Port of Seattle
Lora Lake Apartments Site

Remedial Investigation/ Feasibility Study

Prepared for

Port of Seattle
Aviation Environmental Programs
Seattle-Tacoma International Airport
17900 International Boulevard, Suite 402
SeaTac, Washington 98188-4238

January 16, 2015

FINAL

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Volume I
Text, Tables, Figures, Appendices A through D

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List of Abbreviations/Acronyms

Acronym/ Abbreviation	Definition
1,2-DCE isomers	cis-1,2-Dichloroethene and trans-1,2-dichloroethene
3rd Runway	Third parallel dependent runway constructed at Seattle-Tacoma International Airport
ALS	Approach lighting system
AO	Agreed Order
ARAR	Applicable, relevant, and appropriate requirement
bgs	Below ground surface
BMP	Best management practice
BTEX	Benzene, toluene, ethylbenzene, and xylenes
CAP	Cleanup Action Plan
COC	Contaminant of concern
cPAH	Carcinogenic polycyclic aromatic hydrocarbon
CSL	Cleanup Screening Level
CSM	Conceptual site model
1,2-DCA	1,2-Dichloroethane
trans-1,2-DCE	trans-1,2-Dichloroethene
cis-1,2-DCE	cis-1,2-Dichloroethene
DCA	Disproportionate Cost Analysis
DMCA	1982 Dredged Material Containment Area
DNAPL	Dense non-aqueous phase liquid
EIC	Ecological indicator soil concentration
ENR	Enhanced natural recovery
ESA	Environmental Site Assessment
FAA	U.S. Federal Aviation Administration
FS	Feasibility Study
Golder	Golder Associates
HPAH	High molecular-weight polycyclic aromatic hydrocarbon
IA	Interim action
KCHA	King County Housing Authority
Koc	Soil organic carbon-water partitioning coefficient
Kow	Octanol-water partition coefficient
LL	Lora Lake
LPAH	Low molecular-weight polycyclic aromatic hydrocarbon
MCL	Maximum contaminant level
MNR	Monitored natural recovery
MPU	Master Plan Update
MTCA	Model Toxics Control Act
nPAH	Non-carcinogenic polycyclic aromatic hydrocarbon
NAVD88	North American Vertical Datum of 1988
NRMP	Natural Resources Management Plan
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethene

Acronym/ Abbreviation	**Definition**
PCOC	Preliminary contaminant of concern
PCP	Pentachlorophenol
Port	Port of Seattle
PQL	Practical quantitation limit
PRB	Permeable reactive barrier
PSEP	Puget Sound Estuary Program
RI/FS	Remedial Investigation and Feasibility Study
RAO	Remedial action objective
RPZ	Runway Protection Zone
SCO	Sediment Cleanup Objectives
Site	Lora Lake Apartments Site
SMS	Sediment Management Standards
SR 518	State Route 518
STE	Storm event
STIA	Seattle-Tacoma International Airport
SWIA	Stormwater Interim Action
SVE	Soil vapor extraction
SVOC	Semivolatile organic compound
2,3,7,8-TCDD	2,3,7,8-Tetrachlorodibenzo-p-dioxin
TCE	Trichloroethene
TEE	Terrestrial ecological evaluation
TEQ	Toxicity equivalent
TOC	Total organic carbon
TPH	Total petroleum hydrocarbons
TSS	Total suspended solids
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOC	Volatile organic compound
WAC	Washington Administrative Code
WHMP	Wildlife Hazard Management Plan
WSDOE	Washington State Department of Ecology
WSDOT	Washington State Department of Transportation

Part One—Lora Lake Apartments Site Introduction

1.0 Introduction

The Seattle-Tacoma International Airport (STIA) is the 18th largest air traffic terminal in the United States (Port of Seattle 2011a). In 2010, the STIA served 31,553,166 passengers and 283,425 tons of cargo, resulting in 313,954 passenger and cargo aircraft take-offs and landings.

The Port of Seattle (Port) is a special purpose government that owns and operates the airport on behalf of the citizens of King County, Washington, for the benefit of regional commerce and the traveling public. The Port operates STIA in strict compliance with the rules and regulations set forth by the U.S. Federal Aviation Administration (FAA). Air safety rules comprise a significant component of the airport's regulatory mandates.

In response to the region's air travel needs, regional governments determined that a third parallel dependent runway (3rd Runway) would be constructed at STIA. The Port acquired numerous properties to enable construction of the runway, associated runway safety facilities, and to develop and enhance associated wetland and aquatic species habitat mitigation specifically designed to be compatible with FAA wildlife hazard safety rules.

FAA requirements for runway design include the designation of several types of safety zones adjacent to the runway, referred to as FAA Runway Protection Zones (RPZs). FAA rules significantly restrict the presence of structures and human activity in those safety areas. One of the properties acquired for Port control of land within an FAA RPZ adjacent to the north end of the 3rd Runway was a large apartment building complex, the Lora Lake Apartments.

Prior to construction of the apartments in the mid-1980s and Port acquisition of the property in 1998, contaminants were released to soil and groundwater on the property by industrial activities conducted on the Lora Lake Apartments property between the 1940s and 1980s.

This document is the Final Remedial Investigation and Feasibility Study (RI/FS) for the Lora Lake Apartments Site (Lora Lake Apartments Site, or Site). The Site is located adjacent to the northwest corner of the STIA. The Site comprises the Lora Lake Apartments Parcel at the intersection of Des Moines Memorial Drive and State Route 518 (SR 518), and areas east of Des Moines Memorial Drive inside the fenced airport operations area.

The Lora Lake Apartments property was used as a barrel-washing facility in the 1940s and 1950s. The barrel-washing facility washed out barrels that had contained industrial chemicals, among other things, prior to re-use or disposal of the barrels. The property was next used as an auto-wrecking yard from the 1950s through the mid-1980s. It was converted to apartments in 1987. Soil and groundwater at the apartments property is contaminated by activities conducted during the industrial past use. As the current owner, the Port is now responsible for cleaning up that contamination, and will conduct the cleanup in accordance with the state Model Toxics Control Act (MTCA).

The Port and the Washington State Department of Ecology (WSDOE) entered into Agreed Order (AO) No. DE 6703 for the Lora Lake Apartments Site on July 10, 2009 (WSDOE 2009). The AO Scope of Work requires the Port to prepare a RI/FS Work Plan, conduct an RI/FS, and prepare an RI/FS Report pursuant to Washington Administrative Code (WAC) 173-340-350 in a manner that complies with requirements of the MTCA cleanup regulation, Chapter 173-340 WAC (WSDOE 2007). The objective of the RI/FS process for the Site is to complete a comprehensive site-wide evaluation that will support recommendation of a cleanup alternative to meet MODEL TOXICS CONTROL ACT criteria and be consistent with the Port's future land use goals.

WSDOE approved the Port's RI/FS Work Plan in July 2010, and, subsequently, various Work Plan addenda. Several rounds of investigation have been performed by the Port to characterize contamination in soil, sediment, groundwater, and stormwater and to determine the extent of contamination that is attributable to historical sources at the Lora Lake Apartments property. The Remedial Investigation (RI) portion of this report describes the Site and contamination characteristics. The Feasibility Study (FS) portion of this report describes a set of alternative ways that cleanup could be conducted to meet MTCA requirements and support future property uses.

The Draft RI/FS Report was reviewed by WSDOE and made available for review by the public. This Final RI/FS Report is prepared by the Port in response to comments received from WSDOE and the public. WSDOE used the information in the Draft RI/FS Report to select a cleanup action for the Site, as documented in the Draft Cleanup Action Plan (CAP; WSDOE 2013a), which was also reviewed by the public. The CAP will be finalized based on comments received from the public and information in this Final RI/FS Report.

1.1 BACKGROUND AND OVERVIEW

The Lora Lake Apartments property is located at 15001 Des Moines Memorial Drive in Burien, Washington (Figure 1.1). Through the 1930s, the area was primarily agricultural, containing family farms, suburban development, and supporting commercial businesses. Des Moines Memorial Drive has been a primary thoroughfare since this time. To the east of Des Moines Memorial Drive, a peat bog was excavated in the 1940s and 1950s to mine the peat, resulting in the creation of a small lake, Lora Lake. Houses were built around the lake, which were present through the late 1990s. With the creation of the lake and additional area development, regional stormwater from the surrounding neighborhoods and primary roadways in Burien was directed to the lake, with overflow drainage to Miller Creek.

