used to treat VOCs. Oxidation is less efficient with SVOCs including pesticides, PAHs, and PCBs.	Not applicable: not effective for PCB contaminated soils, for site soil characteristics and may pose additional site risks.
Physical-Extractive Processes			
Soil vapor extraction	Vacuum is applied to the vadose zone soil to induce the controlled flow of air and remove VOCs and some SVOCs.	Effective at extracting VOCs. Not effective at extracting PCBs.	Not applicable: not appropriate PCBs in contaminated soils due to extremely low vapor pressure.
Soil flushing	Water or water containing an additive to enhance contaminant solubility is applied to the soil or injected into the groundwater to raise the water table into the contaminated soil zone. Contaminants are leached into the groundwater, which is extracted and treated.	The technology can be used to treat VOCs, SVOCs, fuels, and pesticides. Technology unproven to treat PCBs to 1 mg/kg.	Not applicable: Unproven technology, possible contaminant migration to surface waters and heterogeneous fill soils. PCBs are strongly adsorbed onto soil particles.

Table 6-1. Review of candidate removal action technologies for the T-117 NTCRA (cont.)

Process Option	Description	Contaminants of Concern Typically Treated	Screening Decision
Fracturing	Cracks are developed by fracturing beneath the surface in low permeability soils to open new passageways that increase the effectiveness of many in-situ processes and enhance extraction efficiencies.	Used on a variety of COCs, depending on the in-situ process it is used in conjunction with.	Not applicable: Some site soils have high permeability.
Thermal treatment	Steam injection, hot air injection, electrical resistance heating, electromagnetic heating, fiber optic heating, or radio frequency heating is used to increase the volatilization rate of SVOCs and facilitate extraction.	Applicable primarily to VOCs, also used for SVOCs, pesticides and fuels. Less effective for PCBs.	Not applicable: Site properties such as debris (e.g., USTs, remnant underground asphalt manufacturing facility structures, foundations, rip-rap, pilings) make effective application infeasible, Not applicable to PCB contaminated soils, lack of full scale demonstration.
Electro kinetic separation	Removes metals and polar organic contaminants from low permeability soil, mud, sludge, and marine dredging through the application of a low intensity direct current between ceramic electrodes that are divided into a cathode array and an anode array.	Typically used for heavy metals, anions, and polar organics. Limited applicability to PCBs.	Not applicable: Technology is not applicable to PCB & TPH contaminated soils, or to highly permeable soils and buried debris.
Physical Immobilization			
Soil solidification	Traps or immobilizes hazardous substances using physical or chemical means.	Generally used for inorganics, solidification for organics is not a proven technology.	Not applicable to PCB contaminated soils and contamination ~~is~~ below the water table, heterogeneous soils, and leaching potential of solidified soils.
Vitrification	Uses an electric current *in situ* to melt sediment or other earthen materials at extremely high temperatures (2,900-3,650 °F). Inorganic compounds are incorporated into the vitrified glass and crystalline mass and organic pollutants are destroyed.	Applicable to inorganic and organic chemicals. Has been tested on PCBs, but not at a full scale and at action levels of 1 mg/kg.	Not applicable: remediation of PCB contaminated soils to 1 mg/kg is unproven. Additional challenges include heterogeneous soils, buried debris, and dewatering of saturated soils. Risks include possibility of generating dioxins and furans as by-products due to high treatment temperatures.
***Ex Situ* Treatment**			
Biological			
Biopiles	Excavated soils are mixed with amendments and placed in aerated aboveground enclosures. Moisture, heat, nutrients, oxygen, and pH can be controlled to enhance biodegradation.	Not applicable to PCBs. Biopile treatment has been applied to treatment of non-halogenated VOCs and fuel hydrocarbons.	Not applicable: Not a technology that is applied to PCB contaminated soils.

Table 6-1. Review of candidate removal action technologies for the T-117 NTCRA (cont.)

Process Option	Description	Contaminants of Concern Typically Treated	Screening Decision
Land farming/ composting	Soil is mixed with amendments and placed on a treatment area that typically includes leachate collection. The soil and amendments are mixed using conventional tilling equipment or other means to provide aeration. Moisture, heat, nutrients, oxygen, and pH can be controlled to enhance biodegradation. Other organic amendments such as wood chips, potato waste, or alfalfa are added to composting systems.	Not applicable to PCBs. Contaminants that have been successfully treated using land farming include diesel fuel, No. 2 and No. 6 fuel oils, JP-5, oily sludge, wood-preserving wastes (pentachlorophenol and creosote), coke wastes, and certain pesticides.	Not applicable: Degradation rates not in keeping with NTCRA objectives. Requires long processing time and large processing area.
Fungal biodegradation	Fungal biodegradation refers to the degradation of a wide variety of organic pollutants by using fungal lignin-degrading or wood-rotting enzyme systems (example: white rot fungus).	Bench scale studies indicate a destruction of PCBs between 29 and 70%. Limited full scale application data.	Not applicable: Limited full scale experience and limited applicability to PCBs.
Slurry-phase biological treatment	An aqueous slurry is created by combining soil with water and other additives. The slurry is mixed to keep solids suspended and microorganisms in contact with the contaminants. Upon completion of the process, the slurry is dewatered and the treated soil is removed for disposal. Sequential anaerobic/aerobic slurry-phase bioreactors are used to treat PCBs.	Techniques have been successfully used to remediate soils, sludges, and sediments contaminated by explosives, petroleum hydrocarbons, petrochemicals, solvents, pesticides, wood preservatives, and other organic chemicals. Effective on PCBs when a sequential anaerobic/aerobic slurry-phase bioreactor is used, but limited in full scale demonstrations.	Not applicable: technology for remediation of PCBs is still developing, and low throughput of available equipment.
Chemical			
Reduction/ oxidation	Reduction/oxidation chemically converts hazardous contaminants to nonhazardous or less toxic compounds that are more stable, less mobile, and/or inert. The oxidizing agents most commonly used are hypochlorites, chlorine, and chlorine dioxide.	Reduction/ oxidation is effective for inorganics and is less effective for SVOCs such as PCBs or soils with high levels of oil and grease; not applicable to the site COCs.	Not applicable to PCB and TPH contaminated soils.
Dehalogenation	Contaminated soils and the reagent (typically potassium polyethylene glycol) are mixed and heated in a treatment vessel. The reaction causes the polyethylene glycol to replace halogen molecules and render the compound nonhazardous or less toxic.	Applicable to treating PCBs.	Not applicable due to infrastructure requirements and reagent and process wastes.
Solvent extraction	Contaminated soil and solvent extractant are mixed in an extractor, dissolving the contaminants. The extracted solution is then placed in a separator, where the contaminants and extractant are separated for treatment and further use (example: B.E.S.T.™ and propane extraction process).	Effective in treating soils containing primarily organic contaminants such as PCBs, petroleum wastes, and VOCs.	Not applicable: due to infrastructure needs, and fate of solvents in soil.

Table 6-1. Review of candidate removal action technologies for the T-117 NTCRA (cont.)

Process Option	Description	Contaminants of Concern Typically Treated	Screening Decision
Soil washing (biogenesis)	Multi-step process of preprocessing, aeration, sediment washing, cavitation and oxidation and liquid/solid separation.	Applicable to treating PCBs, but unproven at full scale to meet RvALs.	Not applicable: unproven technology, time for permitting, and necessary infrastructure.
Physical			
Separation	Contaminated fractions of solids are concentrated through gravity, magnetic or sieving separation processes.	Applicable to SVOCs, fuels, inorganics, and selected VOCs and pesticides. Only applicable to adsorptive COCs that would adhere to the fine-grained soil.	Not applicable: does not destroy contaminants; must be used in conjunction with other technologies; slow throughh put; and extensive infrastructure necessary.
Solar detoxification	Ultraviolet energy in sunlight destroys contaminants through photochemical and thermal reactions.	Limited information on destruction efficiency of PCBs at previous site applications.	Not applicable: unproven technology in large scale application.
Solidification/ vitrification	The mobility of constituents in a solid medium is reduced through addition of immobilization additives. Various additives and processes are available for different COCs.	Primarily used for inorganics; vitrification is effective for organics. Not proven to meet action levels at full scale implementation of PCBs.	Not applicable: slow through-put of available equipment, unpredictable leaching characteristics of solidified PCB contaminated soils.
Thermal			
Onsite incineration	Temperatures greater than 1,400 °F are used to volatilize and combust organic chemicals. Commercial incinerator designs are rotary kilns equipped with an afterburner, a quench, and an air pollution control system.	Applicable to site COCs where concentrations exceed the hazardous waste designation; principally PCBs > 50≥ 50 mg/kg. Would also be effective at destruction of petroleum waste	Not applicable: due to expense and time of PSCAA new source permits.
Low-temperature thermal desorption	Temperatures in the range of 200 to 600 °F are used to volatilize and combust organic chemicals. These thermal units are typically equipped with an afterburner and baghouse for treatment of air emissions.	Used to treat non-halogenated VOCs and fuels and SVOCs at reduced effectiveness.	Not applicable: Not effectively applied to PCB contaminated soils.
High-temperature thermal desorption then destruction	Temperatures in the range of 600 to 1,200 °F are used to volatilize organic chemicals. These thermal units are typically equipped with an afterburner and baghouse for destruction of air emissions.	Applicable to SVOCs, PAHs, PCBs, pesticides, volatile metals, VOCs. Limited full scale demonstrability for PCBs. The process is applicable for the separation of organics from refinery wastes, coal tar wastes, wood-treating wastes, creosote-contaminated soils, hydrocarbon-contaminated soils, mixed (radioactive and hazardous) wastes, synthetic rubber processing waste, pesticides and paint wastes.	Not applicable: does not destroy contaminants; must be used in conjunction with other technologies; slow throughput; and extensive infrastructure necessary.
Pyrolysis	Chemical decomposition is induced in organic materials by heat in the absence of oxygen. Organic materials are transformed into gaseous components and a solid residue (coke) containing fixed carbon and ash.	The target contaminant groups are SVOCs and pesticides	Not applicable: due to requiring specific feed size and materials handling requirements, and dewatering of soil. Does not destroy metals.

Table 6-1. Review of candidate removal action technologies for the T-117 NTCRA (cont.)

Process Option	Description	Contaminants of Concern Typically Treated	Screening Decision
Offs-Site Commercial Disposal			
Containment			
Subtitle D landfill	Off-site disposal at a licensed commercial landfill facility that can accept nonhazardous soil (PCB < 50 mg/kg).	Applicable to site COCs below hazardous waste designations (PCB<50 mg/kg).	Applicable: feasible for soils with PCB concentrations < 50 mg/kg.
Subtitle C landfill	Off-site disposal at a licensed commercial landfill facility that can accept hazardous soil removed by excavation (PCBs ≥>50≥ 50 mg/kg).	Applicable to site COCs exceeding hazardous waste designations (PCB > 50≥ 50 mg/kg).	Applicable: feasible for soils with PCB concentrations > 50≥ 50 mg/kg.
Physical			
Separation	Contaminated fractions of solids are concentrated through gravity, magnetic or sieving separation processes.	Applicable to SVOCs, fuels, inorganics, and select VOCs and pesticides. Only applicable to adsorptive COCs that would adhere to the fine-grained soil.	Not applicable: commercial permitted disposersal facilities not available in the region.
Thermal			
Alternate thermal destruction or incineration	Offsite incineration and disposal at a licensed commercial facility that can accept hazardous soil removed by excavation (PCB > 50≥ 50 mg/kg). Depends on analytical data from excavated soil. Dewatering may be required to reduce water content for transportation.	Applicable to site COCs where concentrations exceed the hazardous waste designation; principally PCBs > 50≥ 50 mg/kg. Would also be effective at destruction of petroleum waste.	Applicable: appropriate for Toxic Substances Control Act (TSCA; PCBs >50≥ 50 mg/kg) material.
Chemical			
Dehalogenation	Contaminated soils and the reagent (typically potassium polyethylene glycol) are mixed and heated in a treatment vessel. The reaction causes the polyethylene glycol to replace halogen molecules and render the compound nonhazardous or less toxic.	Applicable to treating the site COCs.	Not applicable: commercial permitted disposers disposal facilities not available in the region.

BTEX – benzene, toluene, ethylbenzene, and xylene
COC – contaminant of concern
cy – cubic yards
FRTR – Federal Remediation Technologies Roundtable
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PSCAA – Puget Sound Clean Air Agency
RvALs – removal action levels
SVOC – semivolatile organic compound
T-117 – Terminal 117
TPH – total petroleum hydrocarbon
TSCA – Toxic Substances Control Act
VOC – volatile organic compound

As presented in Table 6-1, both *in situ* and *ex situ* treatment technologies were identified and evaluated. *In situ* treatment technologies were not retained because of a variety of implementability and effectiveness limitations, including the following:

- No~~All~~~~Many~~ treatment technologies would likely ~~not~~ meet the RvALs specified for the site or are not applicable because of performance and processing limitations. For example, there is a lack of performance data for *in situ* biodegradation, the site contamination at the T-117 EAA is not limited to the surface so phytoremediation would not be effective, and site soil includes heterogeneous fill and debris, which would be difficult to process using soil flushing, vitrification, or thermal treatment.
- ~~Treatment timeframes would be unacceptably long as compared with those for excavation and would result in a protracted implementation period not in keeping with the concept of an early action (i.e., there would be a much higher likelihood that the NTCRA would not be completed prior to the implementation of remedial action[s] for the LDW).~~
- Possible discharges to the LDW during treatment (e.g., chemicals associated with oxidation, soil flushing, and solidification) could pose an unacceptable risk to LDW sediment, and water quality and would need to be managed. These chemicals include oxidants, such as permanganate, or surfactants that supersaturate contaminants in water; these chemicals would be present at high concentrations and would pose a more significant risk to water quality than is currently posed by site COCs.

Ex situ treatment technologies were eliminated because of a variety of implementability and effectiveness limitations, including the following:

- Treatment technologies cannot be performed onsite because most available land within the T-117 EAA will be subject to excavation during removal action implementation. The largest area within the T-117 Upland Study Area not expected to be excavated is less than 0.10 ac is size; this area is much smaller than the area that would be needed for any *ex situ* treatment system.
- Treatment would not likely achieve RvALs at or below those established for the T-117 EAA, particularly levels sufficient to meet a broad range of possible future land uses (including terrestrial habitat criteria), and offsite disposal would still be required. RvALs are difficult to achieve because the mixture of organic and inorganic COCs and the persistent nature of the organic COCs make it difficult to effectively treat the soil.
- The longer timeframe required to process large volumes of soil could delay completion of the NTCRA. For example, a typical mobile thermal treatment unit would require two to three dry seasons of operation (i.e., years) to treat all of the excavated soil.

- EPA-permitted a~~A~~lternative PCB treatment technologies~~technologies~~ would pose unacceptable constraints on the project, including prolonged timeframes to demonstrate the site-specific efficiency and reliability (e.g., the possible need for pilot or demonstration testing), low probability of institutional acceptance, and performance uncertainties relative to disposal methods specifically approved under TSCA for PCBs.

Preferred disposal options for both soil and sediment would be at Subtitle C (TSCA) and Subtitle D landfills. The conclusion that commercial landfill disposal is a cost~~-~~-effective and environmentally acceptable solution is consistent with the findings of the *Puget Sound Confined Disposal Site Study* (USACE 2003), which was co-sponsored by Ecology, WDNR, and the Puget Sound Water Quality Action team with cooperation from EPA Region 10, US Fish and Wildlife Service (USFWS), and Washington Public Ports Association.

Although there are several alternative technology treatment facilities that are permitted by EPA, these facilities are not located within a reasonable distance from T-117 and are not cost competitive with Subtitle C or D disposal. The closest applicable facilities that have an incinerator and a low-temperature thermal desorption unit, are both located near Salt Lake City, Utah. With disposal, soil would be hauled approximately 5 miles and loaded onto trains for transport to a commercial landfill. Thus, commercial alternative technology treatment ~~technologies~~ facilities were not retained.

6.3 SUMMARY OF RETAINED TECHNOLOGIES

Table 6-2 presents a summary of technologies retained for inclusion in one or more of the removal action alternatives discussed in Section 7.

Table 6-2. ~~Retained R~~Rremoval action technologies retained for the T-117 NTCRA~~EAA~~

Category	Technology/ Method	Applicable Media	Notes
Removal	land-based excavation	upland soil; nearshore sediment	Technology is appropriate and readily available for the scale and site-specific conditions at the T-117 EAA.
	over-water mechanical dredging	sediment	Technology is proven and available within the project area. Special bucket designs and operating procedures can be used for mechanical dredging to limit release of solids.
Containment	in-water cap	sediment	Technology is appropriate for the T-117 Sediment Study Area~~,~~ but ~~will~~ would likely require restrictive covenants on property use to prohibit activities that could disturb the cap, and long-term monitoring of ~~additional analysis of~~ COCs and cap thickness ~~monitoring~~ would be necessary to demonstrate that the cap remains in place and provides the intended isolation of impacted sediment. ~~effectiveness.~~ Capping must consider post-placement hydraulic conditions~~.~~.

Category	Technology/ Method	Applicable Media	Notes
Disposal	Subtitle C landfill disposal	TSCA-designated waste soil or sediment	Method is available and typically used for managing hazardous or dangerous materials, including soil withthat require special landfill design and operation because PCB concentrations that exceed TSCA-specified limits (i.e., equal to or greater than 50 mg/kg). Applicable predominately predominantly to soil and some nearshore/bank sediment.
	Subtitle D landfill disposal	non-hazardous or non-dangerous soil or sediment	Method is available and typically used for managing materials that are not designated as hazardous or dangerous wastes. Applicable to sediment, soils in the Adjacent Streets and Residential Yards soil Study Area, and some T-117 Upland Area Study Area soil.

COC – contaminant of concern
EAA – early action area
na – not applicable
PCB – polychlorinated biphenyl
T-117 – Terminal 117
TSCA – Toxic Substances Control Act

7 Removal Action Alternatives

This section presents the two removal action alternatives identified for the T-117 EAA and describes the No Action alternative, which was developed to provide a basis for the comparative evaluation of alternatives (Section 8). In particular, this section:

- Discusses how each alternative would be applied to the T-117 EAA
- Discusses the implementability, effectiveness, and estimated cost of each alternative
- Presents project completion options

The two removal action alternatives incorporate the technologies evaluated and retained in Section 6 and address the removal of contaminated soil in the T-117 Upland and Adjacent Street and Residential Yards Study Areas and the removal or capping of sediment in the T-117 Sediment Study Area. Because the selected action levels for the upland portion of the site are low enough to provide for a broad range of future land uses (including the need to achieve RvALs sufficient for possible habitat redevelopment in the T-117 Upland Study Area), this EE/CA does not include alternatives that are solely based on current upland land use. Such alternatives might have been considered for the T-117 EAA if the final site use were to be limited to industrial or restricted-access facilities. However, RvALs based on industrial or restricted-access exposure assumptions are not appropriate for the T-117 EAA because of the EPA mandate for unrestricted land use (EPA 2007b), which was based on the T-117 EAA's proximity to residential areas and the LDW shoreline, the site RAOs, and MTCA. The two alternatives retained in this EE/CA represent the "maximum feasible" removal action in terms of the extent and level of site cleanup, rather than a mid-range of options as might otherwise be considered given a more limited future site use and a different set of removal action goals and objectives. .

A range of treatment and disposal technologies for removal of soil and sediment were evaluated in Section 6, and used to assemble two removal alternatives as well as the one technology (i.e., offsite disposal) was retained. The two retained alternatives, as well as the No Action alternative, which are summarized below and in Table 7-1 and the following bullets.

- **No Action alternative** – The No Action alternative has been retained only to provide a basis for comparing the overall effectiveness of the two identified removal alternatives (i.e., Alternatives 1 and 2). The No Action alternative is not a viable removal action alternative and does not meet the requirement to consider a broad range of possible future land uses or potential habitat development goals for this project. Under the No Action Alternative, no activities would be implemented to remove, contain, or treat contaminated upland soil or intertidal and subtidal sediment within the EAA. The site would remain in its current condition with ongoing access restrictions and monitoring similar to that required under the existing O&M plan and post-removal site control plan (RETEC 2007a) implemented for the T-117 Upland Study Area following the 2006 TCRA.

- **Alternative 1, upland soil excavation and sediment excavation/dredging combined with capping –**This alternative involves the excavation of soil from the T-117 Upland Study Area, including the shoreline bank area, as well as the Adjacent Streets and Residential Yards Study Area. As set forth in Section 4, this alternative would include soil removal up to the MTCA-specified depth of compliance of 15 ft as needed to achieve the RvALs. The Upland Study Area would be backfilled to an elevation of +14 -ft MLLW, and the Adjacent Streets and Residential Yards would be backfilled to near original grades. In the T-117 Sediment Study Area, the portion of the mudflat sediment offshore of the toe of the shoreline bank and outward to an elevation of approximately 0 -ft MLLW would be excavated using conventional shore-based earth-moving equipment. The depth of excavation would be approximately 2 to 4 ft. Subtidal sediment removal in the Marina, would be approximately 2 to 5 ft deep, would beand be accomplishedremoved using over-water mechanical dredging to re-establish navigable depths within the Marina. Capping material would be placed throughout the sediment remediation area, except for the Marina, to establish a clean sediment surface in compliance with the sediment RvALs. Map 7-1 shows the Alternative 1 removal area excavation prisms.
- **Alternative 2, upland soil excavation and sediment excavation/dredging –** This Alternative is the same as Alternative 1 regarding excavation and backfilling at the T-117 Upland Study Area and adjacent shoreline bank as well as the Adjacent Streets and Residential Yards Study Area. Alternative 2 only differs from Alternative 1 relative to the nature of the removal action in the Sediment Study Area offshore of the toe of the shoreline bank. Alternative 2 requires dredging of all contaminated sediment within the sediment boundary, including dredging within the Marina to re-establish navigable depths. Dredging depths will range from 2 to 7 ft. The dredged areas, except the Marina, will be backfilled with clean material to re-establish site grades. Map 7--2 shows the Alternative 2 removal area excavation prisms. Map 7-3 presents an overview of the removal areas and the sediment cap area of both Alternatives.