The Lora Lake Apartments property was farmland until the mid-1940s, when the Novak Barrel Cleaning Company was established. Metal drums and other containers were brought from various industrial and other operations to the company for washing in order to prepare the containers for reuse. It is suspected that drainage and residue from the barrel-washing activities were discharged into the ground at the middle of the apartments property. Barrel-washing operations were conducted on the property until the early 1950s, when the property was sold for use as an auto-wrecking yard. The property was used for auto-wrecking and auto storage until the mid-1980s.

In 1987, apartment buildings were constructed on the property. During development, a small excavation to remove contaminated material was completed in the middle of the property. This excavation was in the area where it was suspected that barrel-washing residue had been discharged to the ground. This excavation was reported to WSDOE at the time, and documentation of WSDOE approval of that remedial action is included in the historical records for the Site (Appendix A).

The Port purchased the property in 1998, as part of the new 3rd Runway Project. Concurrently, the Port purchased most properties east of Des Moines Memorial drive, which also were within the expansion area for the new runway. These properties included Lora Lake and its abutting residences. The residences and apartments were demolished by the Port between approximately 2005 and 2009. Heating oil tanks associated with the demolished homes were decommissioned in accordance with state regulations. Site history and site physical and land use characteristics are described in more detail in Section 2.0 of this document.

The Port purchased the Lora Lake Apartment complex aware of the property use history and the potential presence of associated contamination. In purchasing the property, the Port took on responsibility for characterization and cleanup of soil and groundwater contamination associated with historical sources from the Site. Historical owners and operators of the industrial uses at the property are no longer viable as responsible parties. In taking on responsibility for the property, the Port entered into the AO with WSDOE, defining the expectations for site characterization and cleanup.

Contamination present at the Site is associated with the historical barrel–washing and auto-wrecking uses. There is a clearly defined zone of significant contamination in a small focused area of the property where the barrel-washing debris is suspected to have been discharged, and there are moderate and lower levels of contamination over a large percentage of the rest of the Site. Contaminants of concern (COCs) include arsenic, lead, total petroleum hydrocarbons (TPH), pentachlorophenol (PCP), carcinogenic polycyclic aromatic hydrocarbons (cPAHs), ethylbenzene, toluene, tetrachloroethene (PCE), trichloroethene (TCE), 1,2-dichloroethane (1,2-DCA), and dioxins/furans, or dioxin/furan. These contaminants are consistent with the past site uses, assuming that barrel-washing residue would contain a variety of chemicals comprising wood-treating compounds, solvents, and petroleum products. Dioxin/furan compounds are the most prevalent and persistent contaminants at the Site. Even at very low concentrations, these compounds pose health risks. Dioxins/furans are associated with wood-treating and pesticide solutions, and are also associated with urban combustion processes and emissions. Dioxins/furans are also formed in the natural environment when fires occur in the presence of salt (e.g., associated with saltwater-laden wood). Throughout Washington State dioxins/furans are present at low levels in soil, stormwater, groundwater, and sediment as a result of widespread urban and natural sources—forest fires, volcanoes, backyard burn barrels, residential wood burning, and industrial processes consisting of coal-fired power plants, cement kilns, land application of treated sewer sludge, municipal and domestic waste incineration, chlorine bleaching of pulp and paper, and chlorinated pesticide manufacturing. Addressing dioxin/furan contamination at the Site caused by on-site sources versus contamination resulting from widespread urban sources is complex, and is an important part of the work presented in this RI/FS document.

One of the key requirements of the site RI is to determine the nature and extent of contamination associated with on-site sources, and how far beyond the apartments property boundaries the site-related contamination has migrated. In order to make this determination, the Port reviewed the site history and conducted several rounds of investigation. Initially, an investigation was conducted to characterize the soil and groundwater on the Lora Lake Apartments property and the Des Moines Memorial Drive Right-of-Way. An extensive series of monitoring events was also conducted to characterize the quality of stormwater and stormwater solids in pipelines entering and leaving the property. Additionally, an investigation of soil, groundwater, and sediment quality was conducted at the Lora Lake Parcel (LL Parcel) across Des Moines Memorial Drive to the east, to determine whether site contamination had migrated to the lake property, the lake sediments, or to Miller Creek sediments.

Site history research revealed that Lora Lake was dredged in 1982 to address complaints regarding excessive siltation made by residents of the homes surrounding the lake. Dredged material was placed on an adjacent property to the northeast, also owned by the Port. Based on that historical information, the investigation for the Site was again expanded in order to include the 1982 Dredged Material Containment Area (DMCA).

The multiple phases of site investigation identified COCs at the LL Parcel and the DMCA that are similar to the contaminants identified at the Lora Lake Apartments Parcel (LL Apartments Parcel). Many of these contaminants are also present in the regional stormwater that is discharged to the lake. Although the presence of these contaminants on the LL Parcel and DMCA properties is not thought to result solely from the historical operations conducted at the LL Apartments Parcel, a connection between the properties cannot be disproved. Therefore, the Port has concluded that for the purposes of this RI/FS, it is appropriate to expand the definition of the LL Apartments Site to include the LL Parcel and the DMCA in addition to the LL Apartments Parcel. This determination is consistent with the MTCA definition of a “Site” as the location where contamination has come to be located.

1.2 REGULATORY CONTEXT

This RI/FS process is being conducted in accordance with the requirements of the Washington State MTCA: Chapter 173-340 WAC . The Scope of Work to be conducted by the Port is defined in AO No. DE 6703, entered into between the Port and WSDOE in 2009.

The objective of the RI/FS process for the Site is to complete a comprehensive site-wide evaluation that will support recommendation of a cleanup alternative that will meet MTCA criteria and be consistent with the Port’s future land-use goals. In determining appropriate cleanup levels and points of compliance for individual contaminants, MTCA requires incorporation of all known and applicable requirements from other state and federal laws, and requires a thorough evaluation of exposure pathways for current and future land use.

The RI/FS process is being conducted to meet the schedule required by the AO, which would also support the Port’s intended process, working with the City of Burien, to redevelop the Lora Lake Apartments Parcel for commercial or light-industrial airport-compatible use. WSDOE and the Port anticipate that the CAP for the Site will be finalized in 2015, with site cleanup to follow.

1.3 STRUCTURE OF THE REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

The RI portion of this document (Sections 2.0 through 8.0) describes the characteristics of the Site and the nature and extent of contamination. The LL Apartments Parcel FS portion of the document (Sections 9.0 through 14.0) describes a set of alternative ways that cleanup at the LL Apartments Parcel could be conducted to meet MTCA requirements and support future property uses. The LL Parcel FS portion of the document (Sections 15.0 through 20.0) describes a set of alternative ways that the cleanup at the LL Parcel could be conducted to meet MTCA requirements and support future property uses. The report is organized as described below:

- **Section 2.0—Site Description and Setting.** Provides information on the definition and description of the Site, land use and ownership, geology, hydrogeology, and ecology.

Part 2: Remedial Investigation

- **Section 3.0—Site Characterization Activities and Interim Actions.** Describes the scope of all environmental investigations conducted at the Site.
- **Section 4.0—Environmental Investigation and Interim Action Findings.** Discusses analytical results for all investigations conducted at the Site, subdivided by area of the Site and media (soil, groundwater, stormwater, and sediments), as applicable.
- **Section 5.0—Exposure Pathways Analysis and Identification of Appropriate Cleanup Level Regulations.** Based on the preliminary conceptual site model (CSM) and subsequent investigation results, this section updates the identification of exposure pathways and applicable cleanup level regulations for each investigated and impacted environmental medium at the Site.
- **Section 6.0—Site-specific Cleanup Levels for Contaminants of Concern.** Develops the final applicable cleanup levels for site COCs.
- **Section 7.0—Nature and Extent of Contaminants of Concern.** Describes the physical properties, primary source areas, current contamination extent, and behavior of each site COC. Additionally describes the recommended point of compliance for each contaminated medium based on this information.
- **Section 8.0—Conceptual Site Model.** Describes the revised, conceptual understanding of the Site; identifies sources of hazardous substances, how they were released, the types and concentrations of chemicals detected, impacted media, exposure pathways, and receptors.

Part 3: Lora Lake Apartments Parcel Feasibility Study

- **Section 9.0—Feasibility Study Introduction.** Describes remedial action objectives (RAOs) for the proposed cleanup action and identifies applicable laws and regulations relevant to implementing a cleanup action at the LL Apartments Parcel.
- **Section 10.0—Cleanup Areas.** Describes the site-specific conditions that impact remedy application in areas of the LL Apartments Parcel, and divides the LL Apartments Parcel into Cleanup Areas based on those factors.
- **Section 11.0—Identification of Remedial Technologies.** Identifies and describes potentially applicable technologies for use to address the COCs at the LL Apartments Parcel.
- **Section 12.0—Technology Screening and Alternative Development.** Evaluates the technologies described in Section 11.0 based on the site-specific conditions and constraints. Retained technologies are then aggregated into LL Apartments Parcel cleanup alternatives.
- **Section 13.0—Alternatives Evaluation and Disproportionate Cost Analysis.** Evaluates the LL Apartments Parcel remedial alternatives proposed in Section 12.0 according to the MTCA requirements and evaluation criteria for a cleanup action. This evaluation is then summarized in a Disproportionate Cost Analysis (DCA).
- **Section 14.0—Recommendation of the Preferred Remedial Alternative.** Describes in greater detail the alternative recommended to WSDOE for selection as the preferred remedy for cleanup of the LL Apartments Parcel based on the results of the Alternatives Evaluation and DCA.

Part 4: Lora Lake Parcel Feasibility Study

- **Section 15.0—Feasibility Study Introduction.** Describes RAOs for the proposed cleanup action and identifies applicable laws and regulations relevant to implementing a cleanup action at the LL Parcel.
- **Section 16.0—Cleanup Areas.** Describes the site-specific conditions that impact remedy application in areas of the LL Parcel, and divides the LL Parcel into cleanup areas based on those factors.
- **Section 17.0—Identification of Remedial Technologies.** Identifies and describes potentially applicable technologies for use to address the COCs at the LL Parcel.
- **Section 18.0—Technology Screening and Alternative Development.** Evaluates the technologies described in Section 17.0 based on the site-specific conditions and constraints. Retained technologies are then aggregated into LL Parcel cleanup alternatives.
- **Section 19.0—Alternatives Evaluation and Disproportionate Cost Analysis.** Evaluates the remedial alternatives proposed in Section 18.0

according to the MTCA requirements and evaluation criteria for a cleanup action. This evaluation is then summarized in a DCA.

- **Section 20.0—Recommendation of the Preferred Remedial Alternative.** Describes in greater detail the alternative recommended to WSDOE for selection as the preferred remedy for cleanup of the LL Parcel based on the results of the Alternatives Evaluation and DCA.
- **Section 21.0—References.** Provides a list of materials cited in the RI/FS.

Much of the supporting data and evaluations conducted to assist in development of the RI/FS are presented in appendices to this report. A complete list of appendices is presented in the Table of Contents. Data are also available electronically from WSDOE's Environmental Information Management system at the following address: http://www.ecy.wa.gov/eim/index.htm.

2.0 Site Description and Setting

2.1 DEFINITION OF THE LORA LAKE APARTMENTS SITE

The LL Apartments Site is located at 15001 Des Moines Memorial Drive in Burien, Washington (Figure 1.1), near the northwest corner of STIA. The Site, as defined by MTCA Chapter 173-340-200 WAC, consists of the Lora Lake Apartments property, and areas beyond the property boundary where contamination originating at the Lora Lake Apartments property may have come to be located. Prior to the RIs conducted in 2010, environmental investigations at the Site focused on the property referred to throughout this document as the LL Apartments Parcel. Investigations and historical research conducted as part of the RI, determined that concentrations of contaminants identified at the LL Apartments Parcel were also present in soil and sediment on the adjacent property, referred to throughout this document as the LL Parcel, and an area to the northeast of Lora Lake referred to throughout this document as the DMCA. Although the presence of these chemicals on the LL Parcel and DMCA properties is the result of contributions from multiple sources, rather than solely from historical operations conducted at the LL Apartments Parcel, a connection between the properties has not been disproved; therefore, these areas are included in the definition of the “Site” for the purposes of this RI/FS.

2.2 SITE DESCRIPTION

The Site straddles the boundary between the Cities of Burien and SeaTac, Washington (refer to Figure 2.1). The LL Apartments Parcel is located within the City of Burien, at 15001 Des Moines Memorial Drive. The LL Parcel is located immediately across Des Moines Memorial Drive to the east, and the DMCA is located to the northeast of the LL Parcel, both within the City of SeaTac.

2.2.1 Lora Lake Apartments Parcel

The LL Apartments Parcel occupies approximately 8.3 acres of currently vacant land that is bound to the north by SR 518, to the east and southeast by Des Moines Memorial Drive, to the west by 8th Avenue South, and to the south by an open area that was formerly the site of a grocery store, bowling alley, small office complex, and the Former Seattle City Light Sunnydale Substation (Figure 2.1), purchased by the Port in 2011. Land use to the west and north of the LL Apartments Parcel is primarily residential and light commercial. The area of the STIA located just southeast of Des Moines Memorial Drive is reserved for habitat mitigation associated with development of the STIA 3rd Runway. The LL Apartments Parcel vacant land is currently covered by asphalt parking areas, concrete building foundations, and landscaping areas remaining from the previous Lora Lake Apartments complex. The apartment complex was demolished by the Port in 2009 as discussed in Section 2.3.1.1 below. The LL Apartments Parcel ground surface gradually slopes to the southeast across the main portion of the property with steeper slopes located adjacent to Des Moines Memorial Drive and the SR 518 embankment. Existing LL Apartments Parcel topography was created during the construction of the apartment complex in 1987. To the southeast of the existing property boundary, the topography continues to gradually slope towards Lora Lake. Site topography is discussed in greater detail in Section 2.4 below.

2.2.2 Lora Lake Parcel

The LL Parcel is located to the southeast of the LL Apartments Parcel, across Des Moines Memorial Drive. The LL Parcel occupies approximately 7.1 acres of land that includes Lora Lake and a STIA-constructed habitat mitigation area. Prior to construction of the mitigation area, the property to the west and north of the lake was occupied by single family residences. The LL Parcel is bound to the north by the SR 518 highway interchange, to the east and south by Port-owned habitat mitigation area land and the northern boundary of STIA, and to the west and northwest by Des Moines Memorial Drive and the LL Apartments Parcel (Figure 2.1).

The LL Parcel is located within a secured fence associated with the STIA. The LL Parcel is included within a series of habitat mitigation areas developed by the Port in compliance with requirements of the Clean Water Act Section 404 Permit #1996-4-02325 issued by the U.S. Army Corps of Engineers (USACE), and associated with construction of the 3rd Runway (USACE 2002). The mitigation area is designated in the Natural Resource Management Plan (NRMP) as the Miller Creek/Lora Lake/Vacca Farm Wetland and Floodplain Mitigation Area (Parametrix 2001). The LL Parcel and surrounding land parcels are located within the Miller Creek Watershed. Headwaters of Miller Creek flow south (from north of STIA) along the west side of the airport, through a series of Port-owned habitat mitigation properties (including the LL Parcel) established during construction of the 3rd Runway, before turning west, crossing Highway 509, and eventually draining to Puget Sound. Figure 2.2 shows the location of Lora Lake in relation to Miller Creek and the Miller Creek Watershed.

The land located to the north of the LL Parcel, which comprises the SR 518 interchange, is owned and maintained by the Washington State Department of Transportation (WSDOT) as part of the highway interchange system, and the street right-of-way along the southeast side of Des Moines Memorial Drive is owned by the City of SeaTac.

2.2.3 1982 Dredged Material Containment Area

The DMCA is located immediately adjacent to the LL Parcel, to the northeast, on Port property. A City of Burien stormwater outfall system discharges into the northwest corner of Lora Lake. This system carries combined stormwater flow from the City of Burien and the City of SeaTac that is collected along Des Moines Memorial Drive. In 1982, in response to complaints from residents around the lake regarding excessive siltation caused by this stormwater discharge, the then-current owner of the system, King County, agreed to dredge approximately 4 feet of sediment from the lake bottom. King County arranged with the Port to place the dredge material in a specifically-constructed facility on Port-owned property to the northeast of Lora Lake.

The historical project plans for the dredging work indicate that a total of 16,000 cubic yards of material would be dredged, then placed and dewatered inside an approximately 120,000-square-foot area surrounded by a constructed soil berm. According to the project plans, after dewatering, the surface of the containment area was graded to drain to the southeast. No documentation of the actual berm construction dimensions or thickness of dredge material is available.