Table 7-1. Summary of site-wide removal action alternatives

Alternative	Description	Extent of Action and Action Goals Based on Preliminary RAOs		
		T-117 Upland Removal Area	Adjacent Streets and Residential Yards Removal Area	T-117 Sediment Removal Area
No Action Alternative. No removal of contaminated material. Ongoing institutional controls, monitoring and site-wide maintenance would continue as presently required.	Institutional controls (e.g., access controls) Monitoring Site-wide maintenance (inspections, erosion and surface water controls)	None	None	None
Alternative 1. Upland soil removal and sediment excavation/dredging combined with capping	Upland soil excavation Limited intertidal sediment excavation in the mudflat at the toe of the Bank Limited subtidal sediment dredging at the marina Sediment capping to meet the sediment RAOs as needed within the sediment boundary	RvALs based on a broad range of potential future upland site use conditions or use as upland habitat are met based on MTCA[a] and background. Alternative includes the baseline completion approach: backfill with clean soil to restore the site to intermediate elevation of just above +14 MLLW to allow for broad range of future uses (including possible habitat development). Post removal redevelopment options may be chosen by the Port during the removal design (Section 9.3).	Potential future upland site use conditions and associated RvALs met. Restore site to approximate pre-existing grades, with paving and stormwater improvements meeting City of Seattle design codes. Restore yards to pre-existing conditions and restore any improvements that exist at the time of initiation of the cleanup. ~~Restore yards to pre-existing conditions.~~	Combined excavation and dredging with capping to meet sediment RvALs within the T-117 sediment removal area to the specified depth of compliance (45 cm). A thicker cap (~~e.g.,~~ up to 3 ft) could be required depending on final design.

Alternative	Description	Extent of Action and Action Goals Based on Preliminary RAOs		
		T-117 Upland Removal Area	Adjacent Streets and Residential Yards Removal Area	T-117 Sediment Removal Area
Alternative 2. Upland soil removal and sediment excavation/dredging	Upland soil excavation Intertidal sSediment excavation between the bank and subtidal area Subtidal sediment dredging to the extent of the sediment boundary No capping	Same as Alternative 1.	Same as Alternative 1.	Excavation and dredging to meet sediment RAOs within the T-117 sediment removal area to the specified depth of compliance (45 -cm). Capping would not be used except as a contingency for limited areas where sediment excavation or dredging might not be feasible (e.g., around existing structures). Backfilling with clean material would occur in some locations to restore the desired final topography.

[a] According to MTCA unrestricted site use conditions, "Restrictions on the use of the site or natural resources affected by releases of hazardous substances from the site are not required to ensure continued protection of human health and the environment" (WAC 173-340-200).The point of compliance is typically throughout the site to a depth of 15 ft (WAC 173-340-740(6)). MTCA CULs are specific to each contaminant and are derived using default or site-specific assumptions as set forth for soil under WAC 173-340-740 (i.e., the Method A default CUL for total PCBs in soil for unrestricted land use is 1.0 mg/kg). Soil CULs for upland areas to be developed for use as habitat are set forth under WAC 173-340-7493 and may be more stringent than MTCA Method A. Reliance on clean soil covers to provide for habitat development may include requirements for institutional controls to maintain habitat areas and prevent exposure of sensitive species to residual site contaminants located at depth. Soil that is directly erodible into the LDW or that will come to reside within the aquatic portion of the LDW as a result of this removal action will meet sediment RvALs set forth herein.

ARAR – applicable or relevant and appropriate requirement
CUL – cleanup level
LDW – Lower Duwamish Waterway
MTCA – Model Toxics Control Act
na – not applicable
RAO – removal action objective
RvAL – removal action level
T-117 – Terminal 117
WAC – Washington Administrative Code

Both alternatives include the extensive removal of contaminated soil and sediment to meet the RAOs. Both represent a high degree of cleanup, and neither depends on containment or institutional controls in the upland areas. In addition, there is the potential for encountering currently unknown site infrastructure, artifacts, and/or contamination during the removal action, which both alternatives will address, as appropriate.

~~The use of controls or restrictions would only be used as necessary to protect future habitat in both the upland and aquatic areas. Alternative 1 would depend upon institutional controls (in the offshore cap area to help ensure the long-term integrity of these in-water structures.~~

Alternatives 1 and 2 include the assumption that after upland and bank soil removal is completed to remove COCs at concentrations greater than the soil RvALs up to the appropriate depth of compliance (e.g., up to 15 ft below final upland site grade), the excavated portions of the T-117 Upland Study Area will be backfilled to a finished grade just above elevation +14 MLLW, which is slightly above the high water line of +13.8 ft MLLW. For the purpose of this EE/CA, this is referred to as the baseline completion option, which is necessary to develop cost estimates. Additional d~~D~~evelopment options for restoring the T-117 EAA that are compatible with a full range of possible future site uses (i.e., completion options), including habitat restoration, are discussed in Section 7.3.

The following subsections describe the two removal action alternatives in detail and discuss how each would be implemented. Each alternative is discussed relative to specific actions within the three T-117 EAA ~~three~~ study areas and in terms of the overall criteria of implementability, effectiveness, and cost as defined in EPA's *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (1993).

The evaluation of each alternative includes a discussion of:

- Site preparation requirements
- Soil excavation activities
- Sediment excavation/dredging and capping activities
- Management of excavated and dredged materials
- Site completion and coordination with future site uses
- Quantities and costs
- Evaluation of implementability and effectiveness

7.1 Alternative 1: Upland Soil Excavation and Sediment Excavation/ Dredging Combined with Capping

This alternative involves the excavation of soil in the T-117 Upland Study Area (including the shoreline bank) and Adjacent Streets and Residential Yards Study Area to meet the defined soil RvALs at the depths of compliance presented as the RAOs in Section 4.4. In the T-117 Sediment Study Area, mudflat sediment would be excavated using conventional land-based earth-moving equipment, and subtidal sediment would be removed using a barge-mounted dredge to allow for a sufficient post-removal cap depth. The subtidal (submerged) portion of the removal area would then be capped (except in the area offshore of the Marina, where removal without capping would be used to meet the RAOs). The specific combination of excavation and dredging would be established during the remedial design. Surface water quality monitoring parameters and criteria for dredging work would be identified as part of the design phase of the NTCRA. Capping would be used instead of excavation or dredging to address contaminated sediment at locations where capping could be implemented without unacceptable shallowing or constriction of the river channel or Marina. As mentioned previously, specific locations where final cap elevations would need to be consistent with required channel depths would be identified and evaluated during the remedial design. For the purpose of this EE/CA, it is assumed that a cap thickness of 3 ft would be used (see Section 7.1.3). The actual cap thicknesses and layers would be finalized as part of the NTCRA design and could vary depending on the location of the capped area. ~~The first (bottom) layer of the anticipated cap cross section would consist of a 6-in. to 1-ft-thick layer of granular soil, which would serve as a filter layer and be placed directly on the sediment. Above this layer would be a 1-ft-thick layer of cobbles to provide stability and resistance to erosion. The final (upper) portion would consist of a 1-ft-thick layer of habitat-enhancing sand and gravel that would be appropriately sized for stability during normal river flows.~~

7.1.1 Site preparation

Excavated and dredged materials will need to be removed from the site for offsite disposal (Section 7.1.4). A number of site preparation activities would need to be completed prior to the implementation of the removal action. Design details and work plans for implementation would be further developed during the design phase. Site preparation activities are described below.

7.1.1.1 Public notification and traffic control measures

A traffic routing plan would be developed during the design phase with input from the community. Prior to work initiation, public notifications and traffic control measures would be implemented in accordance with the approved routing plan and site-specific construction plans. Notifications would inform the potentially impacted neighborhood residents and businesses of the planned construction dates, duration of work, areas of work, site access restrictions, and possible alternative traffic routes for neighborhood residents and construction trucks. Hours of operations (i.e., working longer hours for shorter overall duration or working shorter hours for potentially longer overall duration) will also be determined with community input. In addition, the timing of road improvement activities (e.g., the pending South Park Bridge replacement project) would need to be considered. Traffic control measures, including signage, warning lights, and the use of traffic control personnel, would be implemented in accordance with applicable construction codes and guidance.

7.1.1.2 Dust control plan

Control of offsite dispersal of dust generated during construction ~~would~~ will be a high priority for the NTCRA design and implementation. A dust control plan ~~would~~will be developed as part of the NTCRA design and would specify methods and criteria for implementing specific dust control measures. Dust control methods and monitoring activities similar to those used during the 2006 TCRA (RETEC 2006) ~~would~~will be evaluated for applicability to the site and used as appropriate.

Monitoring of previous remedial actions has been conducted at the T-117 EAA. Air monitoring was conducted as part of the 2006 TCRA (RETEC 2006). Air sampling and monitoring for the TCRA consisted of air quality monitoring, meteorological monitoring, and odor observations. Air monitoring action levels were~~s~~ specified in the air quality and meteorological monitoring plan[18] (Appendix D in RETEC 2006). Monitoring before (background) and during removal identified particulate and PCB concentrations well below the action levels (RETEC 2007b).

During the 2005 independent removal action conducted by the City, yard soil was removed at 8601 and 8609 Dallas Avenue S. During the removal, wipe samples were collected from metal and painted wood surfaces at the residences. The wipe samples were analyzed for PCBs, which were not detected above the PQL of 2 µg/100 cm^2 (Onsite Environmental 2005).

Finally, WSDOH conducted indoor dust sampling in conjunction with the 2004-2005 independent removal action at two homes on 17th Avenue S (8601 and 8609 17th Avenue S). Dust was collected with a high-~~-~~volume, small-~~-~~surface sampler in areas of high activity in the homes. PCBs were detected (primarily in rugs) at levels ranging from 0.756 to 1.57 mg/kg (dust loading ranged from 2.18 to 16.7 g/m^2), indicating that some PCBs were transported into the home from exterior sources (assumed to be Dallas Avenue S road dust). However, WSDOH concluded that no apparent public health hazard existed~~s~~ for residents exposed to PCBs found in house dust along Dallas Avenue S (WSDOH 2006).

Although previous monitoring has not identified significant issues with regard to dust, dust control and monitoring will be conducted during the removal action. Particular attention ~~would~~ will be ~~given~~ paid to controlling dust during excavation, soil loading activities, and work during dry weather. ~~Meteorological monitoring would also be used as a tool for evaluating dust control needs.~~ As was done for the TCRA, dust management may include the wetting of excavation areas and stockpiles with water, covering of trucks loaded with soil, covering of stockpiles that are not

[18] The action level for PM10 particulates (as measured with DataRAM meters and TE-1000 polyurethane foam cartridge samplers) was 105 µg/m^3 based on a 24-hour average, and the action level for PCB concentrations was 0.11 µg/m^3 at the property perimeter.

being actively loaded or unloaded, and daily sweeping of onsite truck routes and soil handling areas. Meteorological monitoring would also be used to evaluate dust control needs. Odor was not an issue during the 2006 TCRA, but odor control foam will be applied during the NTCRA if odor problems arise. The monitoring methods will be developed in the NTCRA design phase.

7.1.1.3 Construction mobilization

Supporting site facilities, staging areas, drainage and erosion controls, dust suppression equipment and effective decontamination facilities, including facilities for truck wheel washing, would be installed or constructed prior to the initiation of the removal action. Plans for site health and safety, drainage controls (Section 7.1.1.4), construction scheduling, dust and track-out monitoring and control, in-water monitoring (during dredging/capping) and other measures will need to be prepared and fully implemented. Measures will also need to be in place to ensure that truck loads are appropriately lined and covered and vehicles are decontaminated (i.e., wheels have been washed) and inspected prior to leaving the T-117 EAA and entering public streets.

7.1.1.4 Water control systems

Collection, treatment, and disposal systems will be required to address surface runoff coming into or originating from the removal areas. Engineered well-point systems and/or subsurface barriers or interceptor systems would also likely be necessary to limit the influx of groundwater into deeper upland excavations within the T-117 Upland Study Area. A shoreline barrier (i.e., sheet pile wall or soil berm) would be employed as needed to limit tidal influence of groundwater and prevent tidal inundation of upland soil removal areas. For the purpose of the EE/CA, it is assumed that either an upgradient low-permeability cutoff wall (i.e., bentonite/ cement slurry-filled trench) or a groundwater dewatering system would be used to limit groundwater influx from upgradient areas prior to excavation below the water table. Additional water extraction and treatment would likely be necessary for any water that may collect within temporary shoreline/bank barriers (e.g., a sheetpile walls) and the deeper inland soil removal prisms in order to maintain desired work conditions, prevent water intrusion, and facilitate backfilling.

A construction site stormwater management plan would be prepared for the project and would include soil staging areas, the location and design of water storage/treatment facilities, and any associated sediment handling facilities. The plan would specify methods for intercepting, collecting, and managing stormwater, as necessary. BMPs, including the covering of excavated materials, stormwater interception, and collection and treatment of water from excavation and staging areas, will be used to ensure that potential impacts to the adjacent river, properties, and existing residential drainage systems are controlled. The City and County permitting requirements for offsite disposal of collected and treated water will be considered in developing and implementing water management systems.

7.1.1.5 Staging areas

Staging areas for excavated soil would be established within the T-117 EAA, as necessary, to accommodate material storage and loading. Staging will have to be carefully managed for the T-117 Upland Study Area excavation because available space will be limited; the project design will need to consider off-site staging and the direct loading of trucks. Bank soil and sediment excavated using land-based equipment would ~~also~~ be staged and loaded for transport within the confines of the T-~~-~~117 Upland Study Area. Sediment removed using over- water dredging would be transported to an appropriate shoreline transfer location at an existing dock along the LDW or at a Port facility, depending on availability of suitable space. Another option would be to transfer dredged sediment using a specially constructed temporary transfer facility at the T-117 EAA. Safeguards to ensure the clean and safe transfer of materials would be required for the sediment handling location. Temporary material staging time frames for soil or sediment deemed to be hazardous waste would be consistent with limits set forth under RCRA for remediation wastes (typically 90 days unless additional time is authorized by EPA), and the staging location would comply with staging pile rules (WAC 173-303-64690 and 40 CFR 264.554). Bank soil and sediment will be excavated first and will be stored on the T-117 Upland Study Area, in a soil-staging facility, which will be lined and bermed. As mentioned above, the construction site stormwater management plan would include control measures for soil/sediment staging areas and any associated sediment transfer facility.

7.1.1.6 Demolition and removal or relocation of structures and utilities

The T-117 Upland Study Area and Adjacent Streets are paved and include buried slabs, utility corridors, storm drains, and other subsurface features. The north, central, and south buildings at the T-117 EAA and associated shelters, loading docks, and foundations would be demolished and removed during the initial stage of the NTCRA. Closed-in-place USTs located within the projected excavations, the UST in the vicinity of the southwest corner of the north building, and the septic tank that serves the north building and most of the associated drain field to the south would be removed as part of the NTCRA. The decision to remove any additional portions of the septic drain that may be encountered beyond the planned limits of the T-117 Upland Removal Area would be based on field observations and performance sampling results at the time of the NTCRA. The Adjacent Streets would be closed in stages to allow access to the T-117 Upland Study Area and to limit the disruption of residential access. A portion of the Marina floating docks would be temporarily relocated out of the T-117 sediment removal area to an alternate location based on timing and availability of moorage space. This relocation will allow for access to sediment within the northern end of the sediment removal boundary. The Adjacent Streets would be temporarily vacated, as necessary, to allow for the removal of underlying soil.

7.1.1.7 Yard remediation

The Residential Yards are not owned by the City or the Port; therefore, access agreements would need to be established prior to the initiation of any remediation on these private properties. Also, the Residential Yards are landscaped and include fences, utilities, and other surface and subsurface features. These features would need to be removed or worked around if they are located within the excavation prism. Removal activities would be coordinated with property owners prior to initiation and would be conducted in such a manner as to limit the disruption of residential access. Specific procedures for coordination with affected property owners would be developed with community input during the remedial design phase. Any landscaping that is disturbed will be replaced and/or replanted, and surface drainage will be maintained or improved as necessary.

7.1.2 Soil removal

The estimated boundary of the removal action in the T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area is presented on Map 4-1. The estimated extent of the removal action in the T-117 Upland Area and Adjacent Streets is are presented in Maps 7-1 and 7-3. The spatial extent of the removal action is designed to address COCs in the upland soil (see Section 4) and include the removal of the berm of the shoreline bank. Figures 7-1 through 7-5 show the extent of the proposed NTCRA in a series of cross sections. The T-117 Upland removal area is composed of several excavation prisms with depths that range from 1 to 17 ft. The Adjacent Streets and Residential Yards removal area is composed of several excavation prisms that range in depth from 1 to 6 ft along portions of the Adjacent Streets and up to 2 ft within specific Residential Yards. The locations and depths of excavations may be expanded slightly during design to provide for equipment access, slope stability, and sequencing of the excavation process. The modification of excavation locations and depths may also be necessary to address unforeseen conditions encountered during removal, including the presence of structures (e.g., underground utilities). As described in Section 9.3.3.2, final depths will be based on confirmation sampling to ensure that the RvALs are attained.

Slipsheet for 11 x 17

Figure 7-1. Cross section E1 ~~for Alternative 2~~

Slipsheet for 11 x 17

Figure 7-2. Cross section E2 ~~for Alternative 2~~

Slipsheet for 11 x 17

Figure 7-3. Cross section E3 ~~for Alternative 2~~

Slipsheet for 11 x 17

Figure 7-4. Cross section E4 ~~for Alternative 2~~

Slipsheet for 11 x 17

Figure 7-5. Cross section E5 ~~for Alternative 2~~

The yard and street DUs designated for removal are identified based on UCL calculations from MIS sampling results (as detailed in Appendix L, and described in Section 4.4.3).[19] The Adjacent Streets and Residential Yards Study Area is composed of several excavation prisms that range in depth from 1 to 6 ft along portions of the Adjacent Streets and up to 2 ft within specific Residential Yards. Pre~~-~~-removal sampling is anticipated in Residential Yards as part of the design phase to pre-determine the extent of soil removal from yards and at DU25 and DU35, where soils adjacent to a DU designated for removal ~~-~~have not been characterized. The DUs designated for removal and the locations for pre-removal sampling are shown on Map ~~-~~7-3.

The approximate in-place (i.e., pre-excavated) volumes of soil anticipated to be removed from the T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area are presented in Table 7-2.

Table 7-2. In-place volumes of soil and sediment to be removed and estimated sediment capping/backfilling volumes under Alternative 1

Study Area	Component[a]	Quantity (cy)[b]
T-117 Upland Study Area	non-TSCA soil	33,100
	TSCA-designated soil	3,900
Adjacent Streets	non-TSCA soil	7,400
	TSCA-designated soil	900
Residential Yards	non-TSCA soil	1,800
	TSCA-designated soil	0
Total soil to be removed	non-TSCA soil	42,300
	TSCA-designated soil	4,800
Total T-117 Sediment Study Area	non-TSCA sediment	6,450
	TSCA-designated sediment	50
Material required for capping/backfilling		8,000

[a] TSCA soil is defined as soil with total PCB concentrations ≥ 50 mg/kg. A portion of this volume, approximately 250 cy, is estimated to contain total PCBs at concentrations ≥ 500 mg/kg. According to TSCA, all soil ≥ 50 mg/kg is amenable for disposal in accordance with 40 CFR 761.61(a)(5)(iii): "Bulk PCB remediation wastes with a PCB concentration ≥50 ppm shall be disposed of in a hazardous waste landfill permitted by EPA under section 3004 of RCRA, or by a State authorized under section 3006 of RCRA, or a PCB disposal facility approved under this part." Final offsite disposal is subject to review by EPA and will be arranged in accordance with the waste-acceptance policy of the approved disposal facility.

[b] Total volumes include the complete removal of the asphalt and base course material, as necessary, within the T-117 Upland Study Area and Adjacent Streets.

cy – cubic yard

EPA – US Environmental Protection Agency

PCB – polychlorinated biphenyl

TSCA – Toxic Substances Control Act

[19] An option exists to collect additional replicate samples at DUs with only one MIS sample. Based on additional sampling results and the recalculation of the UCL, the status of the corresponding DUs could change.

Total volumes include the complete removal of the asphalt and base course material, as necessary, within the T-117 Upland Study Area and Adjacent Streets. As shown in Table 7-2, some of the soil from the T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area will be TSCA-regulated waste, requiring disposal at a Subtitle C landfill. The majority of the volume will be suitable for disposal at a Subtitle D landfill.

Excavation stability, impacts to groundwater, stormwater controls, and tidal water intrusion will be addressed in the design phase of the NTCRA. The design phase will also address proper sequencing and the selection of effective construction methods (i.e., use of temporary shoreline soil berms, sheet piling, or other types of barriers) and surface water and groundwater controls. The locations and depths of the soil removal prisms will be refined during final design and execution based on site conditions**.**

The majority of the soil within the T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area consists of loose-to-medium-dense silty gravelly sand, with deposits of sand and silt. Based on this soil type, excavation slopes of 2 horizontal to 1 vertical (2H:1V) were assumed and included in the estimated upland soil volumes. The refinement of excavation slopes and methods will be included in the design phase of the NTCRA. Confirmation sampling in the T-117 Upland Study Area will be conducted at the limits of excavated areas and compared to RvALs removal action levels for target COCs. Confirmation sampling of the Adjacent Streets and Residential Yard Study Area soils will include PCBs and dioxins/furans (see Section 9.3.3.2).