Currently, the DMCA appears to be approximately 2.75 acres, based on review of aerial photographs. Approximately 1.5 acres of vacant, vegetated land makes up the eastern side of the area. The remaining approximately 1.25 acres of land is the location of the 3rd Runway Approach lighting system[1] (ALS), which was constructed in 2006. This area has been regraded and covered with gravel (Figure 2.1.)

2.3 LAND USE AND OWNERSHIP

All three areas of investigation described in this document (LL Apartments Parcel, LL Parcel, and DMCA) are currently owned by the Port. The following sections describe the current use and ownership status of each area as well as the ownership history for the LL Apartments Parcel, LL Parcel, and the DMCA, respectively.

2.3.1 Lora Lake Apartments Parcel

2.3.1.1 Current Site Use and Ownership

At the time the Port acquired the property, the Lora Lake Apartments complex consisted of 22 occupied apartment buildings. All tenants of the apartment complex were relocated by the Port in 1999 to accommodate the planned construction of the STIA 3rd Runway. Runway construction was delayed by litigation, and in 2000, the Port and the King County Housing Authority (KCHA) entered into a Housing Cooperation Agreement, temporarily transferring ownership of the apartment complex to KCHA for use as low-income housing until 2005. The agreement was later amended to extend KCHA ownership until 2007. Disputes about the potential for long-term residential use of the property delayed final transfer of the property back to the Port until 2008.

In anticipation of runway-related demolition and construction, the Port conducted environmental investigations at the LL Apartments Parcel that discovered contaminated soil in 2007. The Port entered an RI/FS AO for the LL Apartments Site with WSDOE in July 2009. The apartment buildings were demolished between August and October 2009 as part of an AO Interim Action (IA). All aboveground structures were removed as part of the 2009 demolition activities. The LL Apartments Parcel is currently fenced and vacant.

2.3.1.2 Historical Property Ownership and Land Use

Stirling Consulting reviewed historical public records regarding the ownership and use of the LL Apartments Parcel; findings are presented in Appendix A.

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[1] An **approach lighting system**, or **ALS**, is a lighting system installed on the end of an airport runway where aircraft land. The ALS consists of a series of lightbars, strobe lights, or a combination of the two that extends outward from the runway end. ALS usually serves a runway that has an instrument approach procedure (IAP) and allows the pilot to visually identify the runway environment and align the aircraft with the runway upon arriving at a prescribed point on its approach.

There is little information regarding LL Apartments Parcel history prior to 1940, when the property served as an orchard, farm, and private residences. A 1936 aerial photograph shows multiple residential structures within the current property footprint and rows of trees and other vegetation. Precursor roadways to 8th Avenue South and Des Moines Memorial Drive were also present in 1936.

The LL Apartments Parcel was first converted to industrial use in the early to mid-1940s, when the Novak family purchased the property and established the Novak Barrel Cleaning Company. The 1946 aerial image shows an industrial building identified as a warehouse in the central portion of the property. King County real estate records show that a portion of this structure had a concrete floor, indicating that this portion may have been used for barrel-washing operations. The 1946 aerial also showed a small pond feature located east of the industrial building, potentially identified as a drum cleanout pond. Several smaller parcels, apparently used as residences, surrounded the Novak Barrel Cleaning Company (Figure 2.3 presents locations of known historical site uses and operations at and directly adjacent to the LL Apartments Parcel).

It is not clear how long the barrel-washing facility was in operation. As evidenced by Washington Pollution Control Commission (WPCC) inspection reports, it was in operation until at least 1947 and possibly in 1948 because the potential drum cleanout pond can still be seen in aerial photographs. In 1952, the Novaks sold the property to Benjamin and Grace Arnold who then converted the property into an auto-wrecking yard. The exact time that the parcel began auto-wrecking yard activities is unknown; however, by 1956 most of the southern half of the Site was devoted to the storage of hundreds of automobiles, and the Arnolds were using the presumed former barrel-washing facility building for auto-wrecking operations. The industrial building constructed by the Novak Barrel Cleaning Company remained on the property; however, the potential drum cleanout pond appears to have been filled in by 1980. The yard was unpaved and utilized primarily for end-of-life vehicle storage. The auto-wrecking facility did not occupy the entire LL Apartments Parcel, but expanded significantly since the beginning of operations, as shown in the aerial photographs in Appendix A. Residential homes are visible along the north boundary of the current property footprint in the 1980 aerial photograph. The same photograph shows paved areas to the east and south of the facility.

In 1982, Harold and Grace Malinak (who acquired title to the property as Grace Arnold) sold the property to the Mueller Development Company. The 1985 aerial photograph indicates that the auto-wrecking yard had ceased operations and vacated the property, leaving only the few remaining buildings and fences as markers of the past industrial operations. The residences shown in the 1980 aerial photograph to the north and surrounding Lora Lake are still present in the 1985 aerial, as is the industrial building originally constructed by the Novak Barrel Cleaning Company. The 1985 aerial photo is the last aerial photograph obtained prior to construction of the Lora Lake Apartments in 1987.

Apartment construction activities included regrading, paving, landscaping, and construction of multi-story residential buildings, recreational areas, and in-ground pools. The configuration of the completed apartment building development is shown in the 1992 and 2004 aerial photographs presented in Appendix A, and in Figure 2.4. The existing stormwater drainage system for the LL Apartments Parcel was also constructed in 1987 as part of the apartment building development. The City of Burien's main drainage line already existed in this area and drained to Lora Lake prior to the construction of the existing LL Apartments Parcel stormwater drainage system.

The Equitable Life Insurance Society of the US acquired the property in September 1988 and sold it to Santa Anita Realty Enterprises, Incorporated in July 1991. Pacific Gulf Properties acquired the property in November 1993, and sold the property to the Port in 1998.

2.3.2 Lora Lake Parcel

2.3.2.1 Current Site Use and Ownership

The Port acquired the LL Parcel in the late 1990s as part of planning for construction of the STIA 3rd Runway Project. The LL Parcel lies within the FAA RPZs, as shown in Figure 2.5, with the western portion of the LL Parcel located within the FAA RPZ-Controlled Activity Area, and the eastern portion within the FAA RPZ-Extended Object Free Area. The majority of the LL Parcel is currently located within security fencing, and is monitored and access-controlled by Port security as STIA property; therefore, the only access to the majority of the parcel, including the lake, is limited to Port employees. There is the potential for public access to the unsecured portion of the parcel located outside the Port fencing, such as the portion located between the fence and Des Moines Memorial Drive. Construction of the STIA 3rd Runway was completed in 2008. Consistent with agreements with WSDOE and the USACE, the Port constructed a habitat mitigation area, the "Miller Creek/Lora Lake/Vacca Farm Wetland and Floodplain Mitigation Area," which includes the LL Parcel and other properties located adjacent to the STIA to the north, east, and south of the LL Parcel. Operation and maintenance requirements for the habitat mitigation area are described in the NRMP (Parametrix 2001). Restrictive covenants and local zoning designations prohibit future development on the LL Parcel due to its location within and adjacent to the STIA RPZs and to assure permanent use of the property as a protected wetland aquatic habitat area.

2.3.2.2 Historical Property Ownership and Land Use

Stirling Consulting also reviewed historical public records regarding past ownership and use of the LL Parcel; findings are presented in Appendix B.

There is little readily available information regarding the LL Parcel history prior to 1936. A 1936 aerial photograph shows the parcel to be primarily composed of farm land, with what appears to be farm buildings along the northwestern boundary of the parcel, adjacent to Des Moines Memorial Drive. The existing Des Moines Memorial Drive roadway is present in the 1936 aerial image; however, SR 518 is not present. Lora Lake is not present in this photograph; the future location of the lake appears to be farm land, bordered by single family residences and landscaping to the north.

The LL Parcel was converted from a farming parcel to peat mining sometime between 1936 and 1946. Lora Lake was created by peat mining activities conducted by the Hi-Line

Leaf Mold Products Company (Appendix B). A 1946 aerial image shows the presence of a small water body, representing the initial formation of Lora Lake, near the northern portion of the parcel, and to the east of the current Des Moines Memorial Drive roadway (Tab A of Appendix B). The same residential and landscape structure from the 1936 aerial is present in the 1946 image; however, all but one of the farm buildings that were located along the roadway have been demolished. The evidence of mining activity is supported by the presence of heavy equipment and scarred landscape surrounding the small water body. In the 1948 aerial photograph, the footprint of the lake has more than doubled in size.