The removal of the shoreline berm material will be carried out as part of the removal action in the T-117 Upland Study Area. The portion of the bank to be removed is included within the T-117 Upland Study Area boundary (Map 4-1). All soil that may remain beneath the re-established (i.e., new) bank portions of T-117 EAA completed above +13.8 ft MLLW will meet the applicable soil RvALs to the compliance depth (i.e., up to 15 ft below final ground surface) set forth in Section 4 and shown on Figure 4-1. Most of the upper portion of the bank will be removed and replaced with clean fill that will meet the sediment RvALs. In addition, these actions will ensure that all bank soil that could become intertidal or subtidal sediment (i.e., upon completion of the NTCRA) will meet the applicable sediment RvALs to the specified depth of compliance, either through dredging or a combination of dredging and capping depending upon the selected removal alternative. It is anticipated that some additional bank removal (i.e., soils with COCs concentrations less than the RvALs) may need to be undertaken at some locations to ensure the stability of completed (i.e., new) shoreline banks and accommodate possible final site uses (e.g., aquatic habitat).

7.1.3 Sediment removal and capping

Alternative 1 includes the removal of sediment from the mudflat close to the bank and above elevation 0 ft MLLW following the removal of the impacted bank material (based on appropriate soil or sediment RvALs) and the dredging of impacted sediment from within the Marina (and also re-establishing navigable depths in Marina). This would be followed by the capping of the mudflat and submerged areas within the sediment removal boundary except within the Marina, which would be an impediment to navigation. Removal will be accomplished by excavating a portion of the contaminated sediment and debris from the mudflat (e.g., down to elevation 0 ft MLLW).

Capping designs prepared in accordance with USACE guidance (see Section 6.1.2.2) for PCB--contaminated sediment can include caps that range from 12 to 36 -in. thick. The caps are often multi-layered to provide chemical isolation immediately over the impacted sediment and include a sand and gravel/cobbles layer to prevent erosion from waves and prop wash and a surficial habitat layer of sand and gravel. A robust 3-ft--thick cap configuration has been assumed for the EE/CA. The cap would consist of three layers: a sandy material to provide primary physical and chemical containment of the underlying sediment, an armored layer (cobbles) to protect against erosion, and a surface layer of natural sand and gravel. The final cap design will be based on a hydraulic evaluation to determine an acceptable river channel cross section. The cap construction could also include the placement of a filter layer (fabric in the intertidal zone and granular soil in the subtidal zone).

~~A conceptual cap design for T-117 is shown on~~ The portion of Alternative 1 that would be capped is shown on Map 7-~~2~~3 ~~(plan view)~~ and Figure -7--6 (cross section). The sediment exposed by the mudflat excavation would be sampled and analyzed for COCs and then capped as shown on Figure 7-6 unless post-removal testing showed that COC concentrations in the exposed sediment were less than the RvALs, in which case it would be backfilled using clean material.

Slipsheet (11x17)

Figure 7-6. General sediment excavation and cap cross section

Removal of sediment from within the T-117 Sediment Removal Area will likely be performed after the T-117 Upland Study Area work, which will help ensure that work in the T-117 Upland Study Area does not act as a source of recontamination to the sediment. For the purpose of meeting the RAOs for sediment (Section 4), once the mudflat excavation is complete, the new mudflat surface and submerged portion of the removal area will be capped. The volume of sediment to be removed under Alternative 1 is summarized in Table 7-2.

Sediment removal and capping in the intertidal mudflat area would be completed using land-based excavators or dredges. Removal in the submerged portion of the T-117 sediment removal area would be completed using dredges and barges, working at higher tides as needed to provide the required draft for the barges. For the portion of the T-117 sediment removal area that is within the Marina, the submerged-zone impacted sediment will be removed and not capped or backfilled to re-establish navigation depths.

Engineering controls will be implemented to limit the resuspension of contaminated sediment during removal. A primary method for minimizing sediment resuspension during removal in the intertidal zone is to complete the work when the tides are out while the sediment is exposed to the air. Using this approach, removal does not occur in the water column, and resuspension is essentially eliminated. The excavation process will occur over a few weeks' time, and portions of the excavation will be inundated by the daily rising tides prior to the completion of the removal. Experience with this method of excavation over multiple tidal cycles at the Hylebos Waterway, part of the Commencement Bay Nearshore/Tideflats Superfund site, at several locations (General Metals Graving Slip, J&G Marina, Dunlap log ramp, Arkema South East Shoreline), demonstrated that the repeated inundation of the excavation area did not adversely impact the cleanup (DOF 2009).

Engineering controls to limit suspension during dredging include the use of enclosed dredging buckets to limit wash out during retrieval of the bucket through the water column, and the avoidance of overflow of turbid sediment from the sediment haul barge during dredging. Other examples of engineering controls include using slower cycling times and containment structures to catch bucket spillage and direct materials into the receiving barge or platform. These techniques have been used at other sediment remediation projects in the LDW and other waterways.

The use of silt curtains at the T-117 Sediment Study Area is not considered practical because of the varying river currents and tidal stages. Deploying, maintaining, and working with a silt curtain within the intertidal portion of the T-117 Sediment Study Area would be problematic, and the use of a silt curtain in the subtidal portion of the study area could interfere with navigation in the channel. According to an evaluation of resuspension controls for dredging (Bridges et al. 2008), the installation and maintenance of silt curtains in "moderate- or high-energy areas" can be difficult, and their effectiveness is questionable. Silt curtains that are not fastened to the bottom of the river, which would be extremely difficult to do at the T-117 Sediment Study Area, can allow particles to escape beneath the skirt.

Water quality will be periodically regularly monitored during dredging activities to assess potential water quality impacts during project implementation. Water quality conditions must be within the limits prescribed by EPA's 401 Water Quality Certification. If necessary, appropriate adjustments to dredging activities, such as those described above, will be made to maximize the protection of the environment.

The mudflat excavation will start at the toe of the bank at an elevation of approximately +5 ft MLLW. The mudflat will be removed to an elevation of 0 ft MLLW and then extended horizontally to the existing 0 ft MLLW contour. By setting the deepest extent of the mudflat excavation at 0 ft MLLW, all of the nearshore excavation could be completed "in the dry" while the tides are out (< 0 ft MLLW).

Typical sediment cap designs include layers of granular material designed to contain the contaminated sediment, protect against disturbance, and provide surficial habitat. The cap construction could include the placement of filter layer (fabric in the intertidal zone and granular soil in the subtidal zone) followed by the placement of quarry spalls and a surface layer of sand and gravel. The final cap configuration will include a hydraulic evaluation to determine an acceptable river channel cross section during the design phase of the NTCRA. A conceptual cap design for T-117 is shown on Map 7-2 (plan view) and Figure 7-6 (cross section).

The duration of the marine construction for Alternative 1, for in-water dredging and capping, is estimated to be 20 to 25 working days.

Institutional controls would be required for thea cap under Alternative 1 (to reduce the potential for the disturbance of the cap. Furthermore these controls would and require monitoring and maintenance. The cap would be designed to withstand small-vessel anchorage, fishing, or clamming activities. In addition, the institutional controls would be developed so as to not to affect tribal treaty fishing rights. Individual institutional controls may have limited effectiveness, and thus multiple controls are typically used to ensure long-term effectiveness. If Alternative 1 is implemented, then the details of the institutional control elements would be developed in an institutional controls implementation plan during design, and the controls would be anticipated to include proprietary controls (i.e., restrictive covenants), enforcement tools (i.e., agency orders requiring monitoring and maintenance), and informational devices (i.e., deed notice and state registry) as described below:

- Restrictive covenants would include restrictions on the capped area(s), limited by what is allowed due to the unique status of portions of the LDW as property formerly under the jurisdiction of the KCCWD1. To the extent possible, covenants would limit disturbance of the cap under Alternative 1. Actions such as construction projects that could disturb the cap would require agency approvals, management plans for controls, and restoration of the cap or complete removal of the contaminated materials. Restrictive covenants or other agreements would also require agency notification of any pending sale of the property or any use of the property that might affect the cap, and provide for agency access. The restrictive covenants could "run with the land" and be included in any lease, deed, license, easement, or other use authorization. Specifically, City easements associated with the re-location of the power pole and future stormwater discharge drainage/outfall areas would be subject to the restrictive covenants placed on the upland property.

- Agency orders (an enforcement tool) would be an institutional control that is anticipated to be implemented under Alternatives 1 and 2. The Port and City would sign a CERCLA order with EPA that would require long-term monitoring and maintenance of any capped areas, as applicable. -The details of the monitoring and maintenance requirements would be developed during design in an Agency-approved OMMP. EPA would review the effectiveness of the remedy, including monitoring results and institutional control implementation, no less frequently than once every 5 years, as required under CERCLA.

- Informational devices would be an additional institutional control for any capped areas under Alternatives 1 or 2. -Deed notices describing the restrictions on the property would be filed in the King County Recorder's Office. Placement and maintenance of site information on the state registry (Ecology's Hazardous Sites List – Site Register) would also provide informational tools regarding restrictions on the property.

7.1.4 Management of excavated and dredged materials

Soil and sediment designated as a TSCA waste (i.e., with total PCB concentrations ≥ 50 mg/kg) will be the first material to be removed from each study area and disposed of at a Subtitle C landfill. Soil and sediment determined to be non-hazardous/non-dangerous will be disposed of at a Subtitle D landfill. These landfills have the ability to receive soil or wet dredged sediment delivered by rail. Both types of facilities must have also received the required EPA approval for acceptance of sediment and soil generated at CERCLA sites. EPA's approval takes into account the facilities' compliance with TSCA and/or RCRA permits and governing regulations, including the Off-Site Rule (40 CFR 200.440).

The hauling of material from the T-117 EAA to the disposal site will result in increased truck traffic on neighborhood streets for the duration of the removal phase. A traffic routing plan will be developed during the NTCRA design phase with community input, as discussed in Section 7.1.1.1. The approved routing plan, as well as transportation and safety plans, will be developed by the contractor as part of the removal action work plan documents. These plans will address hours of operations; estimated numbers of trucks and barges required for soil and sediment hauling;

anticipated transport routes; material spill prevention, containment, and response plans; and other protective and mitigating elements.

7.1.5 Completion of the removal action and coordination with future site uses

A principal goal of the removal action is to complete the T-117 Upland Study Area and T-117 Sediment Study Area in a manner that leaves them suitable for a range of final site uses and redevelopment options. An evaluation of final site redevelopment options is currently being performed by the Port and may be ready for implementation concurrent with the completion of the NTCRA or at a date after the NTCRA has been completed. Regardless, the NTCRA design measures will ensure that following the completion of the removal action, the ongoing integrity of the property will be maintained through slope stabilization, stormwater infrastructure, and erosion control measures.

Under Alternative 1, it is assumed that the T-117 Upland Study Area~~EAA~~ will be restored to a baseline condition that has been backfilled and graded to a minimum elevation of +14 ft MLLW. This completion condition (hereafter referred to as the "baseline completion option") is assumed in this EE/CA ~~was used here~~ for costing purposes, inasmuch as it represents a "mid-point" from which a range of final site uses could be accommodated. These final site uses include future commercial uses that could be accomplished through limited additional backfilling, or the creation of intertidal habitat that could be accomplished through minimal backfill removal and contouring. These completion options are discussed further in Section 7.3. If the Port is able to identify a site redevelopment option in conjunction with community involvement prior to or during the design phase of the NTCRA, the design of the NTCRA completion would be coordinated with the final site use design. Restoration of this area will trigger the County's requirements and standards for surface and stormwater management (King County Ordinance 16264, 2009).

The Adjacent Streets and Residential Yards Study Area will be restored to original grades and repaved and/or re-landscaped following the removal action. In addition, the restoration of this area will trigger the stormwater requirements of SMC 22.800 and Development Director's Rules 2009-005 (SPU), 17-2009 (DPD) (City of Seattle 2009a). It is anticipated that stormwater will use one or a combination of possible stormwater drainage, treatment, and potential discharge measures, including swales, underground vault treatment, or catch basin inserts.

The final configuration of the stormwater collection and treatment system will be determined based on implementability, effectiveness, and cost and evaluated to minimize negative impacts on the final site use. Because the final configuration of the roadway stormwater improvements is an equal component of both Alternatives 1 and 2, it does not affect the comparison of alternatives for the NTCRA.

7.1.6 Summary of estimated costs

The total estimated cost for Alternative 1 is approximately $31.70.4 million (Table 7-3), which includes the present-worth cost for an assumed number of four cap-monitoring events over 10 years. The actual frequency of monitoring will be determined later as part of the post-NTCRA monitoring plan (Section 9.54) and may vary slightly from this assumption. A detailed breakdown of the estimated direct capital costs, indirect costs, long-term O&M costs and assumed contingencies is provided in Appendix J.

Table 7-3. Summary of estimated costs for Alternative 1

Study Area	Estimated Cost[a]
T-117 Upland Study Area	$20,100,000
Adjacent Streets and Residential Yards Study Area	$76,6300,000
T-117 Sediment Study Area	$4,000,000
Total estimated cost	$310,7400,000

[a] Assumes baseline completion option for T-117 Upland Study Area with site restored to meet MTCA unrestricted cleanup and habitat protection criteria.

MTCA – Model Toxics Control Act

O&M – operation and maintenance

T-117 – Terminal 117

7.1.7 Evaluation of Alternative 1

This section discusses the implementability and effectiveness of Alternative 1 and provides a basis for the comparison of removal action alternatives presented in Section 8. The assessment of implementability includes consideration of:

- Technical feasibility and availability of technologies
- Administrative feasibility
- Public acceptance
- Cost

Criteria for assessing effectiveness considered here and in Section 8 include both short-term and long-term effectiveness. Long-term effectiveness includes consideration of:

- Overall protection of human health and the environment
- Ability to achieve RAOs
- Compliance with ARARs (including tribal treaty-protected resources)
- Reduction of contaminant toxicity, mobility, and volume

7.1.7.1 Implementability

The successful implementation of Alternative 1 will depend on effective planning and the proper phasing of the work. The safe control of traffic and removal activities within adjacent residential streets and the control of dust generation and offsite dispersion are examples of important factors to be considered. Soil excavation and sediment removal will be implemented using established and proven technologies that are readily available. The depth of soil removal in the upland portion will be accomplished using appropriate dewatering, shoring, staging, and material handling techniques. The alternative does not include any technologies that are experimental or unproven. Nevertheless, the depth of soil excavation, presence of shallow groundwater, and proximity of removal activities to the LDW can present challenges for upland excavation that will have to be addressed through careful planning and execution, including the potential use of physical barriers to control groundwater, a well-point dewatering system, and an associated water treatment system. Sediment removal will also need to be conducted in a highly controlled manner and with regard for specific scheduling constraints (e.g., fish windows).

An assessment of the administrative implementability of Alternative 1 must include consideration of the multiple jurisdictions and regulations applicable to one or more of the study area settings or particular features in which the action will be implemented (i.e., the T-117 Upland Study Area, the Adjacent Streets and Residential Yards Study Area, and the T-117 Sediment Study Area). Some of the site, for example, is located within the County, and the remainder is within the City. The T-117 Sediment Study Area is located within the sediment portion of the LDW; other areas are made up of city street ROWs. As presented in Appendix G, there are a number of ARARs and substantive requirements that include measures to safeguard aquatic resources that must be considered prior to and during the removal action. Construction and permanent maintenance easements will also be required for the installation of a power pole and associated power lines, and stormwater features on the T-117 Upland Study Area (see Section 7.3). Access agreements must also be established with those property owners whose yards require remediation.

7.1.7.2 Effectiveness

Alternative 1 will be highly effective in terms of protecting human health and the environment, complying with ARARs and achieving RAOs, including meeting criteria for a broad range of possible future land uses and protection of terrestrial habitat, where applicable. Contaminants that might otherwise migrate to the adjacent LDW will be removed through the excavation of contaminated soil from the upland portions of the T-117 EAA. Alternative 1 will remove ~~source material~~contaminated soil~~s~~, including that~~particularly those~~ in direct contact with groundwater and or that could possibly come into contact with stormwater, as well as contaminated ~~those present in~~ sediment. It will also include measures to address potential site recontamination.

Short-term risks posed by~~in~~ the proposed removal action exist because of the large size and depth of the excavations. Engineering controls to prevent secondary impacts of soil excavation and transport and sediment dredging and capping will be included as part of the alternative. Special measures, including shoring, and dewatering will likely be required to control groundwater influx that would otherwise occur in deep excavations (i.e., those extending into the saturated groundwater zone). The removal of contaminated bank materials and upland soil in the vicinity of the bank will require special safeguards to limit the potential for impacts on the adjacent LDW. These will include working during low tides and the use of berms, temporary covers (sand/fabrics), or sheet pile walls to isolate work areas. Other short-term risks include the potential exposure of onsite workers and nearby neighbors to contaminants through the ingestion of or dermal contact with soil or through the inhalation of airborne dust. Proven safeguards are available to mitigate these risks and include the use of protective clothing for workers and measures such as dust control and monitoring and track-out prevention to protect the surrounding community. These and other safeguards that will be set forth in a site-specific health and safety plan developed concurrently with the NTCRA work plan.

Of particular importance is the risk to public health and the environment that could result from air emissions (i.e., dust) during limited time periods. Dust could migrate from T-117 to the surrounding community during grading activities. To mitigate potential dust risks, engineering controls such as water sprays will be employed, as necessary, during construction to ensure that dust and particulates are within acceptable regulatory levels. Perimeter air monitoring will be performed during the removal action to monitor potential exposure to the public during excavation. Control of odors that may be generated from the removal of the impacted soil will also be addressed through the use of engineering controls similar to those used for dust. These control measures, together with specific criteria for their application, will be included in the NTCRA health and safety plans.

The long-term effectiveness and permanence of Alternative 1 is expected to be moderately high. Under this alternative, RAOs will be met even if sediment concentrations at depth remain above SMS criteria because potential exposure will be limited by clean backfill or capping. However, these materials could potentially become exposed if overlying cover materials were inadvertently disturbed.

Institutional controls would be required under Alternative 1 to reduce the potential for the disturbance of the cap and require monitoring and maintenance. Caps would likely include an armor layer that would be covered with a sediment layer designed to withstand small--vessel anchorage, fishing, or clamming activities, with an institutional control requiring cap monitoring and maintenance. Institutional controls would be developed so as to not affect tribal treaty fishing rights. The details of institutional controls would be set forth in an institutional controls implementation plan, as described in Section 7.1.3.

~~INSTITUTIONAL SAFEGUARDS TO PROTECT THE IN-WATER CAPS (I.E., RESTRICTIVE COVENANTS AND MONITORING) WOULD BE NEEDED TO PROTECT AGAINST THE POSSIBILITY OF CAP DISTURBANCE FROM ACTIVITIES SUCH AS BOAT ANCHORING. THE CAP WILL INCLUDE AN ARMOR LAYER THAT WILL PROTECT IT FROM DISTURBANCE BY TYPICAL BEACH USE, FISHING, AND CLAMMING THE SELECTION OF SAFEGUARDS AIMED AT LIMITING CAP DISTURBANCE WOULD BE~~

DETERMINED BASED ON THE SPECIFIC ACTIVITIES THAT THEY SEEK TO CONTROL, AND THE EFFECTIVENESS OF THESE SAFEGUARDS WOULD DEPEND ON THE EXTENT TO WHICH THEY ARE ENFORCED.

7.2 Alternative 2: Upland Soil Removal and Sediment Excavation and Dredging

As mentioned previously, Alternative 2 is the same as Alternative 1, except that capping would not be used as an alternative sediment containment measure within the T-117 Sediment Study Area for the purpose of meeting the prescribed sediment RAOs. Instead, the RAOs would be met solely through a combination of sediment excavation and dredging followed by backfilling with clean materials. Clean fill materials will be used to restore the aquatic portions of the site to original grades (except in the Marina), to backfill the T-117 Upland Study Area to an elevation of approximately +14-ft MLLW, and to re-establish site grades in the Adjacent Streets and Residential Yards Study Area.

7.2.1 Site preparation

The same preparation activities described for Alternative 1 would be required for Alternative 2. Areas for sediment handling and transfer equipment capacities might need to be slightly larger to accommodate the increased material volumes from dredging areas that would otherwise be capped in Alternative 1.

7.2.2 T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area removal activities

The Alternative 2 removal activities for the T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area are the same as those described for Alternative 1. The approximate in-place volumes of soil anticipated to be excavated from the T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area are listed in Table 7-2. The estimated extent of the removal action in the T-117 Upland Study Area and Adjacent Streets is presented on Maps 7-2 and 7-3.

7.2.3 T-117 Sediment Study Area removal activities

Alternative 2 is the same as Alternative 1 regarding excavation and backfilling at the T-117 Upland Study Area and adjacent shoreline bank as well as the Adjacent Streets and Residential Yards. Alternative 2 only differs in the sediment removal area offshore of the toe of the shoreline bank as shown on Maps 7-2 and 7-3. Alternative 2 requires the dredging of contaminated sediment within the sediment boundary, including dredging within the Marina to re-establish navigable depths within the Marina. The dredged areas, except the Marina, will be backfilled with clean material to re-establish site grades. A limited amount of sediment within the rock riprap along the toe of the Marina shoreline contains elevated PCBs- (i.e., samples Trans--A-sed, Trans--B-sed, and 99-G, as shown on Map 2-8). Rather than removing the riprap and undermining the Marina shoreline, the sediment within the rip-rap may be removed (manually at low tide or by divers) or contained by a localized cover. The excavation and dredging contours for Alternative 2 are presented on Map 7-12 and shown on cross sections presented as Figures 7-1 through 7-4.

Dredging volumes under Alternative 2 will be greater than those for Alternative 1 because all of the subtidal area is dredged under Alternative 2. The dredged areas will be backfilled to re-establish aquatic site grades so there is no net impact to aquatic habitat elevations. The surface layer of backfill material will be imported, clean, uncrushed sand and gravel of the appropriate size and composition to remain stable under the range of LDW currents and maritime activities (e.g., boat wake, prop wash). It is anticipated that the backfill would be placed with floating equipment, working at higher tides, as necessary, to provide the needed draft for barges. The volume of sediment to be removed and backfilled under Alternative 2 is summarized in Table 7-4.

Table 7-4. In-place volumes of sediment to be removed and estimated sediment backfill volumes under Alternative 2

Study Area	Component[a]	Quantity (cy)
T-117 Sediment Study Area	non-TSCA sediment	13,950
	TSCA sediment	50
Total sediment to be removed		14,000
Material required for backfilling		10,000[b]

a TSCA sediment is defined as sediment with total PCB concentrations ≥ 50 mg/kg.

b No backfilling in the Marina (approximately 4, 000 cy).

cy – cubic yard

PCB – polychlorinated biphenyl

TSCA – Toxic Substances Control Act

The duration of the marine construction for Alternative 2, for in-water dredging and backfilling, is estimated to be 30 to 35 working days.

Dredging safeguards, material transfer, and monitoring would be the same as those presented for Alternative 1.

7.2.4 Landfill disposal of excavated and dredged materials

Methods used for the management and disposal of excavated and dredged materials under Alternative 2 are the same as those described for Alternative 1. The larger volume of sediment removed under Alternative 2 will need to be considered in specifying the operating parameters and sizes for the sediment handling and transfer areas.

7.2.5 Site completion and coordination with future site uses

As with Alternative 1, under Alternative 2, the T-117 Upland Study Area will be backfilled to an elevation of at least +14 ft MLLW. However, final site design may change slightly depending on the timing of the ongoing evaluation and the selection of the final site use (see Section 9.2).

7.2.6 Summary of estimated costs

The total estimated cost for Alternative 2 is approximately $33~~1~~.2~~9~~ million (Table 7-~~6~~5). A detailed breakdown of the estimated costs and assumed contingencies is provided in Appendix J.

Table 7-~~6~~5. Summary of estimated costs for Alternative 2

Study Area	Estimated Costs[a]
T-117 Upland Study Area	$20,100,000
Adjacent Streets and Residential Yards Study Area	$7~~6~~,6~~3~~00,000
T-117 Sediment Study Area	$5,500,000
Total estimated cost	$33~~1~~,2~~9~~00,000

[a] Assumes baseline completion option for the T-117 Upland Study Area with the site restored to meet MTCA unrestricted criteria.

EAA – early action area

O&M – operation and maintenance

T-117 – Terminal 117

7.2.7 Evaluation of Alternative 2

This section discusses the implementability and effectiveness of Alternative 2 and provides a basis for the comparison of removal action alternatives presented in Section 8.

7.2.7.1 Implementability

The implementability of Alternative 2 is very similar to that of Alternative 1. The additional dredging of sediment associated with Alternative 2 will require some additional in-water construction time (10 to 15 working days)~~, which could extend the duration of the removal action to accommodate seasonal restrictions on in-water work~~.

7.2.7.2 Effectiveness

The long-term effectiveness of this alternative is expected to be high. Sediment that contains COCs above the action level will be removed, resulting in a higher degree of effectiveness and permanence than that for Alternative 1 (Section 7.1.7).

7.3 PROJECT COMPLETION OPTIONS

EPA has mandated site-specific goals for the removal action in the T-117 Upland Study Area. One of these goals is to develop removal alternatives that are consistent with a wide range of final site uses, not just those limited to industrial activities. The Port is examining commercial development and habitat restoration alternatives for Port property within the LDW, which includes the T-117 EAA, in coordination with the appropriate agencies.

This section describes two alternative site completion options (Options A and B) that could be implemented following the NTCRA. These completion options could accommodate a variety of future uses and would replace the baseline completion option that was included in the two removal action alternatives for costing purposes. The baseline completion option was assumed for the removal alternatives because it represented a mid-point among the range of possible final site use configurations. The two completion options presented here provide for a broad range of configurations and topography to accommodate a wide variety of potential post-NTCRA developments. It is expected that a final site use will be identified in time to be incorporated into the NTCRA during the design phase. If this occurs, the baseline completion option would not be implemented, and the final NTCRA design would include restoration of the site to final grades appropriate to accommodate the selected final site use. Soil excavation and sediment dredging or dredging/capping would still be conducted to meet the RvALs within the removal areas and to the necessary compliance depths relative to the completed (final) topography. The baseline completion option described below and two alternative completion options would all be protective and would meet the RAOs established for the T-117 removal action set forth in this EE/CA.

- **Option A, Restore the T-117 Upland Study Area to existing elevation –** Under this option, removal excavations in the T-117 Upland Study Area would be backfilled to achieve surface elevations similar to those of the existing T-117 Upland Study Area (elevation of approximately +18 to +21 ft MLLW). The shoreline bank below elevation +14 ft MLLW would be designed as described in the removal action alternatives (with the same degree of improved aquatic habitat), but the elevation of the bank and T-117 Upland Study Area would be brought up to the final elevation of +18 to +21 ft MLLW. Restoring the T-117 Upland Study Area to the existing elevation would still meet the requirement for "unrestricted land use" and could support use for commercial redevelopment and/or public access.
- Option B, No backfilling of the T-117 Upland Study Area; transition directly to habitat creation, among other site improvements – Under this option, a redevelopment project for the creation of aquatic habitat would be implemented immediately following the removal action. Habitat creation would be coordinated with EPA and Ecology to ensure that any newly created intertidal habitat (within the present T-117 Upland Study Area) would meet the sediment RAOs at the appropriate point of compliance. The completion design for Option B (as well as any later redevelopment action) would include provisions for long-term site stability (i.e., protection against erosion and the institution of protective covenants, as needed). The details on the design of the restoration plan are still being developed; therefore, the final site configuration is unknown. As the restoration design progresses, it will be coordinated with the NTCRA design to ensure that sediment and/or soil RvALs are being met.

General cross sections of Options A and B are shown on Figure 7-7, along with the baseline completion approach, which was assumed for both removal action alternatives for costing purposes. ~~All of the completion options (i.e., Options A and B and the baseline completion option) will result in a site that is protective of human health and the environment and will meet the established RAOs.~~ The selection of the appropriate completion option will be made at the time of remedial design based on the results of site-use evaluations.

Slipsheet (8-1/2 x 11)

Figure 7-7. Upland completion options

In the event that Option B is selected and can be integrated into the removal action design, existing upland areas that would be converted into intertidal areas would be further evaluated as part of the redevelopment project and in accordance with the ~~sediment RAOs~~for the sediment NTCRA. Upland soil that would underlie newly created aquatic areas ~~and be located within the applicable depth of compliance~~ would, at a minimum, need to meet the sediment RvALs set forth in Section 4. ~~The large amount of excavation that will occur in the T-117 Upland Study Area under either removal action alternative will remove contaminants to levels estimated to be below the sediment RvALs at all upland locations, except one.~~ This completion option would change the location of the shoreline and could increase the salinity of groundwater further inland.

The large amount of excavation that will occur in the T-117 Upland Study Area under either removal action alternative will remove contaminants to levels estimated to be below the sediment RvALs at all upland locations, except one. A preliminary analysis of contaminant distributions in the upland soil indicates that areas where soil contaminant concentrations after excavation will be below the upland soil RvAL but not necessarily below sediment RvAL are limited to the area within the T-117 Upland Study Area on the west side near Dallas Avenue S. It is expected that this area would remain as upland subsurface soil and would not transition to exposed sediment if a habitat project were to be implemented. Furthermore, minor additional dredging and/or capping would be performed, as necessary, during the redevelopment project to ensure that soil beneath former upland areas that were newly converted to intertidal areas would meet RAOs for sediment.

Site completion under all options would include site grading and the installation of stormwater features in the T-117 Upland Study Area and Adjacent Streets to facilitate upland stormwater management. The installation of these features on the T-117 Upland Study Area would require an easement for construction as well as ongoing maintenance. Furthermore, site completion under all options would provide for the necessary easement to re-establish the LDW power pole crossing at the site. This required easement is shown in a preliminary form in ~~Figure 7-8~~Map 2-1. Final easement requirements will be determined during the NTCRA design phase. Regardless of how the removal action will be completed, the slope of the newly established shoreline will be designed to improve on existing habitat conditions and limit the potential for shoreline erosion.

Either alternative or any completion option could influence the effectiveness of a hypothetical monitored natural recovery regime for LDW sediment in the vicinity of the T-117 EAA. These influences would be minimal because of the relatively small size of the T-117 Sediment Study Area (approximately 1.4 acres).

The Alternative 1 baseline and completion option A would have little impact because these scenarios restore the shoreline and sediment to a topography similar to the existing configuration. Alternative 2 with completion option A~~s~~ would also restore the shoreline topography. Although a cap would change the sediment grade, this would have little effect because of the size of the projected cap area relative to the LDW. Completion option B with either alternative would have a relatively larger impact because the shoreline and sediment grade would be changed. With this completion option it is likely that the area would become more depositional because the contouring for habitat would create depressions in the sediment and quiescent back water areas.

8 Comparative Analysis of Removal Action Alternatives

This section presents a comparative analysis of the two removal alternatives based on the criteria of implementability, effectiveness, and cost as defined in EPA's *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (1993). The primary criteria to be considered are as follows:

- Implementability
  - Technical feasibility and availability
  - Administrative feasibility
- Effectiveness
  - Overall protection of human health and the environment
  - Achievement of RAOs
  - Compliance with ARARs
  - Reduction of toxicity, mobility, or volume through treatment
  - Short-term effectiveness
  - Long-term effectiveness and permanence
- Cost

The discussion of removal action alternatives discussed in Section 7 serves as the basis for the comparative evaluation in this sSection. Throughout this discussion, the specific elements that make each alternative unique are noted (see the discussions entitled "Notable Differences"). As described in Section 7, both alternatives are presumed to include similar completion approaches (i.e., to elevation +14 ft MLLW).

8.1 IMPLEMENTABILITY

This section discusses the three criteria that are important to the implementability of the alternatives. The successful implementation of both Alternatives 1 and 2 will depend to a large degree on the proper sequencing of removal work in the Adjacent Streets and Residential Yards, T-117 Upland Study Area, and the T-117 Sediment Study Area. Sequencing is discussed in Section 9.3.1.

8.1.1 Technical feasibility and availability

8.1.1.1 T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area

Both alternatives are equal in terms of technical feasibility and availability for the T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area. Upland soil removal will be completed using commonly available construction technologies and materials. Work in locations above the highest tide line in the LDW can be completed at any time because it will not be impacted by tidal fluctuations in the river. The upland work would preferably be conducted during the dry summer months to avoid potential construction and runoff problems associated with excessive rainfall. Excavated materials will be trucked offsite using conventional trucking equipment. Bank removal will be completed from the upland when the tides are out or with the use of an offshore barrier to isolate the inboard work area and facilitate access throughout the range of tide stages.

Notable Differences – None.

8.1.1.2 T-117 Sediment Study Area

In the intertidal mudflat, sediment removal for Alternative 2 and the partial sediment removal and capping for Alternative 1 would be completed using commonly available upland construction equipment and materials. Excavated materials would be trucked offsite and imported material brought onsite using conventional trucking equipment. The work for both alternatives can be completed when the tides are out and it would be possible to best control the work being completed. The work would ideally be scheduled between May and August to maximize the number of days with the lowest tides.

For submerged sediment within the removal boundary, the sediment removal for Alternative 2 and the capping for Alternative 1 would be completed using commonly available materials and floating construction equipment. Because of the relatively short duration of the project (20 to 35 days), it is not anticipated that other sediment cleanup projects being performed at the same time would have an adverse impact on the availability of the equipment necessary to perform the work.

Dredged materials could be readily moved offsite and imported material brought onsite using conventional barges. The offloading of dredged sediment from barges to trucks or railcars for landfill delivery could be completed at existing facilities (e.g., another Port terminal). The work for both Alternatives 1 and 2 would need to be completed when tides are high to provide the needed draft for the floating equipment. Further constraints on available work time could be imposed by seasonal prohibitions on in-water work that have been established to protect certain fish species. The LDW fish window is the period of time when in-water work can be conducted, and this work must be coordinated with the tribes in advance. Typical fish windows for the LDW occur from October 1 to February 15 but can vary from year to year depending on the timing of the juvenile salmon out migration. Although in-water work can be accomplished in a manner that will accommodate these constraints ~~(as demonstrated by other successful LDW projects)~~, the overall project schedule may need to be lengthened to account for these seasonal interruptions. Arrangements will need to be made with the Marina to temporarily relocate some of the docks and floating structures in the proximity of the sediment removal area.

Notable Differences – Alternative 1 will result in a reduction in the cross-sectional channel area of the LDW, and a focused river hydraulics analysis will be needed to establish the impact (if any) of the capping on the channel cross section in the LDW. Alternative 1 would involve the removal of less sediment than would Alternative 2 and consequently would require 10 to 15 fewer low-tide days to complete. Both alternatives would result in the placement of import material (cap material under Alternative 1 and backfill under Alternative 2). This could affect the quality of clam habitat, and this effect could be more significant under Alternative 1 which would require erosion--resistant materials for the cap. For both alternatives, design details would be developed with a goal of limiting possible habitat impacts and accommodating fishing and clamming. The removal of less sediment under Alternative 1 also decreases the potential forfrequency of exceeding turbidity limits, so short-term risk is less for Alternative 1 than for Alternative 2. Map 7-3 shows the differences in the removal and capping areas between the two alternatives.

8.1.2 Administrative feasibility

Administrative feasibility involves the activities needed to coordinate with other offices and agencies (e.g., obtaining permits for offsite activities or ROWs for construction). Very littleThe majority of the work for Alternatives 1 and 2 will be completed on land owned or controlled by parties other than the City and the Port., including the Port-owned offshore area of the Marina.

Administrative requirements will include the need for the CityThe City will need to arrange for temporary road closures and/or special access arrangements within the Adjacent Streets and Residential Yards Study Area when removal in that study area is underway. Furthermore, access agreements will need to be established with property owners whose yards require excavation.

As described in Section 7, institutional controls would be required under Alternative 1 to reduce the potential for the disturbance of the cap. These institutional controls would also require monitoring and maintenance. The details of the institutional controls would be developed in an institutional controls implementation plan during design, and the institutional controls would likely include proprietary controls (i.e., restrictive covenants); enforcement tools (i.e., agency orders requiring monitoring and maintenance); and informational devices (i.e., deed notice and state registry). Each of these controls is considered administratively feasible. None of the institutional controls would affect tribal treaty fishing rights.

There are no apparent impediments to imposing restrictive covenants in order to provide long-term protection of the sediment cap areas because all of the affected tidelandInstitutional controls that would limit site disturbance of the sediment cap under Alternative 1 would be developed as part of the design process.

The administrative feasibility of placing temporary barriers, such as berms or sheetpile walls, at or immediately offshore of the T-117 shoreline to facilitate bank removal will be addressed during removal action planning.

Notable Differences – Institutional controls (property deed restrictions, no-anchorage areas) would be required for the sediment cap under Alternative 1. Overall reliance on institutional controls, monitoring, and maintenance would be greater under Alternative 1.

8.1.3 Public involvement

The Port, the City, and EPA will coordinate with the public on issues such as schedule, transportation plans, monitoring plans, permitting, and BMPs. The Port and the City will coordinate with EPA and stakeholders to hold meetings or otherwise provide information and receive input from stakeholders during the review of the EE/CA and subsequent design and removal action work. These activities will focus on issues of concern (e.g., truck traffic and control of the cleanup site, health and safety in the project vicinity, and protection of natural resources).

8.2 EFFECTIVENESS

8.2.1 Overall protection of human health and the environment

Alternatives 1 and 2 are identical for the upland portion of the T-117 EAA and successfully meet the RvALs determined to be protective of human health and the environment. The alternatives will reduce long-term risks to human health and the environment by removing soil and sediment with COC concentrations greater than the selected RvALs, or containing any remaining contaminated sediment with an engineered aquatic cap. Both alternatives will achieve the RAOs and comply with all ARARs (Section 4 and Appendix G, respectively). The alternatives rely on removal and/or combined removal and /capping technologies, which are proven technologies that have been used successfully.

Notable Differences – Alternative 2 removes all of the sediment with COC concentrations that exceed the RvALs within the mudflat and submerged portions of the T-117 Sediment Study Area, and thus does not include a cap. ; whereas In contrast, Alternative 1 includes a combination of removal and capping, with the potential for the subsequent disturbance of the cap, which could expose underlying contamination.

8.2.2 Achievement of RAOs

Both Alternatives 1 and 2 satisfy the RAOs for the T-117 EAA by creating a post removal condition that meets the site RvALs at the specified points of compliance. This is accomplished through the removal (Alternative 2) or a combination of the removal and effective long-term containment of sediment (Alternative 1).

Notable Differences – None.

8.2.3 Compliance with ARARs and other requirements

ARARs were discussed in Section 4. Both alternatives will meet the substantive requirements of ARARs. Both alternatives include the removal of contaminated soil to allow for a broad range of future land uses, including potential redevelopment as habitat, and are therefore equivalent in meeting ARARs pertaining to upland cleanup. For the sediment removal, the SQS is applicable to the T-117 Sediment Study Area and any areas where the cleanup or follow-on site development creates intertidal or subtidal areas. Completion of either alternative will result in COC concentrations that are well below the SQS because of the use of clean backfill or capping material.

Compliance with the Endangered Species Act will be addressed in the biological assessment to be completed during the design phase of the NTCRA. The removal action is expected to be beneficial to threatened Chinook salmon because it greatly reduced their potential exposure to PCBs and other COCs. Under the assumed completion approach, the shoreline bank will be replaced at a grade that is less steep (e.g., 3H:1V) than the existing grade and will provide both long-term stability and improved habitat (i.e., natural sand and gravel substrate underlain by stabilizing layer of quarry spalls) with a small net increase (less than 0.1 ac) in aquatic habitat area.creage.

Both alternatives will comply with TSCA because all soil and sediment with total PCB concentrations greater than 50 mg/kg will be designated for disposal at a TSCA landfill, as described in Section 4.3.1.2. The extent to which the ARARs are met by each alternative is summarized in Table 8-1. As presented in Table 8-1, the two alternatives are similar and meet the same substantive requirements.

Notable Differences – None.

Table 8-1. Comparison of removal action alternatives relative to ARARs and other requirements TBC

Regulatory Requirement	Compliance with ARARs and Other Requirements	
	Alternative 1	**Alternative 2**
ARARs		
Washington State Model Toxics Control Act (WAC 173-340-440)	The removal will comply with these requirements by meeting RvALs based on a broad range of possible future land uses and CULs protective of upland terrestrial species in the upland areas	Same as Alternative 1.
Washington State Water Quality Standards for Surface Waters (WAC 173-201A)	The removal action will comply with these regulations through the implementation of BMPs and a water quality monitoring program.	Same as Alternative 1.
Washington State Sediment Management Standards (WAC 173-204)	Total PCB concentrations will be below the SQS for both alternatives because of the combined action of removal and the use of clean capping material. Restrictive covenants and monitoring will be required for sediment caps to ensure long-term compliance.	Total PCB concentrations will be below the SQS for both alternatives because of the combined action of removal and the use of clean backfill material.
Toxic Substances Control Act (40 CFR 761)	The removal action will comply with TSCA because all soil and sediment with total PCB concentrations greater than 50 mg/kg dw will be designated for disposal at a TSCA landfill.	Same as Alternative 1.
Other Requirements TBC		
Federal Water Pollution Control Act/ Clean Water Act (33 USC 1251-1376; 40 CFR 100-149)	The removal action will comply with these regulations through the implementation of BMPs and a water quality monitoring program.	Same as Alternative 1.
Construction in State Waters, Hydraulic Code Rules (RCW 75.20; WAC 220-110)	The removal action will comply with the substantive requirements of these regulations by implementing BMPs for the protection of fish and shellfish, as recommended by the WDFW.	Same as Alternative 1.
Federal Endangered Species Act of 1973, 16 USC 1531 et seq. (50 CFR 200; 50 CFR 402)	The removal action will comply with the substantive requirements of the act by implementing BMPs for the protection of fish and shellfish, as recommended by NMFS and USFWS.	Same as Alternative 1.
Essential Fish Habitat provisions of the Magnuson-Stevens Fishery Conservation and Management Act (50 CFR 600)	The removal action will comply with the requirements of the act by implementing BMPs for the protection of EFH, as recommended by NMFS, and respond in writing to NMFS's recommendations.	Same as Alternative 1.

Table 8-1. Comparison of removal action alternatives and ARARs (cont.)

Regulatory Requirement	Compliance with ARARs and Other Requirements	
	Alternative 1	Alternative 2
Rivers and Harbors Appropriations Act (33 USC 403; 33 CFR 322)	These substantive permit requirements are anticipated to be applicable to actions such as dredging, which may affect the navigable portions of the waterway. Use of capping as a technology may require special review and approval.	These substantive permit requirements are anticipated to be applicable to actions such as dredging, which may affect the navigable portions of the waterway. Sediment removal and restoration to existing grade (except at the Marina, where backfilling would not be done) is likely to meet these requirements.
Solid Waste Handling Standards (WAC 173-350)	The removal project will comply with these standards.	Same as Alternative 1.
Washington Dangerous Waste Regulations (WAC 173-303)	The removal action will comply.	Same as Alternative1.
Shorelines Management Act (KCC Title 25)	The project will be planned and conducted to meet the substantive requirements for shoreline management.	Same as Alternative 1.

ARAR – applicable or relevant and appropriate requirement

BMP – best management practice

CFR – Code of Federal Regulations

CUL – cleanup level

dw – dry weight

EFH – essential fish habitat

KCC – King County Code

NMFS – National Marine Fisheries Service

PCB – polychlorinated biphenyl

RCW – Revised Code of Washington

RvAL – removal action level

SQS – sediment quality standards

TBC – to be considered

TSCA – Toxic Substances Control Act

USC – US Code

USFWS – US Fish and Wildlife Service

WAC – Washington Administrative Code

WDFW – Washington State Department of Fish and Wildlife

8.2.4 Reduction of toxicity, mobility, or volume through treatment

Neither Alternative 1 nor Alternative 2 includes treatment technologies for reasons detailed in Section 6.