Historical records indicate that the Hi-Line Leaf Mold Products Company conducted peat mining activities at the LL Parcel through the mid-to-late 1950s. Review of publically-available land survey information shows that the north end of the lake was platted for future residential development in the mid-to-late 1950s. Additional land platting was conducted along the western end of the lake (adjacent to Des Moines Memorial Drive) in the early 1960s. Construction of single family homes continued in the northern and western areas of the LL Parcel through the early 1990s, as evidenced by the 1980, 1985, and 1992 aerial photographs (Tab A of Appendix B). Land to the south of the LL Parcel was used primarily as farm land throughout this time period.

2.3.3 Dredged Material Containment Area

2.3.3.1 Current Site Use and Ownership

The DMCA is located on Port-owned property originally purchased by the Port in 1978. This area is located within the FAA RPZ-Extended Object Free Area as shown in Figure 2.5, and is protective of airport operations. The DMCA is currently located within security fencing, and is monitored and access-controlled by Port security as STIA property. Access to the DMCA is limited to only Port employees. In 2006, the Port regraded the western portion of the DMCA to prepare for construction of the ALS for the STIA 3rd Runway. This area is currently covered with gravel and the runway approach lighting structure spans from north to south across the gravel area. The eastern portion of the DMCA is vegetated with grasses, shrubs, blackberries, and other low-growing vegetation. Project plans for the SR 518 stormwater pond construction and lighting strip obtained from the Port indicate that the eastern portion of the DMCA was re-graded in 2005; however, it is unknown if this work was conducted according to plan, as as-built documents were not available. Other remnants from construction and grading activities in the area, such as soil berms, are still present and visible at the DMCA. Silt fences that may have been associated with previous construction were removed by the Port in 2011.

2.3.3.2 Historical Property Ownership and Land Use

A review of historical public records regarding ownership and use of the DMCA was conducted by Stirling Consulting, and the results of this research are presented in Appendix C. The Port obtained the property in 1978 as part of STIA operations. Ownership prior to 1978 was not obtained during the public records review. Review of aerial photographs show this area was vegetated and vacant until around 1969, when portions of the area were cleared and utilized as part of the SR 518 construction. The

DMCA remained vacant after SR 518 construction until 1982, when King County used the area to contain approximately 16,000 cubic yards of sediment dredged from Lora Lake in response to citizen complaints (Appendix C). Aerial photographs of the Site show land-clearing activities in the 1990s to 2000s, but do not indicate any development of the DMCA until construction of the 3rd Runway ALS, which was completed prior to 2007, and is located on the western half of the DMCA. The eastern half of the DMCA remains vacant and vegetated.

2.3.4 Potential Future Site Use

The Port's current objective for the LL Apartments Parcel is to complete the AO obligations, conduct appropriate remediation of site contamination, and then redevelop the city block of which the LL Apartments Parcel is a part for airport-compatible commercial or light industrial use.

The FAA defines restrictions on allowable development and structures for runway and runway approach safety areas (USDOT FAA 1989). Figure 2.5 identifies where the FAA's Runway Protection & Approach Transition Zones for STIA overlay the LL Parcel, the DMCA, and the LL Apartments Parcel. The northeast portion of the LL Apartments Parcel is located within the FAA RPZ-Controlled Activity Area (Figure 2.5), which places restrictions on the type and size of development and structures allowed within the area. Future site development at the LL Apartments Parcel will comply with the FAA restrictions for these areas and will be coordinated with the FAA during the design phase of site redevelopment. These FAA restrictions are not expected to impact proposed remedial actions at the Site.

As previously mentioned, restrictive covenants and local zoning designations prohibit any future development on the LL Parcel, which will be maintained in perpetuity as a protected wetland aquatic habitat area.

Similarly, FAA restrictions prohibit any future development on the DMCA, which will be maintained as a FAA-defined RPZ-Extended Object Free Area as long as STIA is an operating airport (Figure 2.5). The Ports planned future use of the DMCA is for airport-compatible uses such as equipment storage and temporary construction laydown that comply with the FAA RPZ restrictions.

2.4 GEOLOGY AND HYDROGEOLOGY

2.4.1 Regional Geology

Substantial investigations of the regional geology in the area of the Site have been conducted by others, including a Port commissioned STIA Groundwater Study (Aspect Consulting and S.S. Papadopulos 2008), and were used in the development of the geology and hydrogeology summaries in the following sections.

The Puget Lowland is underlain at depth by volcanic and sedimentary bedrock, and is filled to the present-day land surface with both glacial and non-glacial sediments (non-glacial or inter-glacial sediments are those derived between periods of glaciation) deposited during the Quaternary Period (within the last 2 million years; Aspect Consulting 2010).

The Quaternary geologic history of the Puget Sound region is dominated by a succession of at least six dated and named periods of ice sheet glaciations. In the Puget Lowland, the most recent continental glacier was present as a lobe of ice that reached its maximum extent just south of Olympia during the Vashon stade (a short period of regional glacial advance) of the Fraser glaciation (a major period of region-wide glaciation). The Vashon stade locally occurred between about 13,000 and 15,000 years ago and consists of (from youngest to oldest): recessional lacustrine deposits (Qvrl), Vashon recessional outwash (Qvr), weathered Vashon glacial till (Qvtw), Vashon glacial till (Qvt), Vashon advance outwash (Qva), and transition beds (Qpf_f), which include Vashon glaciolacustrine silt and clay and pre-Fraser fine-grained non-glacial deposits.). These sediments are generally found near the surface in the vicinity of the Site, as illustrated on a surficial geologic map of the area (Booth and Waldron 2002; refer to Figures 2.6a and 2.6b). Underlying the Vashon glacial deposits are non-glacial deposits that are collectively referred to as "pre-Fraser."

During the Vashon stade, glacial ice was about 3,000 feet thick in the study area (Thorson 1980). Sediments that were overridden by the glacier are termed glacially overconsolidated. The weight of the ice compacted the underlying sediments to a very dense state. Sediments that were not glacially overridden and thus were not overconsolidated are termed normally consolidated. These sediments, such as recessional outwash and recent alluvium, are typically much less dense or hard.

During the glacial cycles, a tremendous amount of sediment was deposited in the lowland; however, during both the glacial and non-glacial cycles, some of the glacial sediment deposits were eroded and re-deposited elsewhere. As a result of these cycles of deposition, erosion, and re-deposition, there may be gaps in the stratigraphic sequences, and very young deposits may rest on much older deposits. For example, in the vicinity of the Site, there may be areas where the till was eroded during the deposition of the recessional outwash, and the transition beds were eroded during the deposition of the advance outwash.

Geologic processes following the Fraser glaciation are dominated by erosion of the uplands and deposition of recent alluvium and lacustrine deposits in the valleys and water bodies of the Puget Lowland. Extensive filling of former wetlands and grading for construction projects has further modified the land surface. Sediments that were deposited after the Vashon stade of the Fraser glaciation (during the Holocene Epoch) are usually termed "recent" to identify their stratigraphic position relative to the older deposits. These deposits include: modified land (m), which includes both fill and topsoil, recent alluvium (Qal), and recent lacustrine deposits.

2.4.2 Site Geology

The LL Apartments Parcel geologic data have been obtained and evaluated based on multiple environmental investigations, including the recent RI activities. Previous investigations by GeoScience Management and ENSR|AECOM installed a total of 27 soil borings in 2007 and early 2008 to characterize subsurface physical and environmental conditions within the LL Apartments Parcel (GeoScience Management 2008, ENSR|AECOM 2008a and 2008b). All borings were less than 30 feet deep, and 11 locations were completed as groundwater monitoring wells (MW-1 to MW-11). Five of these wells (MW-7 to MW-11) were located downgradient of the LL Apartments Parcel in the Des Moines Memorial Drive Right-of-Way. Recent RI activities included the installation of 38 additional soil borings, and the installation of 3 new shallow monitoring wells (MW-12 to MW-14) and 3 deeper zone monitoring wells (MW-15 to MW-17). The deeper zone monitoring wells were screened at the contact with the first confining unit beneath the Site, which was encountered about 40 to 60 feet below ground surface (bgs). Figure 2.7 presents the location of all soil borings and monitoring wells installed at the Site.

Based on the surficial geologic map of the area (Figure 2.6a), glacial recessional outwash deposits are present at the surface in areas where no fill is present. These recessional outwash deposits are part of a relatively large southwest-northeast trending channel feature. With the exception of the northern portion of the LL Apartments Parcel, the surface topography across the remainder of the LL Apartments Parcel reflects significant regrading that was performed during construction of the apartment complex. The majority of the current LL Apartments Parcel surface consists of asphalt paving, concrete paving, and a smaller amount of landscaped areas. Though the apartment buildings were demolished as part of an IA completed in summer 2009, building foundations and site paving remain intact. Surface topography for the Site is presented in Figure 2.8.

Data collected from soil borings and monitoring well installations indicate that the subsurface geology at the LL Apartments Parcel consists of a discontinuous fill layer that overlays glacial recessional outwash deposits. At the bottom of the recessional outwash deposits a silt unit about 10 feet thick was encountered in the eastern portion of the LL Apartments Parcel during the drilling of the deeper zone monitoring wells (MW-15 to MW-17). Based on the STIA Groundwater Study, this silt unit is likely indicative of a transition from recessional outwash deposits into glacial till deposits (Aspect Consulting and S.S. Papadopulos 2008). Figure 2.9 provides the locations of the RI borings and monitoring wells used in development of a hydrogeologic and two geologic cross sections. Figures 2.10, 2.11, and 2.12 respectively provide these cross sections that depict the geologic units encountered beneath the Site based on the recent RI, historical investigations, and the previous STIA Groundwater Study (Aspect Consulting and S.S. Papadopulos 2008).

The fill unit in the vicinity of the LL Apartments Parcel is observed to have a variable thickness of up to 15 feet, but is absent in the northern portion of the property, based on cross sections created as part of previous investigations and observations from explorations completed during the RI (ENSR|AECOM 2008a and 2008b). The fill is composed of medium dense to dense, fine to coarse grained sand with rounded gravel. The underlying native glacial recessional outwash deposits are variable in thickness, but can be as much as 45 feet thick in the vicinity of the LL Apartments Parcel (Figure 2.10). The recessional outwash deposits are characterized as dense to very dense, fine to coarse grained sand, with gravels up to 2 inches in diameter and occasional silt lenses. As previously discussed, there is a stiff to very stiff clayey silt unit found near the bottom of the recessional outwash deposits (about 10 feet thick), which is likely indicative of a transition into the glacial till deposits. The till deposits typically consist of very dense silty, gravelly sand. These glacial till deposits are observed in borings located to the southeast of the LL Apartments Parcel, as illustrated on Figure 2.10, and are estimated to be between 10 and 15 feet thick. The silt unit and the underlying till deposits together provide a confining unit (aquitard) beneath the eastern portion of the LL Apartments Parcel. Although there are no deeper explorations completed in the western portion of the Site, it is inferred based on the STIA Groundwater Study that the confining unit is also present beneath this portion of the Site (Aspect Consulting 2010).

To the southeast of the LL Apartments Parcel, the LL Parcel is also underlain by recessional outwash deposits, which are exposed at the surface. Beneath the recessional outwash deposits, it is inferred, based on the cross section, that the till deposits are also present and create a perched layer on which Lora Lake and the surrounding wetlands are formed (Figure 2.10).

2.4.3 Hydrogeology and Groundwater Flow

As part of the initial and supplemental groundwater investigations completed by AECOM in 2008, a network of 11 groundwater monitoring wells were installed and monitored within the LL Apartments Parcel boundary and east of Des Moines Memorial Drive. These wells were installed in the recessional outwash aquifer, at depths ranging from approximately 15 to 30 feet bgs (AECOM 2009b). As part of the 2010 to 2011 RI activities, three additional monitoring wells were installed in this same aquifer in the northeast corner of the LL Apartments Parcel, with another three monitoring wells installed near the bottom of the aquifer, at the contact with the first confining unit encountered beneath the Site. Groundwater at the LL Apartments Parcel was observed at depths ranging from approximately 5 to 22 feet bgs in wells within the native recessional outwash deposits and some site fill materials. Groundwater in downgradient off-property wells was observed at depths ranging from approximately 10 to 15 feet bgs.

Groundwater level measurements were collected from all of the monitoring wells located on the LL Apartments Parcel and the downgradient LL Parcel during three subsequent monitoring events (August 2010, January 2011, and April 2011) conducted as part of the RI. In addition, surface water elevations from Lora Lake and Miller Creek were also monitored during these monitoring events, as well as groundwater levels from a piezometer (HPA1-1) located between Lora Lake and Miller Creek on the LL Parcel (refer to Figure 2.7).

Figure 2.13 provides hydrographs summarizing the groundwater and surface water level measurements recorded during the 2010 to 2011 groundwater investigations. The hydrographs demonstrate that groundwater levels generally responded to an increase in precipitation, with lower groundwater levels observed in August and higher groundwater levels observed in January (with the difference ranging between 1 foot and 6 feet). Groundwater levels in all of the monitoring wells were significantly higher than surface water levels in Lora Lake and Miller Creek. These data suggest that the surface water bodies may be “gaining” water from groundwater discharge (refer to Section 2.5 for additional discussion). Groundwater elevation contour maps were generated for the seasonal low (August 2010) and seasonal high (January 2011) water level measurements from the RI monitoring events to determine groundwater flow directions within the recessional outwash aquifer in the vicinity of the Site. Figure 2.14 provides groundwater elevation contours and flow directions for seasonal low groundwater levels (August 2010) and Figure 2.15 provides groundwater elevation contours and flow directions for seasonal high groundwater levels (January 2011). Based on both groundwater elevation contour maps, groundwater flow in the vicinity of the Site is primarily to the southeast, towards Lora Lake, with slightly lower horizontal groundwater gradients (between 0.008 and 0.017) across the western portion of the Site, compared to the eastern portion of the Site (between 0.044 and 0.051).

Vertical groundwater gradients were calculated based on shallow/deep well pairs completed within the recessional outwash aquifer (MW-1/MW16, MW-4/MW-17 and MW-5/MW-15) and are presented in Table 2.1. As can be seen on Table 2.1, there is a slight downward vertical gradient at the MW-1/MW-16 well pair (between 0.02 and 0.05); a slight upward vertical gradient at the MW-4/MW-17 well pair (between 0.02 and 0.04); and a more significant upward vertical gradient at the MW-5/MW-15 well pair (between 0.13 and 0.16). As can be seen on the groundwater elevation contour maps, the vertical gradients change from a slight downward vertical gradient to a more significant upward vertical gradient as groundwater travels horizontally downgradient across the Site to the southeast (Figures 2.14 and 2.15). This is likely due to groundwater recharge from precipitation occurring at the higher, upgradient topographic elevations (northwest portion of the Site) and groundwater discharging to Lora Lake at the lower, downgradient topographic elevations (southeast portion of the Site).

2.5 HYDROLOGIC SETTING

The hydrologic conceptual model for the Site is based on the preliminary CSM presented in the RI/FS Work Plan (Floyd|Snider 2010a), and discussed further in Section 8.0. According to the conceptual model, precipitation that falls across the uplands of the Site can either infiltrate directly into the ground, flow as overland flow into stormwater catch basins, flow along drainages as surface water, evaporate, or be taken up and transpired by vegetation. Precipitation that infiltrates into the ground provides recharge to the uppermost regional aquifer. Groundwater within this aquifer flows downgradient across the Site, from areas of high to low groundwater elevations (heads), before interacting with nearby surface water features. If groundwater levels within the aquifer are higher than surface water levels, groundwater discharges into the surface water features, assuming no confining units (aquitards) are present between the aquifer and the respective surface water feature. In this case the respective surface water feature is “gaining.” In contrast, if groundwater levels in the aquifer are below the surface water levels, the respective surface water feature provides recharge to the groundwater aquifer, again assuming no confining units are present between the aquifer and the respective surface water feature. In this case the respective surface water feature is “losing.” The following sections provide a description of the hydrologic setting for the Site, including the regional groundwater aquifers and groundwater interaction with Lora Lake and Miller Creek.