Notable Differences – None.

8.2.5 Short-term effectiveness and implementation risk

8.2.5.1 T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area

Short-term effectiveness includes an assessment of risks associated with the implementation of the removal action (in contrast to long-term effectiveness, which considers the effectiveness of the action after completion). Short-term effectiveness can often be enhanced through the use of BMPs and appropriate planning, which will be developed during the design phase. The removal of impacted soil from the T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area has the potential for the short-term release of contaminated material to the river and surrounding areas (e.g., adjacent properties) if not properly planned and controlled. The highest concentrations of PCBs and other COCs are present in the upland soil, and precautions will be taken during the removal action to ensure that the LDW and the surrounding community will not be exposed to soil from the interior upland removal areas.

Runoff controls and other safeguards similar to those used during the TCRA (RETEC 2007b) will be implemented under both removal alternatives. Soil will be removed from the shoreline bank under both alternatives, and safeguards will be used during this phase of the work, including engineering controls (i.e., completing the excavation during low tide, covering the excavated areas soon after they are exposed, and using berms or sheetpile walls to isolate the work area from the river). Such measures will greatly limit the potential for releases from the upland and upper shoreline work zones. The completion of the upland/bank excavation from the top of the shoreline berm to the intertidal area will ensure that any material released from the upper reaches of the cut during excavation will be captured as part of the other removal work in the lower portion of the bank (i.e., down to the intertidal mudflat elevation).

Notable Differences – None~~,~~ (because the same removal action is identified for both Alternatives 1 and 2).

8.2.5.2 T-117 Sediment Study Area

The disturbance of impacted sediment within the removal area will likely result in some short-term release of PCB-containing material to the immediate ~~LDW~~ vicinity of the LDW. Engineering controls (i.e., completing the excavation in the mudflat when the tide is low and covering the excavated face soon after it is exposed) may reduce the release potential from this portion of the sediment removal area. Experience at other intertidal sediment remediation projects at the Hylebos Waterway (Section 7.1.3) has shown that by completing the excavation during low tide, the excavated face does not need to be covered soon after exposure in order to limit short--term releases. Scheduling the bank/mudflat soil removal during periods of very low tide during May through August will allow for the greatest amount of work to take place during days with very low tides, when the potential for sediment to be released as a result of contact with the rising tide is lowest.

Alternative 1 involves a partial removal, all above elevation 0 ft MLLW; whereas Alternative 2 involves complete removal in the mudflat zone to a cut elevation as low as -2 ft MLLW. Consequently, Alternative 2 has a slightly higher risk of release because some of the excavation ~~will~~ may be completed in 1 to 2 ft of water near the edge of the mudflat excavation if berms or sheet pile walls are not used for the excavation.

The removal of sediment from the submerged zone will be done using dredging equipment rather than upland-based equipment. Engineering controls (i.e., dredging and barge filling practices designed to limit turbidity) will limit the potential for releases from the submerged zone to the extent reasonably possible. Water quality monitoring will be conducted to verify that concentrations in the water column are within acceptable limits.

Notable Differences – Alternative 1 involves the capping of submerged sediment and does not include dredging in the submerged portion of the sediment removal area; Alternative 2 involves the complete removal in the submerged area. Thus, Alternative 2 has a higher potential for release during implementation because ~~of~~ the disturbance of submerged sediment ~~by means of~~during dredging is typically greater than that associated with controlled capping. Differences between the two alternatives regarding the relative need for institutional controls is discussed in Section 8.2.6.2. Alternative 1 would require institutional controls for the in-water cap.

8.2.6 Long-term effectiveness and permanence

8.2.6.1 T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area

Both Alternatives 1 and 2 involve the permanent removal of COC-contaminated material from the T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area to meet the specified RAOs. For these areas, both alternatives are equivalent in terms of potential long-term effectiveness and permanence.

Notable Differences – None.

8.2.6.2 T-117 Sediment Study Area

Alternative 1 relies on the long-term effectiveness of sediment capping at locations where this technology is used. Removal provides the greatest long-term reliability because contaminated sediment is removed and thus not available for potential release to LDW sediment in the future. Alternative 2 does not involve any significant in-water capping. However, under Alterative 2, a limited amount of sediment within the rock riprap along the toe of the Marina shoreline contains elevated PCBs (i.e., samples Trans--A-sed, Trans--B-sed, and 99-G, as shown on Map 2-8). Rather than removing the riprap and undermining the Marina shoreline, the sediment within the riprap may be removed (manually at low tide or by divers) or contained by a localized cover.

The cap proposed for Alternative 1 would be designed to remain stable and provide long-term containment of the remaining impacted material beneath the capped areas. The ~~T-117 Sediment Study Area~~cap would be located outside of the f~~F~~ederally authorized navigation channel, which is ~~is~~ generally the area ~~outside of areas of activity~~ where ship traffic or prop wash could cause damage. However, vessel traffic outside of the navigation channel is not uncommon and could result in the disturbance of the cap.

The long-term reliability of sediment caps would be augmented with institutional controls as described in Section 7, ~~can be maintained that would~~including restrictive covenants and informational devices to limit the potential for cap disturbance, along with enforcement tools ~~and enhanced through the implementation of in an operation, maintenance, and monitoring plan (OMMP)~~ that would require periodic monitoring and maintenance~~repair~~ ~~of the cap~~ as well as adaptive management, if necessary. The cap's performance would be monitored to ensure long-term containment and the protection of human health and the environment. ~~EPA typically requires that a cap's performance be assessed at least once every 5 years for as long as deemed necessary~~

Monitoring a cap's performance will be regularly required as specified in an EPA-approved OMMP to ensure the long-term containment of contaminants beneath the cap. ~~to ensure the long-term containment of contaminated sediment remaining on site beneath the cap.~~ Ecology has similar monitoring and periodic review requirements set forth under MTCA (WAC 173-340-410 and 420) that must be considered as an ARAR for Alternative 1. Additional discussion of long-term cap monitoring is included in Section 9.3.3.

Notable Differences – The l~~L~~ong-term effectiveness and permanence ~~reliability~~ of Alternative 1 depends on continued integrity and performance of the sediment cap, which would also require institutional control to ensure long-term effectiveness and permanence. Alternative 2 does not include capping, so it has a greater degree of permanence and long-term effectiveness without reliance on institutional controls. Thus, Alternative 1 has a higher potential of future release of COCs as compared to Alternative 2. -This potential is associated with the possibility of disturbance of the cap. However, this potential is considered small for Alternative 1 and would be minimized and managed through cap design elements, institutional controls, monitoring, and maintenance as needed. Finally, Alternative 2 also allows for maximum design flexibility in that the final site contours can be designed without the need to accommodate permanent intertidal cap structures. This will be particularly advantageous in locations where habitat redevelopment or other final site uses will be selected and implemented in cooperation with the South Park Community.

8.2.6.3 Magnitude of risk

Upon completion, Alternative 1 would have a slightly higher magnitude of risk than would Alternative 2. This higher risk is associated with the relatively large portion of contaminated sediment that would remain in place, isolated beneath the sediment cap, in the T-117 Sediment Study Area. Applicable design guidance would be used in the design of the cap if Alternative 1 were to be selected, but the cap would need to be closely monitored to ensure its integrity and performance. Cap integrity and maintenance would also need to rely, in part, on the institutional controls that have been described previously in this EE/CA. The extent to which some of these controls are implemented and maintained, and their effectiveness over the life of the remedy, could contribute to the relative future risk associated with the capping option. In contrast, Alternative 2 will have a slightly lower magnitude of risk because all of the contaminated sediments will be removed and a cap will not be needed to isolate material that would otherwise remain in place. Both alternatives have the same estimated magnitude of risk for the upland areas of the T-117 EAA because the removal actions proposed for those areas will be the same.

Notable Differences – The relative magnitude of risk associated with Alternative 2 is slightly higher than that for Alternative 1. This is higher risk would result from contaminants and residuals that would still remain beneath the sediment cap located within the LDW after completion of the NTCRA.

8.3 COST

The estimated costs for Alternatives 1 and 2 are summarized in Table 8-2. These costs are based on present value[20] and include long-term monitoring and maintenance costs.[21] When long-term monitoring and maintenance costs are considered, the cost difference between Alternatives 1 and 2 is $1.5 million.

[20] Present net worth analysis based on 2008 year 0, and 5% net discount rate.

[21] Long-term monitoring costs based on four events over 10 years. Maintenance costs were assumed to have a present value of one-fourth the construction cost of the cap.

Table 8-2. Comparison of costs for Alternatives 1 and 2

Component	Estimated Cost[a]	
	Alternative 1	Alternative 2
Capital costs	$14,790173,000	$15,236860,000
Contingencies, design, management and oversight	$14,016620,000	$154,280679,000
Long-term monitoring and maintenance	$430,000	$100,000
Sales tax	$1,89031,000	$1,910854,000
Total estimated cost (rounded)	**$310,7400,000**	**$331,2900,000**

[a] Present net worth analysis based on 2008 year 0, and 5% net discount rate.

8.4 SUMMARY OF COMPARATIVE ANALYSIS

In summary, Alternatives 1 and 2 are similar in their implementability and effectiveness. The estimated cost for Alternative 1 is slightly less than that for Alternative 2, although the c.osts for both alternatives are considered to be relatively high relative to other sites where less-restrictive RAOs are required and a broader range of lower-cost alternatives are considered appropriate. Alternative 2 offers the advantage of the increased removal of COCs from the T-117 Sediment Study Area without reliance on capping, but has slightly more significant short-term water quality impacts during excavation and dredging and a slightly higher overall cost than does Alternative 1. Alternative 1 offers the advantage of a lower potential for short-term releases because of the lower volume of sediment removed, less reliance on over-water dredging, and lower initial cost. However, Alternative 1 also has a slightly higher potential of long-term contaminant release from the capped areas and higher long-term costs associated with cap monitoring and adaptive management, if necessary. Table 8-3 provides a summary comparison of the two removal action alternatives. Removal volumes are listed, together with summary comments on the comparative criteria discussed in Section 8.2.

Table 8-3. Summary of comparative analysis

Component	Ability to Meet RAOs	
	Alternative 1	Alternative 2
Protection of human health and the environment	Alternative is protective.	Alternative is protective.
Achievement of RAOs	RAOs[a] are achieved.	RAOs[a] are achieved.
ARARs	Alternative complies with ARARs.	Alternative complies with ARARs.
Effectiveness		
Long-term effectiveness and permanence	Alternative is effective and permanent. Removes contaminated soil from the T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area. Sediment cap requires long-term monitoring and maintenance.	Alternative is effective and permanent. Removes contaminated soil from the T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area.
Short-term effectiveness	Upland removal: Contaminated soil excavated under tightly controlled conditions, greatly reducing the short-term potential for release to surrounding areas or the LDW. Sediment removal: Completed from upland during low tides as feasible to reduce risk of COC releases to LDW. Alternative does not involve excavation in water because upland excavation will not go deeper than 0 ft MLLW contour. Alternative 1 involves dredging of about 35% of the dredged volume estimated for Alternative 2. Short-term impacts to water quality will be of slightly shorter duration as compared with those for Alternative 2. Short-term impacts to water quality will be managed through engineering controls and BMPs.	Upland removal: Contaminated soil excavated under tightly controlled conditions, greatly reducing the short-term potential for release to surrounding areas or the LDW. Sediment removal: Completed from upland during low tides to reduce risk of COC releases to LDW. Alternative involves some upland-based excavation in the water close to the existing 0 ft MLLW contour. Alternative 2 involves more extensive submerged zone dredging than does Alternative 1. Short-term impacts to water quality will be managed through engineering controls and BMPs.
Implementability		
Upland removal	Upland soil removal under both alternatives can be readily implemented with proper site preparation and water management measures in place. Shoring and barriers will need to be included in the removal design to ensure upland remediation areas are not inundated by the river and deeper excavations can be completed with stable side walls.	Upland soil removal under both alternatives can be readily implemented with proper site preparation and water management measures in place. Shoring and barriers will need to be included in the removal design to ensure upland remediation areas are not inundated by the river and deeper excavations can be completed with stable side walls.

Component	Ability to Meet RAOs	
	Alternative 1	Alternative 2
Sediment removal	Intertidal bank and mudflat work is best completed in May through August when very low tides occur. Alternative 1 does not involve any upland-based sediment removal below elevation 0 ft MLLW and is easier to implement than Alternative 2. Work is completed with conventional upland and waterway-based equipment. Alternative 1 involves mudflat and submerged zone capping that will result in a slight decrease of the cross-sectional area of the LDW. ~~Work will be completed on land owned or controlled by the Port.~~ ~~There are no apparent impediments to imposing restrictive covenants to provide long-term protection of the capped area because all of the affected land is controlled by the Port.~~	Intertidal bank and /mudflat work is best completed in May through August when very low tides occur. Alternative 2 involves some upland-based sediment excavation in the water at the existing 0 ft MLLW contour (2 ft deep to elevation -2 ft MLLW) and is more difficult to implement than Alternative 1. Work is completed with conventional upland and waterway-based equipment. ~~Work will be completed on land owned or controlled by the Port.~~
Cost[b]	**$31~~0~~,7~~4~~00,000**	**$33~~1~~,2~~9~~00,000**

[a] RAOs:

Human health – seafood consumption. Reduce human health risks associated with the consumption of resident LDW fish and shellfish by reducing sediment and surface water COC concentrations to protective levels.

Human health – direct contact. Reduce human health risks associated with exposure to COCs through direct contact with sediments and incidental sediment ingestion by reducing sediment concentrations of COCs to protective levels.

Ecological health – benthic. Reduce toxicity to benthic invertebrates by reducing sediment COC concentrations to comply with SMS.

Ecological health – seafood consumption. Reduce risks to crabs, fish, birds, and mammals from exposure to COCs by reducing concentrations of COCs in sediment and surface water to protective levels.

Sediment Protection. Reduce PCB concentrations in upland soils to ensure protection of sediments.

~~[a] Volumes of PCBs removed are estimates.~~

[b] Includes the baseline completion approach. Costs are life-cycle costs. For details see Appendix J.

ARAR – applicable or relevant and appropriate requirement

BMP – best management practice

COC – contaminant of concern

LDW – Lower Duwamish Waterway

MLLW – mean lower low water

PCB – polychlorinated biphenyl

Port – Port of Seattle

RAO – removal action objective

SMS – Washington State Sediment Management Standards

T-117 – Terminal 117

9 Recommended Removal Action Alternative~~s~~ and Implementation

This section presents the conclusions for the EE/CA and discusses:

- **The recommended removal action alternative** – The EE/CA recommends Alternative 2 for the T-117 NTCRA.
- **Removal action sequencing and schedule** – The sequencing, which is proposed to start in the Sediment Study Area and progress upland, finishing with the cleanup of the Adjacent Streets and Residential Yards. The cleanup implementation is anticipated to begin in 2012.
- **NTCRA work plan development** – The work plan will be provided as part of the T-117 NTCRA design.
- **Long-term ~~operation, maintenance, and monitoring plan~~OMMP** – The OMMP will be developed during the T-117 NTCRA design.

9.1 Recommended Removal Action Alternative

The recommended alternative for the T-117 NTCRA is Alternative 2. The key advantage of Alternative 2 is that it provides for maximum long-term effectiveness and permanence. Although Alternative 2 would cost slightly more to implement because of the added quantity of dredged material, this addition cost will be offset in part by the elimination of ~~lower~~ post-NTCRA cap monitoring and performance review costs that would be required under Alternative 1.

Both alternatives have the potential for short-term impacts associated with the release of COCs from the disturbance of contaminated sediment during either dredging or capping. Alternative 2 ~~also~~ has the greater potential for the disturbance of contaminated sediment because it involves more dredging, which increases ~~greater~~ short-term impacts~~, associated with additional dredging,~~ ande dredging disturbs more sediment than does capping. In either case, ~~but~~ these short-term impacts of capping and dredging can be reduced~~mitigated~~ through the use of ~~proper~~ BMPs~~dredging project design and controls~~.

Because Alternative 2 does not involve capping, it does not require institutional controls to protect the sediment. Institutional controls would be required under Alternative 1 to reduce the potential disturbance of the cap. These institutional controls would also require monitoring and maintenance. While Alternative 1 has a higher potential for the future release of COCs compared with Alternative 2, this potential is considered small and would be limited and managed through appropriate cap design, institutional controls, monitoring, and maintenance, if needed.

Alternative 2 also allows for maximum design flexibility because final site contours can be designed without the need to accommodate permanent intertidal cap, which structures. This will be particularly advantageous in locations where habitat redevelopment or other final site uses areto be selected and implemented in cooperation with the South Park Community. Final site contours can be designed without the need to accommodate permanent intertidal cap structures. Under Alternative 2, A limited amount of sediment located within the spaces between the rock riprap along the toe of the Marina shoreline contains elevated concentrations of PCBs. Rather than removing the rip-rap and undermining the Marina shoreline, the sediment within the rip-rap may be removed and/or contained by a localized cover. capping would be limited to only those locations where dredging is not feasible (e.g., around the base of intertidal structures). Alternative 2:

- Is protective of human health and the environment
- Achieves the site-specific RAOs
- Complies with ARARs
- Provides long-term effectiveness through the removal of the majority of contaminant mass at the site
- Is feasible and relies on technologies that are readily available

Monitoring and maintenance of the T-117 Sediment Study Area will be a part of the post-NTCRA activities.

9.2 REMOVAL ACTION SEQUENCING AND SCHEDULE

9.2.1 Sequencing

The successful implementation of the removal action will depend to a large degree on the sequencing of removal work in the T-117 Upland Study Area, the Adjacent Streets and Residential Yards Study Area, and the T-117 Sediment Study Area. An example of project sequencing is provided in Table 9-1. Other sequencing approaches that do not require a barrier wall may be considered during the design stage of the project. Sequencing within the T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area will take into consideration access logistics, potential traffic impacts on the surrounding community, and the limited availability of soil and sediment staging areas. Remedy implementation and the scheduling of in-water construction activities will be coordinated with the tribes to minimize impacts on tribal fishing. Proper sequencing within the T-117 Sediment Study Area will involve the removal of the most highly contaminated sediment first in order to eliminate the potential for recontamination of the remaining sediment areas.

Table 9-1. Example NTCRA sequencing overview for primary construction tasks

Step	Task	Benefits	Issues
1	Install barrier wall in vicinity of top of bank	– No aquatic impacts to be mitigated No in-water work permit required – No in-water work window schedule constraints – No net loss of aquatic habitat – Ability to control groundwater discharge during upland activities	– May require pre-excavation as a result of the presence of debris – Will likely require steel Z-piles – Will likely require interim groundwater control, treatment, and discharge
2	Excavate bank and intertidal mudflat from upland at low tide	– No aquatic impacts to be mitigated No in-water work permit required – No in-water work window schedule constraints – Bank excavation before sediment dredging greatly reduces sediment recontamination potential – Excavation allows for better removal along piles than dredging	– Capping of sediment under Alternative 1 should immediately follow the bank/mudflat excavation (e.g., same tidal cycle).
3	Dredge sediment	– Dredging sediment prior to upland excavation means upland is still in place to provide a location for sediment staging, if needed – Upland source controlled by piles, groundwater control – May be able to use groundwater treatment system for dewatering sediment, if required – Limits amount of work under in-water work window	– Capping of sediment under Alternative 1 2 should immediately follow the bank/mudflat excavation or dredging (e.g., same tidal cycle)..
4	Excavate T-117 Upland Removal Area	– Control of upland impacts Removal of contaminants and physical containmentControl orf upland control of contaminant pathways to sediment allows schedule flexibility so the upland cleanup can be coordinated with and habitat restoration to be coordinated if appropriate mitigation agreements are in place – Sheetpile wall or similar barrier may be left in place after cleanup without creating net loss of aquatic habitat – Habitat design flexibility is maintained by allowing re-grading behind sheetpile wall or similar barrier – Barrier wall limits potential for releases during construction	– Will require appropriate security and access control if upland left as an open excavation behind the sheetpile wall or similar barrier – Groundwater control, treatment and discharge may continue to be required until piles are removed

Step	Task	Benefits	Issues
5	Excavate Adjacent Streets and Residential Yards Study Area	– Existing stormwater controls could stay in place until all sediment and upland excavation is complete – Dallas Avenue S excavation could be coordinated with the adjacent excavation in the T-117 Upland Study Area – Adjacent Streets excavation could be coordinated with soil removal ~~if required~~ in the Residential Yards – Stormwater drainage could be incorporated into the final completion of the T-117 Upland Study Area – Because this study area has less contaminated material, it will be cleaned up last to prevent recontamination from the cleanup activities at other study areas	– Requires stormwater controls to be implemented during the excavation of the Adjacent Streets and Residential Yards Study Area

T-117 – Terminal 117

The following is a detailed example of how the project work could progress and demonstrates how the actions could be implemented in phases. It is assumed that the work would progress according to the general order of primary construction tasks outlined in Table 9-1.

1. Relocate marina docks as needed to allow access for sediment removal and undertake environmental surveys of T-117 EAA study area buildings (for asbestos and lead paint) as may be needed prior to demolition.
2. Establish traffic control measures within the site and for safe access to and from the site.
3. Abandon all onsite wells located within the study areas.
4. Construct temporary decontamination and work areas for demolition of T-117 EAA structures.
5. Establish and monitor perimeter controls.
6. Protect catch basin inlets and provide drainage control as needed for demolition.
7. Demolish and remove T-117 EAA buildings and other above-ground structures to prepare for soil removal.
8. Re-establish work and decontamination areas, as necessary, to make effective use of new areas within the T-117 Upland Study Area formerly occupied by buildings.
9. Remove known subsurface features within the T-117 Upland Study Area as needed to facilitate subsequent large-scale soil removal (e.g., USTs, remnant utility corridors, and building foundations and floor slabs from removed

structures) and re-stabilize removal areas using temporary backfill, paving, or other appropriate measures.