2.5.1 Groundwater Aquifers

The uppermost aquifer in the vicinity of the Site is the recessional outwash aquifer. Based on the groundwater elevation contour maps presented in Figures 2.14 and 2.15, groundwater flow in the recessional outwash aquifer in the vicinity of the Site is to the southeast, towards Lora Lake. Due to the absence of any confining units within the recessional outwash deposits that prevent groundwater flow between the recessional outwash aquifer and Lora Lake (refer to Figure 2.10), and based on the calculated vertical groundwater gradients, the recessional outwash aquifer is likely in hydraulic continuity with Lora Lake. Lora Lake and the predecessor peat-dominated wetland formation likely formed on top of glacial till deposits that act as a confining unit (aquitard) beneath the recessional outwash aquifer in the eastern portion of the Site. This aquitard acts as a low permeability barrier to groundwater flow and limits downward flow into the deeper glacial advance outwash deposits and regional aquifers.

The drinking water supply for residences and business surrounding the Site is provided primarily by the Highline Water District's municipal drinking water system. The closest groundwater supply/extraction wells are located approximately 1 to 2 miles downgradient and cross-gradient to the Site. These wells are screened in the deeper regional aquifer units (more than 100 feet bgs) and are unlikely to have hydrologic connection to the near-surface shallow aquifer (recessional outwash aquifer) because of the presence of underlying aquitards, including till deposits and, potentially, the fine grained units of the transition beds.

2.5.2 Lora Lake and Miller Creek

As previously discussed, Lora Lake was created from peat mining activities prior to 1946 (Section 2.3.2). The lake is located in the Miller Creek watershed. Lora Lake receives stormwater runoff from the LL Apartments Parcel, City of Burien residential and commercial drainage areas upgradient of the LL Apartments Parcel, and surrounding roadways downgradient of the LL Apartments Parcel (e.g., Des Moines Memorial Drive, SR 518 interchange, City of SeaTac) through a single outfall located near the northwestern edge of the lake (refer to Figure 2.16) and via non-point source overland flow from the LL Parcel. The main outfall described above discharges into a sediment settling basin that is typically a swampy area approximately 50 feet by 50 feet. This settling basin is densely vegetated, and contains standing water. Another outfall, made of concrete, was observed about 3 feet to the west of the main outfall. The 18-inch concrete outfall was observed to be partially submerged in the sediment settling basin, with no water discharging on March 2, 2011, when observed during a rain event. On this same date, water was also observed entering Lora Lake from the nearby wetlands to the south, indicating surface water connectivity between the wetlands and lake. Field staff also observed water from a drainage channel flowing into Lora Lake in the southwest corner of the lake. This drainage channel heads west, then curves north near the base of the slope below Des Moines Memorial Drive. The channel is man-made, with water approximately 1 foot deep in some locations along the channel. The channel was constructed as part of the wetland mitigation area construction. The channel ends near the northwest corner of the lake in a small ponded area. The ponded area is located approximately 75 to 100 feet northwest of the outlet of the City of Burien storm drain outfall into the Lora Lake sediment settling basin.

An overflow discharge culvert and overflow berm is present at the southeast end of the lake. Seasonally, when Lora Lake surface water levels are elevated, lake water discharges to Miller Creek through the discharge culvert and by overtopping the overflow berm. When Miller Creek surface water elevations are elevated (i.e., during periods of heavy rainfall), Miller Creek surface water discharges to Lora Lake via the same culvert and overflow berm. Figure 2.13 provides the hydrographs for Lora Lake and Miller Creek based on the RI water level measurements. Figure 2.16 presents the features discussed above surrounding the lake and creek.

2.6 ECOLOGICAL SETTING

Currently, the majority of the LL Apartments Parcel is covered with paved parking areas and apartment building foundations. The parcel is vacant and is surrounded by a fence. There is no significant ecological habitat located on the LL Apartments Parcel. The only ecological areas currently present at this parcel exist along the parcel margins, are located on median strips and dividers in the parking lots, or are in areas where plants have colonized breaks in the pavement.

The LL Parcel is currently a constructed wetland aquatic habitat mitigation area, part of the Miller Creek/Lora Lake/Vacca Farm Wetland and Floodplain Mitigation Area, which is actively managed by the Port. The LL Parcel is densely vegetated and contains a mixture of grasses, forbs, emergent wetland plants, and a canopy of mixed deciduous trees. Surface water bodies associated with the LL Parcel consist of Lora Lake and Miller Creek (which runs past the southeast margin of Lora Lake). The Miller Creek/Lora Lake/Vacca Farm Wetland and Floodplain Mitigation Area was enhanced by the Port to support aquatic, amphibian, and wetland habitat as part of the mitigation requirements associated with development of the STIA 3rd Runway (Port of Seattle 2011b). The operation and maintenance requirements for the Miller Creek/Lora Lake/Vacca Farm Wetland and Floodplain Mitigation Area are described in the NRMP (Parametrix 2001). The mitigation plan requirements support specific ecological functions, but these are managed within the context of the Port's Wildlife Hazard Management Plan (WHMP; Port of Seattle 2005a), which is the controlling requirement for this special use area. The WHMP maintains careful control over birds, mammals, and plants within the area to minimize aircraft navigation dangers associated with bird strikes and wildlife in the runway area.

The eastern half of the DMCA is currently a vegetated area covered by a mixture of grasses and invasive and pioneering plant species, while the western half of the DMCA lies underneath the ALS for the STIA 3rd Runway, is covered in gravel, and is maintained by the Port to be free of vegetation. The DMCA is located outside of the Miller Creek/Lora Lake/Vacca Farm Wetland and Floodplain Mitigation Area, but remains subject to the WHMP as it is located within the FAA RPZ-Extended Object Free Area.

Part Two—Remedial Investigation

3.0 Site Characterization Activities and Interim Actions

This section describes the various environmental investigations performed on the LL Apartments Site.

Several investigations were conducted prior to the WSDOE-supervised RI work completed in 2010 to 2011. In 1986, Golder Associates (Golder) conducted an investigation on behalf of the then-current owner and site developer, the Mueller Group (Golder 1987). From 2007 to 2008, the Port conducted environmental investigations of the LL Apartments Parcel soil and groundwater (GeoScience Management 2008, ENSR/AECOM 2008a).

Since the AO was implemented in July 2009, additional RI data collection and analytical testing has been performed by Floyd|Snider on behalf of the Port for the LL Apartments Parcel, as well as the downgradient LL Parcel and DMCA. The results of the previous environmental investigations were used by the Port, in consultation with WSDOE, to determine additional activities required to define the nature and extent of contamination at the Site. The following sections summarize the scope and methods of all environmental investigations conducted to date. Table 3.1 provides a list of all investigations conducted. Findings from the historical investigations, as well as the recent RI activities, are presented and discussed in Section 4.0.

3.1 SUMMARY OF PREVIOUS ENVIRONMENTAL INVESTIGATIONS

This section provides a summary of the environmental investigations completed at the LL Apartments Parcel prior to the RI activities conducted in 2010 by the Port. This includes the cleanup action completed by Golder in 1987, the subsequent 2007 GeoScience Management investigation, and the AECOM 2008 investigations. Further detail on the analytical results for the GeoScience Management and AECOM investigations are provided in Section 4.0. Data tables from these previous investigations are provided in Appendix D.

3.1.1 1987 Golder Associates Site Investigation and Cleanup

In 1986 Golder conducted a geotechnical investigation at the Site, consisting of 30 test pits, on behalf of the Mueller Group. The intent of the investigation was to determine soil conditions at the LL Apartments Parcel prior to developing a multi-building apartment complex. During the test pit investigation, a waste pit containing visibly-contaminated soil was discovered. Metals, volatile organic compounds (VOCs), and semivolatile organic compounds (SVOCs) were detected in a composite sample of contaminated soil collected from the sidewall of a test pit excavation located near the suspected source area.

In March and April 1987, Golder subcontracted Chemical Waste Management to perform a targeted excavation of impacted soil. During the excavation, an area of soil contamination not previously identified and a concrete sump-like structure containing visibly-contaminated soil were discovered. In addition to the impacted soil, the sump and the sludge it contained were removed from the Site. Analytical samples were collected from the excavation sidewalls and floor and generally indicated that limited concentrations of contaminants, including lead, zinc, and VOCs, remained in the area. The approximate location of the Golder excavation area is shown in Figure 3.1. The confirmation samples collected from the excavation sidewalls and base and the initial test pit sidewall composite sample were the only soil samples collected by Golder at the Site. Since the location and source of the collected samples were not well documented by Golder, the location of these samples cannot be reproduced with precision. The approximate final excavation extent is shown in Figure 3.1.