10. Re-evaluate site drainage and enhance as needed to ensure proper controls and treatment.
11. Construct soil and sediment staging areas and establish surface drainage controls (i.e., stormwater diversion, interception, and treatment) for the first stage of soil removal.
12. Establish vehicle loading and wheel wash facilities. Implement monitoring required for soil removal activities.
13. Install sheetpile wall, as needed, along the top of the shoreline bank. Install barriers and groundwater controls (dewatering or subsurface barriers) as needed to protect the LDW and limit or divert groundwater influx during bank and sediment removal work.
14. Excavate soil from the bank and adjacent intertidal mudflat. Load soil into haul trucks for offsite disposal at Subtitle D or C landfill in stages in order to ensure a controlled and manageable removal process.
15. Adjust and relocate site controls, drainage collection and treatment facilities, and staging areas for next phase of soil and sediment removal.
16. Implement additional measures as needed to ensure stability and proper drainage controls within the T-117 Upland Study Area (grading, planting, and paving).
17. Construct temporary sediment receiving and staging facilities for in-water dredging operations, if needed. Dredge sediment within the T-117 Sediment Study Area and backfill as required. Conduct monitoring as required during dredging to ensure compliance with specified water quality parameters and proper positioning of the dredge. Transport dredged sediment directly to the upland area or transport sediment by barge to an onsite or offsite transfer/loading facility for subsequent loading into haul trucks or rail cars for disposal at Subtitle D or C landfill. Dismantle and restore upland sediment staging areas and associated facilities upon completion of dredging.
18. Install subsurface soil dewatering systems (e.g., hydraulic barriers, well-point system) in close proximity of deep inland (non-shoreline) soil removal prisms for the removal of groundwater, establish onsite storage and treatment for extracted groundwater, and dewater the excavated areas (details regarding the extent to which these prisms are dewatered and excavated at once or in stages will be set forth in the detailed project plans).
19. Excavate soil from removal prisms located above the water table in phases. Load soil into haul trucks for offsite disposal at Subtitle D or C landfill, and

grade and/or provide temporary covers and drainage controls (as needed) to stabilize removal areas, particularly those located along the shoreline bank. Adjust staging areas and drainage controls as needed to accommodate subsequent soil removal phases and ensure continued control of site runoff.

20. Excavate deep inland soil removal prisms and backfill to above the water table as necessary to provide proper drainage, allow continued site access, and reduce the accumulation of rainwater in isolated removal prisms. Load soil into haul trucks for offsite disposal at Subtitle D or C landfill.
21. Conduct soil removal in Adjacent Streets and Residential Yards in stages and in accordance with detailed project plans and with agreements with affected property owners. Modify street access controls as removal progresses within the street alignments to limit the impacts on residential access.
22. Construct new stormwater infrastructure.
23. Conduct monitoring and control dust and runoff during soil removal to ensure protection of the public and prevent recontamination of adjacent areas. Restore streets and yards and install improved drainage collection and treatment facilities.
24. Install long-term monitoring wells as needed to monitor post-removal performance.

For this example, it was assumed that the T-117 Upland Study Area would be completed to a minimum elevation at or above +14 MLLW in accordance with the baseline completion option. Alternate completion options, such as those described in Section 7.3 and Figure 7-7, could require slightly different phasing and backfilling approaches for the upland soil and near-shore sediment removal activities.

9.2.2 Schedule

The following schedule elements are based on the T-117 EE/CA SOW:

- 2010
  - EE/CA is approved, and EPA issues an amended Action Memorandum.
  - NTCRA design process is initiated.
- 2011
  - Consent Order issued to respondents.
- 2012 to 2013
  - NTCRA design and work plans are completed.
  - NTCRA is implemented.

- 2013 to 2014
  - Site re-development (e.g., habitat restoration) is initiated.

~~The~~ This ~~draft final~~ final EE/CA ~~will be submitted~~is for public comment. ~~within 30 days of receipt of EPA comments on the interim draft final EE/CA. The public comment period is 60 days. The final EE/CA will be published within 30 days after EPA's~~ EPA will prepare ~~publication of their~~ a responsiveness summary based on public comments and issue an amended Action Memorandum for the T-117 EAA NTCRA, which will replace the Action Memorandum issued on July 22, 2005. This Action Memorandum will be issued no later than September 30, 2010.

The initial NTCRA design package will be prepared and submitted to EPA within 1 year (2011) after EPA issues ~~an~~ the amended Action Memorandum. ~~based on an approved EE/CA (i.e., sometime in 2011) and will likely be finalized sometime in 2012.~~ The implementation of the NTCRA will begin the following year (~~2013~~2012) after EPA has approved the design package. Timing of ~~the EE/CA,~~ the design phase, and NTCRA implementation may be adjusted, if necessary, to accommodate a selected site completion option (see Section 7.3). External factors, such as coordination with other LDW projects, the South Park Bridge replacement, weather, and salmon migration may also affect the NTCRA implementation schedule. Typical fish windows for the LDW occur from October 1 to February 15 but can vary from year to year depending on the timing of the juvenile salmon out-~~-~~migration. Activities that occur after completion of the EE/CA are not part of the current ASAOC and are subject to revision in accordance with the negotiated Consent Order with EPA~~next agreement~~.

9.3 NTCRA Work Plan Development

The work plan for the 2006 TCRA (RETEC 2006) will serve as a starting point for the NTCRA work plan and will be modified and augmented as needed to address the requirements set forth in the eventual NTCRA SOW. The TCRA work plan included health and safety procedures; routine inspection, maintenance, and monitoring tasks, such as cap inspection and maintenance, stormwater system maintenance, soil handling procedures, notification requirements, groundwater monitoring procedures and other performance standards directly applicable to the T-117 EAA and the NTCRA project. Several of the key elements of the NTCRA work plan are discussed in the following subsections.

9.3.1 Health and Safety

A detailed HSP will be prepared for the NTCRA and will be applicable to all site workers, as well as those providing oversight. The plan will also address controls and safety measures designed to protect personnel and nearby residents.

9.3.2 Site Controls

The NTCRA work plan will specify temporary erosion and sediment controls for all aspects of the construction work, including excavation, and soil or sediment stockpiling in the truck loading areas. Erosion control measures and controls for stormwater will be developed according to guidance contained in Ecology's *Stormwater Management Manual for Western Washington* (Ecology 2005b) and the *King County, Washington, Surface Water Design Manual* (King County 2009). Particular emphasis will be placed on control measures that prevent the offsite transport of contaminated materials (e.g., truck wheel washes, stormwater controls, and dust controls). The NTCRA work plan will include a schedule for the inspection and maintenance of these controls during all applicable phases of the project.

Noise monitoring and abatement criteria and procedures will also be specified. The NTCRA work plan will also include procedures for air quality and meteorological monitoring similar to those used for the TCRA to ensure that potential airborne contaminants are monitored so that they can be sufficiently controlled. Excavation, grading, and capping activities will be carried out in a manner that minimizes dust and the emission of odor (i.e., fugitive emissions). Stockpiles will be covered when there is no loading or unloading activity~~to the extent practicable~~ to further minimize dust during construction. Water trucks will be used to control site dust, as necessary.

9.3.3 Performance m~~M~~onitoring

The NTCRA remedial design work plan will include, but not be limited to, a sampling and analysis plan that specifies the sampling objectives and methods to be used for verification that soil and sediment above the RvALs have been removed. The plan will include a schedule of samples to be obtained, as well as a map indicating appropriate sampling locations within the T-117 EAA study areas.

9.3.3.1 Post-dredging verification sampling

Post-dredging verification sampling will be performed at locations where sediment has been removed as part of the NTCRA. The purpose of this sampling will be to ~~augment existing data and~~ document that sufficient sediment has been removed to meet RvALs where no capping or fill is anticipated. Sampling will include surface samples to document that acceptable target COC concentrations have been achieved throughout the depth of compliance. At locations where capping or filling is anticipated, surface sediment samples will be collected prior to the placement of new material in order to establish pre-cap placement COC concentrations. These data will be used to evaluate the results of subsequent long-term cap/removal area recontamination monitoring.

9.3.3.2 Soil excavation and sidewall verification sampling

Verification sampling of excavation sidewalls and bottoms will be performed as part of the NTCRA to confirm that the COC concentrations that remain at the boundary of the removal areas are below the soil RvALs. It is anticipated that for the T-117 Upland Study Area excavation samples will consist primarily of composites from each sidewall and bottom of pre-designated removal areas.

Verification sampling in the Adjacent Streets and Residential Yards Study Area will be limited to bottom samples because horizontal boundaries have been set by the MIS sampling method per agreement with EPA. In some cases, additional sampling of adjoining areas (e.g., un-sampled portions of yards adjacent to portions of yards being excavated) may be required. If sampling results indicate that soil at the vertical limit of excavation contains PCBs and dioxins and furans at concentrations that exceed their respective RvALs, additional excavation will be performed up to the full depth of compliance (i.e., 15 ft). ~~At locations where removal did not extend to the full depth of compliance , additional excavation may be performed if the verification sampling results indicate that remaining soil contains PCBs and dioxins and furans target COCs at concentrations that exceed their respective RvALs.~~

9.3.3.3 Material specifications and construction QA/QC

The NTCRA work plan will include detailed specifications for all material placed onsite, including imported structural fill; seed beds; gravel; material placed under asphalt, concrete, or roads; backfill for yards or upland soil or sediment landscaped areas with no structural features~~non-structural areas~~; and sediment cap materials. There will be no caps in the Adjacent Streets and Residential Yards, caps will be use only in the sediment areas or upland areas that may become sediment. Specifications will include compaction rates, material size, and specific product types. A construction QA/QC plan that describes how construction procedures and material specifications will be verified, as well as any material testing that may be required following placement of construction components will be prepared for the T-117 NTCRA.

9.3.3.4 Monitoring of dredging activities

Monitoring will be conducted during dredging activities and will include ~~periodic~~ turbidity measurements at upstream and down-current locations required by the water quality certification, as well as visual observations for floating debris and sheens. Periodic depth soundings will be conducted to ensure that the dredging is removing the designated material without excessive over-dredging. Response actions will be described in the NTCRA project plans.

9.4~~5~~ ADDITIONAL INFORMATION NEEDS

This section identifies additional data and information needs~~s~~ to be considered before implementation of the removal action. These additional needs are summarized in

Table 9-2. This information will be ~~,~~evaluated during the design phase, and incorporated in the design report. Activities needed to ensure that the removal action is being conducted in accordance with the removal action work plans and design and that the ~~s~~RAOs are being met were described in Section 9.3. Post-removal action monitoring to evaluate the long-term effectiveness of the removal action and inspect for potential recontamination is described in Section 9.5.

Table 9-2~~1~~. Supplementary information needed to support the removal action design

Information Need	Rationale
~~Design~~	
~~Additional~~ Streets and Yards Study Area ~~Information~~	
Additional g~~G~~roundwater quality data	Assess groundwater quality in portions of the Adjacent Streets and Yards Study Area and provide better hydraulic gradient information
Soil conditions	Determine horizontal extent of removal areas at some yard locations. Determine vertical extent of soil removal in yards.
~~Additional~~ RAA Information	
Additional groundwater monitoring	Further assess recontamination potential to post-removal downgradient areas
Storm solids quality in the Marina catch basins	Further assess recontamination potential.
Marina NPDES stormwater discharge data	Further assess recontamination potential.
Map of Marina stormwater system and drainage basins	Further assess recontamination potential.
~~Additional~~ Groundwater and Geotechnical ~~Information~~	
Additional hydraulic conductivity and pump test data	Needed for dewatering system design, if necessary, and post-removal recontamination assessment.
Additional groundwater monitoring~~d~~ and horizontal and vertical gradient information	As needed to support design and post-NTCRA sediment recontamination evaluations
Limited pre-design tidal study	As needed to supplement existing tidal study data
Geotechnical boring data~~s~~	As needed to support design
Sources of shoreline seeps and possible control options, if needed	As needed to address active seeps in the removal action design
Refinement of excavation prism	
Excavation prism data	Identify potential locations for supplementary pre-design sampling, as needed.
Site Preparation and Constraints	
Hazardous materials assessment (e.g., lead paint and asbestos survey)	Needed prior to demolition of T-117 Upland buildings.
Mapping of subsurface debris and ~~/~~obstructions	Determine locations of former foundations, buried concrete, septic tank, and backfill areas that might hinder excavation.
Utility locate	Identify current utility information.
SCL tower location and ~~/~~design	Integrate with removal action activities and site completion design.
SPU s~~S~~tormwater discharge location and design	Integrate with removal action activities and site com~~-~~pletion design.
Marina dock design	To facilitate temporary relocation during sediment removal action.

Information Need	Rationale
Coordination of Final Grade for Site Restoration TransitionHabitat	
Conceptual restoration grading plan	Integration of final land use (e.g., habitat) with removal action
Community	
Development of community protective measures	Minimize exposure of residents.

NPDES – National Pollutant Discharge Elimination System

NTCRA – non-time-critical removal action

RAA – recontamination assessment area

SCL – Seattle City Light

SPU – Seattle Public Utilities

T-117 – Terminal 117

9.4.1 Additional Streets and Yards Study Area iInformation

Additional information regarding groundwater beneath the Adjacent Streets and Residential Yards -is needed in order to better assess groundwater quality and provide a baseline understanding of the hydraulic gradients and groundwater flow directions in portions of the Streets and Yards Study Area. The number and location of additional pre-design groundwater monitoring wells to be installed and monitoring to be conducted to verify that groundwater beneath this study area is not impacted will be evaluated in the design phase.

Additional soil sampling in yards will be conducted during the design phase. Some yard areas that have not been sampled and are adjacent to DUs identified for removal will be sampled to define the extent of removal. Sampling to determine the vertical extent of removal in yards is also anticipated prior to removal.-

9.4.2 Additional RAA iInformation

Additional groundwater monitoring is planned in order to further assess the potential for groundwater from these two properties to contribute to recontamination. Data necessary to assess some of the pathways are limited. The adequacy of the upgradient and downgradient monitoring well network in the vicinity of the Basin Oil property will be reviewed and, if necessary, an additional well will be installed to evaluate groundwater quality associated with that EAA. Additional monitoring wells may also be needed to assess groundwater flow directions near the boundary between T-117 Upland Study Area and the Marina. This is primarily a post--NTCRA consideration, but monitoring wells can be installed during the design phase to provide useful information.

Section 5.2.1.3 described the need for additional information regarding the Marina storm drain system in order to fully evaluate the potential for sediment recontamination. A map of the Marina storm drain system and a new outfall to the LDW were identified during a recent site visit. This additional information will be used to assess the potential for the transport of COCs from the Marina to the T-117 Sediment Study Area. If it is concluded that the stormwater pathway poses a risk of sediment recontamination, then additional stormwater controls and/or monitoring will be required. These will be developed in cooperation with the Marina owner and in consultation with Ecology.

9.4.3 Additional g~~G~~roundwater and g~~G~~eotechnical i~~I~~nformation

Groundwater monitoring to date has focused on groundwater quality, observations of non-aqueous-phase liquid and calculations of groundwater flow direction. Prior to the design of the removal action, pump tests will likely be performed in select wells in order to estimate hydraulic conductivity. This information could be useful in the design of dewatering systems ~~as~~that may be needed to allow for deep excavation during soil removal.

Several additional pairs of groundwater monitoring wells may be installed to measure vertical groundwater gradients at select locations within the site. -These well pairs include one deep well and one shallow well. The difference in observed water levels in each well provides an indication of upward or downward groundwater gradients between the two depths at which the wells are screened.

The methods and results of tidal studies already completed at the site will be reviewed to determine the extent to which they meet data needs for the removal action design. If data gaps that cannot be addressed by the above-described pump tests~~,~~ are noted, a limited pre-design tidal study will be performed using select wells within the expanded monitoring well network to supplement the understanding of hydraulic conductivity across portions of the site. The methods and data quality objectives for the study will be included in a work plan to be submitted to EPA for approval prior to implementation.

The removal action designers may require additional geotechnical information to assess soil conditions relative to excavation, shoring, or final site grades. Should this need arise, geotechnical borings will be advanced at locations within the EAA, either as a stand-alone field task or in coordination with the installation of monitoring wells or other subsurface work (e.g., additional soil sampling). The possible sources and, if needed, control methods for shoreline seeps will also be addressed during the remedial design phase.

9.4.4 Refinement of e~~E~~xcavation p~~P~~risms

The proposed T-117 Upland Study Area soil removal prisms are discussed and presented in Section 7.1.2. As noted therein, the locations and depths of these prisms will be refined during final design and execution The existing removal prisms will be reviewed during the removal action design to identify locations where there may be uncertainty regarding the required extent of removal. Those locations where additional pre-design sampling is needed to refine the depth and/or lateral extent of soil removal will be identified. A work plan for addressing soil removal data gaps will be prepared and submitted to EPA for review prior to implementation.

9.4.5 Site pPreparation and cConstraints

Table 9-2 identifies a number of information needs necessary to provide the level of detail needed for final removal action design. Remaining structures within the T-117 Upland Study Area will need to be demolished and removed prior to excavation. A hazardous materials assessment will be needed to ensure that this work includes the abatement of any hazardous materials that may be present in these structures (e.g., asbestos or lead paint). Known subsurface structures and utilities will also need to be identified and shown on project drawings. These include the former utility corridors, underground tanks, septic tank, former building foundations, backfill areas, gas and water lines, electrical lines, and other features and utilities that may need to be protected or will require special methods for removal and disposal.

Several design constraints will need to be addressed in the removal action and site completion designs. The first is the foundation and easement for restoration and maintenance of the western tower of Seattle City Light's high--voltage cable span across the LDW. The required easement and tower location and design will need to be identified so they can be integrated into the overall removal action design. The other design constraint involves SPU's plans to restore stormwater discharge to the LDW from a limited portion of the Streets and Yards Study Area through an outfall to be located somewhere within the T-117 EAA shoreline. The outfall location will need to be specified together with the appropriate outfall design in coordination with the eventual site completion design., This will ensure that the outfall can be integrated into the overall removal action and site completion. Information on the Marina's dock design and an access agreement with the Marina will also be needed to facilitate the planning for temporary dock relocation and subsequent restoration before and after sediment removal in the marina vicinity.

9.4.6 Coordination of final grade for site restoration transitionhabitat

The NTCRA will be coordinated with known future site use concepts for the restoration of the T-117 EAA after completion of the soil and sediment removal activities. Available information on the final site configurations will be considered in the development of final site grades. If no site configuration is selected in time for the removal action design, then the site will be restored to the baseline completion grade.

-9.54 LONG-TERM OPERATION, MAINTENANCE, AND MONITORING PLAN

Post-NTCRA conditions at the T-117 EAA will be monitored and maintained to ensure that the RAOs and RvALs are being met, there is compliance with ARARs, and the remedy continues to be protective of human health and the environment. A long-term OMMP will be prepared in accordance with appropriate guidance documents WAC

173 340 410 during the design phase of the NTCRA and will address the final site configuration, site uses, caps, drainage systems, habitat areas, and additional redevelopment details. The post-NTCRA OMMP is envisioned to be a single document prepared with EPA, and Ecology, and with stakeholder review and input. The OMMP will include sampling and analysis plans as appendices, as well as a schedule for implementation. Each section of the plan will address each of the principal study areas, groundwater monitoring, and the monitoring and maintenance requirements for storm drainage systems serving the upland portions of the EAA. upland habitat resources. The post-removal monitoring plan will be designed to evaluate the effectiveness of source controls measures put in place. These source controls will include periodic comprehensive review of SPU and Port stormwater data for discharges, acquisition of Marina discharges data for sediment COCs, and monitoring of groundwater to establish baseline conditions and changes to flow and character that may occur after the NTCRA. Elements addressed in the OMMP will include, but not necessarily be limited to, the following:

- Post-removal site conditions and property uses
- Utility locations
- Site controls, institutional controls, and access restrictions
- Perimeter security fencing and on-site buildings
- Inspection and maintenance of upland caps and coversareas
- T-117 EAA inspection, monitoring, and maintenance
- Groundwater and seep monitoring
- Stormwater system descriptions, operation, maintenance, and storm solids monitoring
- Erosion and sediment controls
- Stormwater systems
- Documentation and reporting
- Health and safety and waste management for routine and non-routine maintenance

The OMMP will also address procedures for managing underlying site soil that may be encountered at depth during any future during post-NTCRA construction within the upland portions of the T-117 EAA (i.e., after completion of the removal action and restoration work done as part of the NTCRA). These procedures will include making necessary notifications, implementing health and safety measures, using appropriate methods for soil stockpiling, performing analytical testing, and pursuing options for soil reuse or disposal at the offsite waste management facility. Additional discussion of the OMMP elements for each T-117 EAA study area is provided in the following subsections. A summary of subjects and activities to be addressed in the OMMP is presented in Table 9-3.

Table 9-3. Subjects and activities to be addressed in the T-117 OMMP

Subject or Activity	Rationale
Post Removal Action Conditions and Facilities	
Site features	Document final locations
Stormwater drainage and treatment systems	Document final locations
Informational signage	Document locations and address maintenance
Utility locations	Document final locations
Stormwater	
Stormwater monitoring	Ongoing assessment of recontamination potential in the EAA and the RAAs
Stormwater system maintenance	Preventative measure for recontamination, source control
Stormwater treatment system operation	Preventative measure for recontamination, source control
Groundwater and Geotechnical Information	
Development of post-removal groundwater monitoring network	Necessary to conduct post--removal action groundwater monitoring and tidal study
Groundwater monitoring	Verify that post--removal groundwater RvALs are being met
Post--removal tidal study	To determine how the removal action alters groundwater flow, particularly at the south end of the Marina
Sediment Removal Area Monitoring	
Sediment area reconnaissance	Performance monitoring of sediment backfill/cap areas, if necessary
Sediment sampling	Assessment of recontamination
Requirements for Upland Subsurface Construction	
Notifications prior to construction	To ensure that Port and City control post-removal activities as appropriate within the EAA
Construction restrictions	To ensure that drainage, backfill areas, and erosion control measures are not compromised
Soil handling, disposal, and backfill procedures	To ensure safe handling and proper disposal and that final site conditions are properly maintained
Site restoration	To ensure future construction area(s) are properly restored
Upland Area Inspections	
Performance of erosion control measures (pavements, backfill, planted areas, BMPs)	Source control measure for preventing recontamination.
Response Actions and Adaptive Management Strategies	
Groundwater	Identify process if post--removal--action groundwater exceed RvALs.
Stormwater	Identify process if post--removal--action stormwater solids exceed sediment RvALs.
Upland areas	Identify process if post--removal--action soil becomes recontaminated and exceeds RvALs.
Sediment area	Identify process if post--removal--action sediment becomes recontaminated and exceeds RvALs.

BMP – best management practice

EAA – early action area

OMMP – operation, maintenance, and monitoring plan

RvAL – removal action level

9.5~~4~~.1 T-117 Sediment Study Area

Long-term monitoring of sediment removal areas will include both physical and chemical monitoring to assess site integrity and potential recontamination. Although the intent of the selected alternative is to not rely on capping, if any limited areas are capped (e.g., immediately around in-water structures where dredging might not be feasible), then physical monitoring would be conducted in those areas to evaluate the physical stability of the cap. This would include measurements to evaluate cap thickness and sediment particle size and bathymetric measurements to evaluate evidence of scour from vessel movement or from high-flow events. The Port intends to monitor sediment quality within the T-117 Sediment Study Area, particularly near outfall and seep locations, to determine if recontamination is occurring. Chemical testing will be used following the NTCRA to ~~evaluate~~ ensure that ~~RAOs~~ RvALs, ARARs, and removal objectives are being met, the NTCRA is protective of human health and the environment, and source control continues to be assessed~~continue to be met and assess source control progress~~ with respect to potential recontamination.

9.5~~4~~.2 T-117 Upland Study Area

Post-NTCRA operation, maintenance, and monitoring activities for the T-117 Upland Study Area will depend to a large degree on the final site use of this area. ~~Special controls and m~~Maintenance procedures and periodic monitoring will be required to ~~maintain~~ ensure that ~~and protect~~ any future habitat resources as ~~that~~ may be established meet their respective performance criteria. If the site is redeveloped for tenant use, then measures will be needed to make sure tenant activities do not compromise the performance of the NTCRA or pose a threat of recontamination to the T-117 Sediment Study Area.

The TCRA work plan that was completed for the T-117 Upland Study Area in 2006 (RETEC 2006) provides a good model for post-removal O&M activities, including the monitoring and maintenance of stormwater conveyances and erosion and stormwater controls, inspection and repair of paved areas, and procedures for documenting O&M activities. In addition to these elements, the OMMP will also include prescribed adaptive management procedures to be followed in the event that inspection and monitoring activities detect potential soil erosion and/or recontamination of the T-117 Sediment Study Area originating from the T-117 Upland Study Area.

~~Long-term O&M~~ The OMMP will also include a description of necessary ~~will also discuss (if necessary)~~ procedures for any future post-site development or construction work. These will include notifications prior to construction to ensure that the Port and

City are made aware of work plans and that appropriate measures are in place to preserve site drainage controls, backfill, and other key structures. Procedures for proper site restoration will also be specified and followed. penetration of the capped areas or excavation at depths that might encounter underlying site soils or sediment. These procedures would include health and safety standards, issues associated with soil stockpiling or analytical testing, and soil reuse or disposal options at the disposal facility. In accordance with the above documents, soil will need to be handled and managed in a manner that is protective of human health and the environment. Site maintenance staff and contractors will be required to follow the relevant OMMP the same procedures as those outlined in the future NTCRA work plan when when performing any post-removal maintenance and construction activities at the T-117 EAA. These procedures will include notification requirements (including contingencies for any activities beyond the planned scope), soil handling procedures, waste management plans and procedures, and required measures for site restoration.

Groundwater monitoring will also be required to check for the potential recontamination of the T-117 Upland Study Area and the T-117 Sediment Study Area. Groundwater monitoring points will be located along the future shoreline and Dallas Avenue S.will be located upgradient of the zone of impacted groundwater (i.e., in the vicinity of the boundary between theT-117 Upland Study Area and Dallas Avenue S), with selected wells monitored periodically to confirm stable or decreasing COC concentrations. A full tidal study will be undertaken using monitoring wells within the T-117 upland areas to evaluate the post-removal groundwater regime and how the modified shoreline and site grade has influenced groundwater flow patterns. Monitoring well installation, development, gGroundwater sampling and tidal studies will be completed in accordance with an approved field sampling plan (FSP) and quality assurance project plan (QAPP) to be developed in conjunction with the OMMP. The FSP will include details on sampling methods and frequency, including a long-term monitoring schedule. The QAPP will include project organization, objectives, activities, and quality procedure to be implemented during the compliance monitoring actions.

9.54.3 Adjacent Streets and Residential Yards Study Area

As discussed in Section 5.2, since the cessation of asphalt manufacturing facility operations in the mid-1990s, the potential for the recontamination of soils has largely been restricted to the redistribution of existing contaminants. The NTCRA is expected NTCRAs are expected to eliminate the potential for recontamination to T-117 Upland Study Area and Adjacent Streets and Residential Yards Study Area soils from this historical source.

9.54.3.1 Stormwater

Stormwater runoff from the Adjacent Streets and Residential Yards Study Area is currently collected in two separate systems that can be roughly divided into areas west and east of 17th Avenue S (see Map 2-2). To the west, runoff is currently discharged to the CSS. The cleanup of both of these areas will trigger the stormwater requirements of SMC 22.800 and Directors' Rule 2009-005 (SPU), 17-2009 (DPD) (City of Seattle 2009a). Cleanup west of 17th Avenue S will likely consist of upgrading streets and curbing to current codes, with continued discharge to the CSS. Cleanup options for the area east of 17th Avenue S will include the installation of a permanent stormwater collection/treatment system in accordance with the City and County stormwater codes with discharge to the LDW. The final configuration will be determined in the design phase of the NTCRA and coordinated with the final completion of the T-117 Upland Study Area (e.g., matching drainage and grades with topography of final upland configuration). The method of treating runoff from the adjacent streets will be determined during design. Options include biofiltration swales, filter strips, bioretention cells, wet vaults, and media filtration. The treatment system will be operated and maintained in accordance with SPU protocols. SPU employs standard protocols, which define procedures for inspecting and maintaining the treatment system and associated structures, for each type of system to ensure that these systems remain functional.

Stormwater solids monitoring will continue to be performed in accordance with the City's source-tracing program, which is administered by the LDW SCWG. This monitoring will be coordinated with Ecology and EPA to verify that the stormwater solids are not a recontamination concern for LDW sediments.

After completion of the NTCRA and implementation of stormwater treatment measures, SPU will monitor the drainage system to evaluate the effectiveness of the removal action and treatment system in controlling PCBs and other contaminants in the runoff from this area. A detailed post-NTCRA monitoring program will be developed during project design;, however, it is anticipated that storm drain monitoring will be conducted by the City and in conjunction with the larger LDW source control program. As currently envisioned, drainage system monitoring will focus on evaluating the chemical characteristics of solids present in this system. Samples of storm solids have proven to be an effective means for identifying pollutant sources and have been used as a benchmark in the assessment of the potential for stormwater solids to recontaminate LDW sediment. Stormwater solids results will be compared with SMS, and threshold concentrations will be identified, which, if exceeded, will trigger additional source investigations. Currently, CSL concentrations are used as a benchmark for triggering source tracing. An adaptive management strategy that will phase in increasingly more aggressive source investigations until the source(s) of any future contamination is identified and controlled will be developed. The adaptive management plan would specify the following:

- Continued monitoring of solids as may accumulate in stormwater structures (e.g., traps, catch basins, manholes) for the presence and concentration of COCs.

- If concentrations of COCs approach some source control reference levels in storm solids samples, the City will determine the source and any additional controls that may be warranted, in which case, storm solids will continue to be monitored once the new/additional control is in -place.-

- If additional control of COC sources is not feasible, then additional stormwater treatment will be evaluated.

9.54.3.2 Groundwater

Section 2.3 discusses groundwater conditions beneath the Residential S~~s~~treets and Adjacent Y~~y~~ards Study Area. Available data indicate that groundwater beneath Residential Streets and Adjacent Yards Study Area has not been impacted. Based on the depth to groundwater (approximately 12 ft) and generally shallow depth of soil removal prism (anticipated to be no greater than 6 ft bgs), it is anticipated that groundwater will not be impacted by the NTCRA. Nevertheless, a pre- and post-NTCRA groundwater monitoring program is necessary, and a groundwater monitoring program for the Adjacent Streets and Residential Yards Study Area will be implemented. ~~The need for and design of a pre- and post-NTCRA groundwater monitoring is anticipated, and a program for Adjacent Streets and Residential Yards Study Area will be evaluated during the design phase of the NTCRA.~~

9.5.4 -Long-term OMMP summary

The post-removal monitoring plan will be designed to evaluate the long-term effectiveness of the NTCRA in the three T-117 EAA study areas, including compliance with RAOs and RvALs, effectiveness of source control and other recontamination prevention efforts. The plan will also include procedures for identifying any recontamination effects on the post-NTCRA site and appropriate responses. This may involve strategic sediment sampling (i.e., sampling focused on potential source discharge areas, such as outfalls and seeps) within the T-117 Sediment Study Area, periodic comprehensive review of SPU stormwater data for discharges, the collection of data from Marina discharges for sediment COCs and monitoring of groundwater to establish a groundwater baseline conditions and changes to flow and characteristics that occur as a result of~~because~~ ~~of~~ the NTCRA.

10 References

AECOM. 2009a. Lower Duwamish Waterway Superfund Site, Terminal 117 Early Action Area. First quarter 2009 interim groundwater monitoring data results - non-time critical removal action. Prepared for the Port of Seattle and the City of Seattle. AECOM, Seattle, WA.

AECOM. 2009b. Lower Duwamish Waterway Superfund Site, Terminal 117 Early Action Area. Second quarter 2009 interim groundwater monitoring data results - non-time critical removal action. Prepared for the Port of Seattle and the City of Seattle. AECOM Environment, Seattle, WA.

AECOM. 2009c. Lower Duwamish Waterway Superfund Site, Terminal 117 Early Action Area. Third quarter 2009 interim groundwater monitoring data results - non-time critical removal action. Prepared for the Port of Seattle and the City of Seattle. AECOM Environment, Seattle, WA.

AECOM. 2009d. Terminal 117 time-critical removal action - 6th semiannual (July-December 2009) operations and maintenance report. AECOM, Seattle, WA.

Allwine H. 2005. Personal communication (telephone conference between H. Allwine, SDOT, and B. Schmoyer, Seattle Public Utilities, Seattle, WA, regarding paving of S. Cloverdale St. and surrounding streets). Seattle Department of Transportation, Seattle, WA. November 17, 2005.

Basin Oil. 1995. Spill prevention control and countermeasure (SPCC) plan. Revised August 1995. Basin Oil Company, Seattle, WA.

Battelle. 2002. Application, performance, and costs of biotreatment technologies for contaminated soils. Prepared for National Risk Management Research Laboratory, US Environmental Protection Agency. EPA/600/R-03/037. Battelle, Columbus, OH.

Booth D, Herman L. 1998. Duwamish industrial area hydrogeologic pathways project: Duwamish basin groundwater pathways conceptual model report. Prepared for City of Seattle Office of Economic Development and King County Office of Budget and Strategic Planning. Produced by Hart Crowser, Inc., Seattle, WA.

Bridges T, Stephen E, Hayes D, Mount D, Nadeau S, Palermo M, Patmont C, Schroeder P. 2008. The four Rs of environmental dredging: resuspension, release, residual, and risk. Prepared for the US Army Corps of Engineers, Dredging Operations and Environmental Research Program. ERDC/EL TR-08-4.

Chen W, Hainsworth G. 2009. Memorandum dated December 28, 2009 to Roy Kuriowa, Port of Seattle: T-117 TCRA - stormwater sediment control enhancement plan. AECOM and Crete Consulting, Seattle, WA.

City of Seattle. 2005. Seattle Public Utilities South Park soil remediation project [online]. Seattle Public Utilities, City of Seattle, WA. [Cited November 2005.] Available from: http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/Projects/South_Park_Soil_Project/index.asp.

City of Seattle. 2007a. City of Seattle Department of Planning and Development GIS [online]. City of Seattle, WA. Updated 2007. [Cited November 20, 2009.] Available from: http://web1.seattle.gov/dpd/maps/dpdgis.aspx.

City of Seattle. 2007b. Comprehensive Plan: Future land use map, City of Seattle, WA. Updated 2/14/07. [Cited 11/19/09.] Available from: http://www.seattle.gov/DPD/cms/groups/pan/@pan/@plan/@proj/documents/web_informational/dpdp_019479.pdf.

City of Seattle. 2009a. Directors' rules for Seattle Municipal Code, Chapters 22.800-22.808, Stormwater Code: volume 3, Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual, Directors' Rule 2009-005 (SPU), 17-2009 (DPD). Department of Planning and Development, Seattle Public Utilities, City of Seattle, Washington.

City of Seattle. 2009b. Directors' rules for Seattle Municipal Code, Chapters 22.800-22.808, Stormwater Code: volume 4, Stormwater Code Enforcement Manual, Directors' Rule 2009-007 (SPU), 18-2009 (DPD). Department of Planning and Development, Seattle Public Utilities, City of Seattle, Washington.

Clemens JM. 2007. Personal communication (e-mail and attachments to Sarah Fowler, Windward Environmental, regarding Duwamish flow rates). Public Affairs/Media Relations, Washington Water Science Center, US Geological Survey, Tacoma, WA. June 1, 2007.

Creative Environmental Technologies. 1996. Level 1 environmental site assessment report, southwest Seattle property located at 8661 Dallas Avenue South. Prepared for Basin Oil Company, Inc. Creative Environmental Technologies, Inc., Tacoma, WA.

Crow G. 2010. Personal communication (site visit with J. Florer, Windward Environmental, regarding South Park Marina drainage). Owner, South Park Marina, Seattle, WA. April 30, 2010.

Davila B, Whitford KW, Saylor ES. 1993. Engineering issue: technology alternatives for the remediation of PCB-contaminated soil and sediment. EPA/540/S-93/506. Technology Innovation Office, Office of Solid Waste and Emergency Response, US Environmental Protection Agency, Washington, DC.

DOF. 2009. Revised agency review draft - Remedial action construction report. Head of Hylebos Waterway Problem Area. Commencement Bay Nearshore/Tideflats

Superfund site, Tacoma, Washington. December 28, 2009. Dalton, Olmsted & Fuglevand, Inc., Seattle, WA.

Ecology. 1992a. Dangerous waste compliance inspection report for Basin Oil, Inc., WAD988477501, for inspection on December 8, 1992. Washington State Department of Ecology, Bellevue, WA.

Ecology. 1992b. Letter dated November 13, 1992, from Joanne Phillipson, Ecology Hazardous Waste Information and Planning, to Dave Lundstrom, Ecology Northwest Regional Office, regarding falsified manifests from Basin Oil, Inc., WAD988477501. Washington State Department of Ecology, Bellevue, WA.

Ecology. 1993a. Letter dated August 3, 1993, from J Summerhays, Hazardous Waste Inspector, to Terry Drexler, Basin Oil, Inc., WAD988477501, regarding dangerous waste compliance inspections). Washington State Department of Ecology, Bellevue, WA.

Ecology. 1993b. National Pollutant Discharge Elimination System (NPDES) Waste Discharge Permit No. WA-002987-4; Boeing-South Park. Letter from John Glynn to L.M. Babich, III, Boeing Commercial Airplane Group, December 21, 1993. Washington Department of Ecology, Bellevue, WA.

Ecology. 1994a. Letter dated February 24, 1994, from J Summerhays, Hazardous Waste Specialist, to T Drexler, Basin Oil, Inc., regarding recent dangerous waste site visits and compliance issues. Washington State Department of Ecology, Bellevue, WA.

Ecology. 1994b. Letter dated June 22, 1994, from J Summerhays, Hazardous Waste Specialist, to M Frico, Seattle Department of Land Use and Construction, regarding Project No. 9402048, Basin Oil Tank Farm. Washington State Department of Ecology, Bellevue, WA.

Ecology. 1994c. Natural background soils metals concentrations in Washington State Toxics Cleanup Program. Publication #94-115. Washington Department of Ecology, Olympia, WA.

Ecology. 2000. Hazardous Waste and Toxics Reduction Program Compliance Report, Basin Oil Co., Inc., RCRA ID WAD988477501. Inspection on 9/26/00. Washington State Department of Ecology, Bellevue, WA.

Ecology. 2003. Letter dated February 5, 2003, from T Yelton, Hazardous Waste Compliance Inspector, to T Drexler, Basin Oil, Inc., regarding Ecology's 2000 hazardous waste compliance inspection. Washington State Department of Ecology, Bellevue, WA.

Ecology. 2004a. Lower Duwamish Waterway source control strategy. No. 04-09-043. Washington Department of Ecology, Northwest Regional Office, Toxics Cleanup Program, Bellevue, WA.

Ecology. 2004b. Property review: Basin Oil Company, Inc. Early Action Area 5, Terminal 117 property reviews. Facility site ID 2202, Seattle, King County [online]. Toxics Cleanup Program, Washington Department of Ecology, Olympia, WA. Updated June 18, 2004. [Cited 6/17/08.] Available from: http://www.ecy.wa.gov/programs/tcp/sites/lower_duwamish/sites/terminal_117/property_reviews/reviews.htm

Ecology. 2004c. Property review: Boeing South Park. Early Action Area 5, Terminal 117 property reviews. Facility site ID 2202, Seattle, King County [online]. Toxics Cleanup Program, Washington Department of Ecology, Olympia, WA. Updated June 25, 2004. [Cited 6/17/08.] Available from: http://www.ecy.wa.gov/programs/tcp/sites/lower_duwamish/sites/terminal_117/property_reviews/reviews.htm

Ecology. 2005a. Lower Duwamish Waterway source control action plan for the Terminal 117 early action cleanup. Washington Department of Ecology, Northwest Regional Office, Bellevue, WA.

Ecology. 2005b. Stormwater management manual for Western Washington. Water Quality Program, Washington State Department of Ecology, Olympia, WA.

Ecology. 2007. Letter dated March 13, 2007 to S. Eckman, EPA Region 13, regarding Dallas Avenue cleanup. Northwest Regional Office, Washington State Department of Ecology, Bellevue, WA.

Ecology. 2008. Letter dated April 25, 2008 from B. Smith to T. Drexler, Basin Oil, regarding Scope of Work and schedule due May 4, 2008, confirmational sampling at Basin Oil. Northwest Regional Office, Washington State Department of Ecology, Bellevue, WA.

Ecology, SAIC. 2008. Lower Duwamish Waterway source control status report, April 2008 through August 2008. No. 08-09-068. Northwest Regional Office, Washington Department of Ecology, Bellevue, WA, and Science Applications International Corporation, Bothell, WA.

Ecology. 2009a. Personal communication (e-mail communication from R. Thomas to P. Peterson Lee, EPA Region 10, regarding dioxin data). Washington State Department of Ecology, Bellevue, WA. July 7, 2009.

Ecology. 2009b. Unpublished data, boring logs, and field notes, Basin Oil investigation. Washington State Department of Ecology, Bellevue, WA.

EMCON. 1996. Draft removal action work plan, Malarkey Asphalt site, Seattle, Washington. Prepared for Malarkey Asphalt Company. EMCON, Bothell, WA.

ENSR. 2006. Voluntary cleanup program application form. Provided by B. Smith, Washington Department of Ecology, Northwest Regional Office, Hazardous

Waste and Toxics Reduction Program, via email to A. Cardenas, Integral Consulting, Inc. ENSR, Seattle, WA.

ENSR. 2008a. Bankline repair and maintenance activities completion report, Terminal 117, Port of Seattle. July 9, 2008. ENSR, Seattle, WA.

ENSR. 2008b. Request for approval of Terminal 117 shoreline repair activities. May 29, 2008. Prepared for Port of Seattle. ENSR, Seattle, WA.

ENSR | AECOM. 2008. Lower Duwamish Waterway Superfund Site, Terminal 117 Early Action Area. First quarter interim groundwater monitoring data results - non-time critical removal action. Final. Prepared for the Port of Seattle and the City of Seattle. ENSR | AECOM, Seattle, WA.

ENSR | AECOM. 2009. Feasibility study, Lower Duwamish Waterway, Seattle, Washington. Draft. April 24, 2009. ENSR | AECOM, Seattle, WA.

Environmental Partners. 2006. CMS phase quarterly shoreline ground water monitoring report, August 2006, Boeing Plant 2, Seattle/Tukwila, Washington. Environmental Partners, Inc., Issaquah, WA.

EPA. 1989. Risk assessment guidance for Superfund, volume 1: Human health evaluation manual, Part A. EPA/540/1-89/002. Office of Emergency and Remedial Response, US Environmental Protection Agency, Washington, DC.

EPA. 1990. Superfund guidance on remedial actions for Superfund sites with PCB contamination. OSWER Directive No. 9355.4-01. EPA/540/G-90/007. US Environmental Protection Agency, Washington, DC.

EPA. 1993. Guidance on conducting non-time-critical removal actions under CERCLA. EPA/540-R-93-057. Office of Emergency and Remedial Response, US Environmental Protection Agency, Washington, DC.

EPA. 1995. Docket No. 10-95-0131-OPA (Administrative Complaint). In the Matter of Basin Oil Company, Inc., Respondent. Issued to Terry J. Drexler, Basin Oil Company by Leroy Loiselle, Unit Manager, Emergency Response and Site Cleanup Unit #1, Office of Environmental Cleanup. October 19, 1995. US Environmental Protection Agency, Seattle, WA.

EPA. 1996a. Administrative order on consent for removal action, Malarkey Asphalt Company. US Environmental Protection Agency Region 10, Seattle, WA.

EPA. 1996b. EPA Region 10 supplemental risk assessment guidance for Superfund. Draft. Office of Environmental Assessment, Risk Evaluation Unit, US Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 1997a. Ecological risk assessment guidance for Superfund: Process for designing and conducting ecological risk assessments. EPA/540/R-97/006. Interim final.

Environmental Response Team, US Environmental Protection Agency, Edison, NJ.

EPA. 1997b. EPA Region 10 supplemental ecological risk assessment guidance for Superfund. EPA/910/R-97/005. Region 10 Office of Environmental Assessment Risk Evaluation Unit, US Environmental Protection Agency, Seattle, WA.

EPA. 1998. Approach for addressing dioxin in soil at CERCLA and RCRA sites. Memorandum dated April 13, 1998 to regional offices. OSWER Directive 9200-4.26. Office of Solid Waste and Emergency Response, US Environmental Protection Agency, Washington, DC.

EPA. 1999. Asian and Pacific Islander seafood consumption study in King County, Washington. Exposure information obtained through a community-centered approach. Study results and education outreach. EPA 910/R-99-003. Office of Environmental Assessment, Risk Evaluation Unit, US Environmental Protection Agency Region 10, Seattle, WA.

EPA. 2000. Administrative order on consent for removal action, Malarkey Asphalt Company and Port of Seattle, and Statement of Work. US EPA docket no. 10-2000-0222. US Environmental Protection Agency Region 10, Seattle, WA.

EPA. 2001. Frequently asked questions about atmospheric deposition. EPA-453/R-01/009. Office of Wetlands, Oceans, and Watersheds and Office of Air Quality Planning and Standards, US Environmental Protection Agency, Washington, DC.

EPA. 2002. National recommended water quality criteria: 2002. EPA-822-R-02-047. US Environmental Protection Agency, Washington, DC.

EPA. 2005a. Action memorandum for a non-time-critical removal action at the Terminal 117 Early Action Area, Lower Duwamish Waterway Superfund Site, Seattle, Washington. US EPA CERCLA docket no. 10-2006-0103. July 21, 2005. US Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 2005b. Administrative settlement agreement and order on consent for removal action, Lower Duwamish Waterway Superfund Site Terminal 117 Early Action Area, Seattle, Washington. US EPA CERCLA docket no. 10-2006-0103. December 22, 2005. US Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 2005c. Administrative Settlement Agreement order on consent for Terminal 117 Upland Investigation. US EPA Docket No. CERCLA 10-2006-0072. US Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 2005d. Contaminated sediment remediation guidance for hazardous waste sites. OSWER 9355.0-85. EPA-540-R-05-012. US Environmental Protection Agency, Office of Solid Waste and Emergency Response Washington, DC.

EPA. 2005e. Supplemental guidance for assessing susceptibility from early-life exposure to carcinogens. EPA/630/R/03/003F. Risk Assessment Forum, US Environmental Protection Agency, Washington, DC.

EPA. 2006a. Action memorandum for a time-critical removal action at the Terminal 117 Early Action Area, Lower Duwamish Waterway Superfund site, Seattle, Washington. US Environmental Protection Agency Region 10, Seattle, WA.

EPA. 2006b. Statement of work, T-117 Early Action Area, Lower Duwamish Waterway Superfund site, Seattle, Washington, CERCLA time-critical removal action. US Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 2007a. Environmental fact sheet, May 2007. Basin Oil, King County, Washington. US Environmental Protection Agency Region 10, Seattle, WA.

EPA. 2007b. Reasonably anticipated future land use at T-117 Early Action Area, Lower Duwamish Superfund Site, Seattle, Washington. Letter from Piper Peterson Lee, Remedial Project Manager, Region 10, to Doug Hotchkiss, Port of Seattle. US Environmental Protection Agency Region 10, Seattle, WA.

EPA. 2007c. Statement of work, T-117 Early Action Area. Amendment no. 1: non-time-critical removal action, Lower Duwamish Waterway Superfund site, Seattle, Washington. US Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 2008a. Commercially permitted PCB disposal companies as of May 2007 [online]. US Environmental Protection Agency, Washington, DC. Updated February 20, 2008. Available from: http://www.epa.gov/pcb/pubs/stordisp.htm.

EPA. 2008b. Request for approval approved via electronic e-mail. June 9, 2008. US Environmental Protection Agency Region 10, Seattle, WA.

EPA. 2009a. Comments on T-117 engineering evaluation/cost analysis section 3. October 6, 2009. US Environmental Protection Agency Region 10, Seattle, WA.

EPA. 2009b. Draft recommended interim preliminary remediation goals for dioxin in soil at CERCLA and RCRA sites. Public review draft. OSWER 9200.3-56. Office of Superfund Remediation and Technology Innovation, US Environmental Protection Agency, Washington, DC.

EPA. 2009c. Management meeting administrative decision made directing the Adjacent Streets to be expanded. August 10, 2009. US Environmental Protection Agency Region 10, Seattle, WA.

EPA. 2009d. Memorandum dated June 26, 2009 from J E Woolford and J E Reeder to Superfund National Policy Managers, Regions 1-10, regarding summary of key existing EPA CERCLA policies for groundwater restoration. OSWER Directive 9283.1-33. Office of Solid Waste and Emergency Response, US Environmental Protection Agency, Washington, D C.

EPA. 2009e. Preliminary remediation goals: screening levels for chemical contaminants [online]. US Environmental Protection Agency Region 9, San Francisco, CA. Updated April 2009. [Cited 11/10/09.] Available from: http://www.epa.gov/region09/superfund/prg/.

EPA. 2009f. Regional screening values, from Regional Screening Levels for Chemical Contaminants at Superfund Sites database [online]. US Environmental Protection Agency, Washington, DC. Updated 12/09. Available from: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm.

EPA. 2010. Comments on the Revised Engineering Evaluation/Cost Analysis (EE/CA) dated January 19, 2010. April 2, 2010. US Environmental Protection Agency Region 10, Seattle, WA.

Exponent. 1998. Duwamish Waterway phase I site characterization report. Prepared for The Boeing Company. Exponent, Bellevue, WA.

Hart Crowser. 1992. Site assessment UST decommissioning, Malarkey Asphalt Company. Prepared for Duwamish Properties, Inc. Hart Crowser, Inc., Seattle, WA.

Hart Crowser. 2005. Soil quality testing report 8601 and 8609 17th Avenue South, 8603 Dallas Avenue South, and 16th Avenue South Right of Way, Seattle, WA. Prepared for Hart Crowser by KPFF. Hart Crowser, Inc., Seattle, WA.

Herman L, Wineman M. 1997. Criteria and approach for area-wide determination of surface water protection as most beneficial use of groundwater. Hart Crowser, Inc., Seattle, WA.

Herrera. 2004. Sampling and analysis plan, Diagonal Avenue South drainage basin pollutant source investigation. Prepared for Seattle Public Utilities Herrera Environmental Consultants, Inc., Seattle, WA.

Hohmann JD. 1992. Personal communication (internal memo from J.D. Hohmann to Dangerous Waste file for Basin Oil, Inc., WAD988477501, regarding common address and other concerns for Basin Oil and Frontwater Services). Northwest Regional Office, Washington State Department of Ecology, Bellevue, WA. May 8, 1992.

Huber K. 2009. Personal communication (telephone call with Beth Schmoyer, Seattle Public Utilities). King County Department of Natural Resources and Parks, Wastewater Treatment Division, Seattle, WA.

Huntington A, Hainsworth G. 2009. Memorandum dated December 22, 2009 to Roy Kuriowa, Port of Seattle: T-117 catch basin solids sampling - September 2009. AECOM and Crete Consulting, Seattle, WA.

Integral. 2005. Site characterization plan, South Park remediation project, Seattle, Washington. Prepared for Seattle Public Utilities. Integral Consulting Inc., Seattle, WA.

Integral. 2006a. Draft feasibility study, South Park soil remediation project, Seattle, Washington. June 28, 2006. Prepared for Seattle Public Utilities. Integral Consulting, Inc., Mercer Island, WA.

Integral. 2006b. Site characterization data report, South Park soil remediation project. Prepared for Seattle Public Utilities. Integral Consulting, Inc., Mercer Island, WA.

Integral. 2006c. Terrestrial ecological evaluation. Appendix E in: Site characterization data report, South Park Soil Remediation Project, Seattle, Washington. Prepared for Seattle Public Utilities. Integral Consulting Inc., Mercer Island, WA.

Integral. 2008a. Proposed approach for investigation of potential dioxin contamination in soil: City of Seattle streets and yards adjacent to the T-117 Early Action Area. Memorandum prepared for T. Meyer, Seattle City Light. June 6, 2008. Integral Consulting, Inc., Mercer Island, WA.

Integral. 2008b. Toxic equivalent concentrations of TCDD in source sediments and street dirt. Prepared for Seattle Public Utilities. Integral Consulting, Inc., Mercer Island, WA.

Integral. 2009. PCB boundary refinement data report. Draft. Prepared for the Port of Seattle and the City of Seattle. Integral Consulting Inc., Seattle, WA.

Kerwin J, Nelson TS, eds. 2000. Habitat limiting factors and reconnaissance assessment report, Green/Duwamish and Central Puget Sound watersheds (WRIA 9 and Vashon Island). Washington Conservation Commission, Lacey, WA, and King County Department of Natural Resources, Seattle, WA.

King County. 1999a. King County combined sewer overflow water quality assessment for the Duwamish River and Elliott Bay. Vol 1, Appendix A: Problem formulation, analysis plan, and field sampling work plan. King County Department of Natural Resources, Seattle, WA.

King County. 1999b. King County combined sewer overflow water quality assessment for the Duwamish River and Elliott Bay. Vol 1, Appendix B2, B3, & B4: human health, wildlife, and aquatic life risk assessments. King County Department of Natural Resources, Seattle, WA.

King County. 2005. Duwamish current meter analysis, December 10, 2003 - February 10, 2004. King County Department of Natural Resources, Seattle, WA.

King County. 2008. Lower Duwamish Waterway Source Control Project: Passive atmospheric deposition sampling, Lower Duwamish Waterway: Monitoring report - October 2005 to April 2007. King County Department of Natural Resources and Parks, Seattle, WA.

King County. 2009. King County, Washington surface water design manual. King County Department of Natural Resources, Seattle, WA.

King County, SPU. 2005. King County and Seattle Public Utilities source control program for the Lower Duwamish Waterway: June 2005 progress report. King County Department of Natural Resources and Parks and Seattle Public Utilities, Seattle, WA.

Mickelson S, Williston D. 2006. Technical memorandum: Duwamish River/Elliott Bay/Green River water column PCB congener survey: transmittal of data and quality assurance documentation. King County Department of Natural Resources, Seattle, WA.

NOAA. 1998. Duwamish Waterway sediment characterization study report. Damage Assessment Center, National Oceanic and Atmospheric Administration, Seattle, WA.

Onsite. 2000a. PCB removal/containment action, South Park Site. Prepared for Port of Seattle. Onsite Enterprises, Inc., Redmond, WA.

Onsite. 2000b. Underground storage tank removal site check/assessment report, South Park Site (Formerly Malarkey Asphalt Company), Seattle, Washington. Prepared for the Port of Seattle. Onsite Enterprises, Inc., Redmond, WA.

Onsite. 2003. Groundwater monitoring well sampling At T-117: Proposed approach project memo. Onsite Enterprises, Inc., Redmond, WA.

Onsite. 2004. Terminal 117 south building "planter" areas: soil sampling procedures and results. Prepared for the Port of Seattle. Onsite Enterprises, Inc., Redmond, WA.

Onsite Environmental. 2005. Letter to Seattle-King County Department of Public Health transmitting laboratory results. March 7, 2005.

Palermo M, Maynord S, Miller J, Reible D. 1998. Guidance for in-situ subaqueous capping of contaminated sediments. EPA 905-B96-004. Great Lakes National Program Office, US Environmental Protection Agency, Chicago, IL.

Palermo MR, Schroeder PR, Estes TJ, Francingues NR. 2008. Technical guidelines for environmental dredging of contaminated sediments. ERDC/EL TR-08-29. Environmental Laboratory, US Army Engineer Research and Development Center, Vicksburg, MS.

Parametrix. 1991. Site hazard assessment summary report for Malarkey Asphalt Company, Seattle, Washington. Prepared for Washington State Department of Ecology. Parametrix, Inc., Bellevue, WA.

Phoinix. 2007. Terminal 117 stormwater inspection report. Prepared for Port of Seattle. The Phoinix Corporation, Seattle, WA.

Platinum International. 2002. Remediation technologies screening matrix and reference guide, Version 4.0. Prepared for Federal Remediation Technologies Roundtable [online]. Platinum International, Inc., Alexandria, VA. Updated January 2002. Available from: http://www.frtr.gov/matrix2/section1/toc.html.

QEA. 2008. Lower Duwamish Waterway sediment transport modeling report. Prepared for Lower Duwamish Waterway Group. Quantitative Environmental Analysis, LLC, Montvale, NJ.

RETEC. 2005. Identification of candidate technologies for the Lower Duwamish Waterway. Prepared for the Lower Duwamish Waterway Group. Draft January 2005. The RETEC Group, Inc., Seattle, WA.

RETEC. 2006. Time-critical removal action work plan, Terminal 117, Seattle, Washington. September 11, 2006. Prepared for Port of Seattle. The RETEC Group, Inc., Seattle, WA.

RETEC. 2007a. Operations and maintenance plan and post-removal site control plan, Terminal 117, Seattle, Washington. January 8, 2007. Prepared for Port of Seattle. The RETEC Group, Inc., Seattle, WA.

RETEC. 2007b. Time-critical removal action final report, Terminal 117, Seattle, Washington. March 26, 2007. Prepared for Port of Seattle. The RETEC Group, Inc., Seattle, WA.

Rodin J. 2007. Personal communication (e-mail to T. Meyer, City of Seattle, City Light Department, Environmental Affairs, regarding Basin Oil sampling). US Environmental Protection Agency, Seattle, WA. June 13, 2007.

SAIC. 2007a. Lower Duwamish Waterway source control status report. Prepared for Toxics Cleanup Program, Washington State Department of Ecology. Science Applications International Corporation, Bothell, WA.

SAIC. 2007b. Lower Duwamish Waterway, South Park Marina: summary of existing information and identification of data gaps. Prepared for Toxics Cleanup Program, Washington State Department of Ecology. Science Applications International Corporation, Bothell, WA.

SAIC. 2008. South Park Marina, Seattle, Washington: additional site characterization activities data report. Final. Prepared for Toxics Cleanup Program, Washington State Department of Ecology. Science Applications International Corporation, Bothell, WA.

SAIC. 2009. Final technical memorandum: Lower Duwamish Waterway, South Park Marina, sediment recontamination assessment, June 22, 2009. Prepared for

Washington State Department of Ecology. Science Applications International Corporation, Bothell, WA.

Santos JF, Stoner JD. 1972. Physical, chemical, and biological aspects of the Duwamish River Estuary, King County, Washington, 1963-1967. Geological Survey water supply paper 1873-C. Stock no. 2401-1207. US Government Printing Office, Washington, DC.

Schock K, Zhong J, Shuman R, Munger S. 1998. Simulating water quality in the Duwamish Estuary and Elliott Bay: comparing effects of CSOs and other sources. Puget Sound Research '98 Proceedings, Puget Sound Water Quality Action Team, Olympia, WA. King County Department of Natural Resources.

SECOR. 1997. Focused site characterization report, Malarkey Asphalt site, 8700 Dallas Avenue South, Seattle, Washington. SECOR International Incorporated, Seattle, WA.

SECOR. 1998. Focused feasibility study, Malarkey Asphalt site. SECOR International Incorporated, Seattle, WA.

Simenstad CA, Tanner CD, Thom RM, Conquest LL. 1991. Estuarine habitat assessment protocol. EPA 910-9/91-91-037. US Environmental Protection Agency, Region 10, Seattle, WA.

Suter GW. 1993. Ecological risk assessment. Lewis Publishers, Boca Raton, FL.

Thomas R. 2008a. Personal communication (telephone conversation with P. Zieber, Integral Consulting, regarding status of Basin Oil cleanup. Northwest Regional Office, Washington Department of Ecology, Bellevue, WA. May 13, 2008.

Thomas R. 2008b. Personal communication (telephone conversation with P. Zieber, Integral Consulting, regarding status of Basin Oil cleanup). Northwest Regional Office, Washington Department of Ecology, Bellevue, WA. May 7, 2008.

URS. 1994. Site inspection report for the Malarkey Asphalt Company, Seattle, Washington. Prepared for the US Environmental Protection Agency, Region 10. URS Consultants, Seattle, WA.

USACE. 2003. Puget Sound confined disposal site study, Washington. U.S. Army Corps of Engineers, Seattle District, Seattle, WA.

USGS. 2007. Washington State real-time stations (monitoring data for USGS 12113000, Green River gaging station near Auburn, 6/25/07) [online]. US Geological Survey, Washington Water Science Center, Tacoma, WA. Available from: http://wa.water.usgs.gov/realtime/dcpstations.html.

Weston. 1999. Site inspection report, Lower Duwamish River (RK 2.5-11.5), Seattle, Washington. Vol 1-Report and appendices. Prepared for US Environmental Protection Agency, Region 10. Roy F. Weston, Inc., Seattle, WA.

Weston Solutions. 2005. Human health risk assessment, GE/Housatonic River Site - Rest of river. Volume IV, Appendix C, Consumption of fish and waterfowl risk assessment. Submitted to US Army Corps of Engineers, New England District, and US Environmental Protection Agency, New England Region, Boston, MA. Weston Solutions, Inc., Seattle, WA.

Wilbur Consulting. 2003. Final work plan, South Park bridge: preliminary site investigation for waste characterization and geotechnical data. Prepared for King County Department of Transportation. Wilbur Consulting, Inc., Seattle, WA.

Windward. 2003a. Lower Duwamish Waterway remedial investigation. Phase 1 remedial investigation report. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2003b. Lower Duwamish Waterway remedial investigation. Task 5: Identification of candidate sites for early action, technical memorandum: Data analysis and candidate site identification. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2004. Lower Duwamish Waterway remedial investigation. Intertidal clam survey data report. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2005a. Lower Duwamish Waterway remedial investigation. Data report: Chemical analyses of benthic invertebrate and clam tissue samples and co-located sediment samples. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2005b. Lower Duwamish Waterway remedial investigation. Technical memorandum: Results from survey of potential human access locations on the Lower Duwamish Waterway. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2007a. Lower Duwamish Waterway remedial investigation. Baseline ecological risk assessment. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2007b. Lower Duwamish Waterway remedial investigation. Baseline human health risk assessment. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2007c. Lower Duwamish Waterway remedial investigation. Remedial investigation report. Draft. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2008. Lower Duwamish Waterway remedial investigation. Remedial investigation report. Draft final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2009. Lower Duwamish Waterway remedial investigation. Remedial investigation report. Draft final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward, Integral. 2009. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. Dioxin investigation and PCB sediment removal boundary delineation data report. Prepared for the Port of Seattle and the City of Seattle. Windward Environmental LLC, Seattle, WA; Integral Consulting, Inc., Mercer Island, WA.

Windward. unpublished. T-117 tidal study results, July 2006 unpublished data. Windward Environmental LLC, Seattle, WA.

Windward, DOF. 2006. Terminal 117 upland area soil investigation field sampling and data report. Prepared for the Port of Seattle. Windward Environmental LLC and Dalton, Olmsted & Fuglevand, Inc., Seattle, WA.

Windward, Onsite. 2004. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. T-117 abandoned utility corridor—excavation, removal and replacement of structurally unsuitable and contaminated fill materials. Prepared for the Port of Seattle. Windward Environmental LLC and Onsite Enterprises, Inc., Seattle, WA.

Windward, QEA. 2005. Lower Duwamish Waterway remedial investigation. Data report: sediment transport characterization. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA and Quantitative Environmental Analysis, Montvale, NJ.

Windward, QEA. 2008. Lower Duwamish Waterway remedial investigation. Sediment transport analysis report. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA and Quantitative Environmental Analysis, Montvale, NJ.

Windward, DOF, Onsite. 2003. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. Task 1: Summary of existing information and data gaps analysis report. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmsted & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, Onsite. 2004. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. Sediment field sampling, cruise and data report. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmsted & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, Onsite. 2005a. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. T-117 - South Park Marina sediment sampling data report. Draft. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmsted & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, Onsite. 2005b. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. T-117 sediment, soil and water field sampling, cruise and data report. Final. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmsted & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, Onsite. 2005c. Lower Duwamish Waterway Superfund site, Terminal 117 early action area. Terminal 117 engineering evaluation/cost analysis. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmsted & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, Onsite. 2005d. Lower Duwamish Waterway Superfund site, Terminal 117 upland area. T-117 upland soil - June 2005 field sampling and data report. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmsted & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, DOF, Onsite. 2005e. T-117 uplands soil sampling - August 2005 data memorandum. Prepared for the Port of Seattle. Windward Environmental LLC, Dalton, Olmsted & Fuglevand, Inc., and Onsite Enterprises, Inc., Seattle, WA.

Windward, ENSR | AECOM, Integral, DOF. 2008. Terminal 117 Early Action Area. Work plan for revised engineering evaluation/cost analysis. Final. Prepared for the Port of Seattle and the City of Seattle. Windward Environmental LLC, Seattle, WA; ENSR | AECOM, Seattle, WA; Integral Consulting, Inc., Mercer Island, WA; and Dalton, Olmsted & Fuglevand, Inc., Seattle, WA.

WSDOH. 2006. Health consultation: exposure investigation report, Dallas Avenue Neighborhood PCB, Seattle, King County, Washington. DOH Pub # 334-101. Washington State Department of Health, Olympia, WA.