The Mueller Group submitted Golder's 1987 *Investigation and Clean-Up Report* to WSDOE summarizing the cleanup action (Golder 1987). An "Opinion" letter was then issued by WSDOE to the Mueller Group in December 1987 stating that no additional cleanup actions were required. The WSDOE letter stated that the Golder cleanup had been performed "…in a professional manner using environmentally sound criteria which will protect the Public. At this time, no additional investigation is required." (WSDOE 1987). This work was previously summarized in the AECOM Summary Report (AECOM 2009b).

While useful for historical reference, the Golder data are not included in the site dataset (i.e., not used to evaluate nature and extent of contamination), due to the lack of precise sample location and the age and quality of the data, which was collected more than 20 years ago.

3.1.2 2007 GeoScience Management Investigation

In 2007, GeoScience Management conducted a soil and groundwater investigation on behalf of the Port. This investigation was focused in the vicinity of the former historical site operations to further evaluate the area previously remediated by Golder in 1987. The Port initiated this activity in support of anticipated future site redevelopment. GeoScience Management issued the results of the investigation to the Port in a letter report dated April 2008 (GeoScience Management 2008). As part of the GeoScience Management investigation, nine temporary soil borings (LLP-1 through LLP-9) were advanced within the study area, and a permanent groundwater well (MW-1) was installed northeast of the apartment complex Recreation Building, a location thought to be very near the location of the drum cleanout pond, which was the suspected source area. The location of the soil borings and groundwater well are shown in Figure 3.1 along with outlines of the historical site operations areas.

GeoScience Management collected eight subsurface soil and seven groundwater samples from these soil borings. Samples were selectively analyzed for benzene, toluene, ethylbenzene, xylenes (BTEX), TPH (diesel range, heavy oil range, and gasoline range), VOCs, SVOCs, polychlorinated biphenyls (PCBs), and metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver). Two soil samples and one groundwater sample were collected from the permanent well, MW-1, and selectively analyzed for VOCs, SVOCs, and dioxins/furans. GeoScience Management reported a screening level comparison of these analytical results against the most stringent MTCA cleanup levels, Method A or Method B.

Generally, screening level exceedances were observed within the former barrel-washing area (LLP-4, MW-1) shown on Figure 3.1. The analytes that exceeded the GeoScience Management screening levels in soil and/or groundwater were TPH, VOCs (xylenes), PCP, cPAHs, and dioxins/furans. Arsenic, barium, chromium, and lead were detected at concentrations less than the GeoScience Management screening levels. No other metals or PCBs were detected.

The GeoScience Management groundwater data are considered qualitative because the samples were collected from a Geoprobe and are not representative of low turbidity groundwater conditions. While useful for historical reference, the data are deemed unreliable for evaluating the nature and extent of contamination and are not included in the site dataset.

3.1.3 2008 AECOM Investigations

3.1.3.1 AECOM Soil, Groundwater, and Sub-slab Air Investigation, March/April 2008

AECOM completed a site-wide sampling and investigation program in 2008 on behalf of the Port to further delineate soil, groundwater, and soil vapor contamination at the LL Apartments Parcel. This investigation is summarized in the Soil, Groundwater, and Sub-slab Air Investigation Report, issued June 2008 to the Port (ENSR|AECOM 2008a). Investigation activities completed in 2008 are described below.

In this investigation, a total of 44 shallow and subsurface soil samples were collected from 13 locations across the LL Apartments Parcel (Locations LL-01, LL-07 through LL-12, and MW-2 through MW-6). In five of these locations, groundwater wells were installed to investigate shallow groundwater (MW-2 through MW-6). Soil samples were collected for chemical testing from soil borings, and groundwater monitoring well locations. All soil and groundwater sampling locations associated with this investigation are shown in Figure 3.1. Soil samples were analyzed for total metals (antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc), VOCs, SVOCs, PCBs, TPH, and dioxins/furans. Groundwater samples were analyzed for dissolved metals, VOCs, SVOCs, TPH, and dioxins/furans. Physical parameters, such as total suspended solids (TSS), total organic carbon (TOC), turbidity, and pH, were not analyzed as part of this event. AECOM compared the results of the investigation to the most stringent MTCA cleanup levels, Method A or Method B (ENSR|AECOM 2008a).

In general, soil and groundwater contamination was observed most commonly in the suspected source area northwest of the apartment complex Recreation Building in the area of the former drum cleanout pond (Figure 3.1). Contaminants detected in groundwater at concentrations greater than the investigation screening levels were primarily in the sample collected from MW-1, and included arsenic, PCE, TCE, PCP, cPAHs, and dioxins/furans. Elevated concentrations of TPH were also observed in the northeast corner of the Site, in Well MW-6. Dioxin/furan contamination in shallow soil samples was also observed across the Site, with the highest concentrations in the area of the former barrel-washing facility. The analytes identified in the AECOM investigation report as exceeding screening levels are arsenic, lead, TPH, VOCs (TCE and PCE), PCP, cPAHs, and dioxins/furans. Contamination exceeding the investigation screening levels did not include PCBs.

AECOM sampled and analyzed soil vapor beneath eight apartment complex buildings (Samples SV-D, SV-F, SV-H, SV-N, SV-R, SV-RB, SV-T, SV-Q), including the Recreation Building. Soil vapor sample locations and former building locations are shown in Figure 3.1. A vapor sampling probe composed of stainless-steel tubing was installed through the slab of each of the 8 buildings, extending about 1.5 inches into the sub-slab material. Approximately 1 inch of tubing fitted with a plug remained above the slab for sample collection. Samples were analyzed for VOCs. AECOM evaluated the sample data and determined that the concentrations of VOCs in soil gas at the LL Apartments Parcel were not at levels expected to affect the indoor air quality at the Site (ENSR|AECOM 2008a).

3.1.3.2 AECOM Supplemental Groundwater Investigation, August 2008

In August and October 2008, AECOM completed a supplemental groundwater investigation to further characterize site groundwater and evaluate potential migration of contamination in groundwater downgradient (to the southeast), and outside the LL Apartments Parcel property boundary (ENSR|AECOM 2008b). In this investigation, four additional monitoring wells (MW-7 through MW-11) were installed to the east and southeast of the LL Apartments Parcel, on the properties directly east of Des Moines Memorial Drive (refer to Figure 3.1). Groundwater samples were collected from the four newly-installed wells and three existing wells (MW-3, MW-4, and MW-5) located on the LL Apartments Parcel and analyzed for dissolved metals, TPH, SVOCs, and PCP.

AECOM's supplemental groundwater investigation did not identify concentrations of site chemicals in groundwater that would indicate a plume of contaminated groundwater migrating off of the LL Apartments Parcel. Similar to previous investigations, groundwater contamination was, for the most part, limited to the area of historical operations around MW-1 and LLP-4. Concentrations of dioxins/furans did exceed the AECOM screening level in one downgradient well (MW-10); however, laboratory method blank contamination was observed in this sample and the laboratory qualified the results. The laboratory indicated that this sample result may not be accurate due to method blank contamination.

3.1.3.3 AECOM Groundwater Sampling Event, December 2008

A third groundwater sampling event was completed by AECOM in December 2008. During this event, two on-property wells (MW-2 and MW-6) and two off-property wells (MW-7 and MW-10) were sampled. The groundwater was analyzed selectively for dissolved metals, TPH, PCP, and dioxins/furans. During this investigation, TPH in Well MW-6 was the only contaminant detected at concentrations greater than AECOM's screening levels. The elevated TPH result at MW-6 was associated with a sample collected without stabilization of groundwater quality parameters prior to sampling. The results of this groundwater sampling event are summarized in the AECOM Summary Report (AECOM 2009b).

3.1.3.4 AECOM Summary Report—2008 Investigations and Data Gap Evaluation, September 2009

In September 2009, AECOM submitted a document summarizing the available information on historical land use, remedial actions, and AECOM investigations conducted at the LL Apartments Parcel in 2008 (AECOM 2009b). This report briefly summarized previous investigations by Golder and GeoScience Management between 1986 and 2007, and presented a detailed discussion of the AECOM site investigations beginning in March 2008. AECOM presented a preliminary CSM that considered the nature and extent of site contamination, environmental fate and transport, potential exposure pathways, and potential receptors, based on the available data at the LL Apartments Parcel. Finally, the summary report identified data gaps at the LL Apartments Parcel and suggested potential future investigations to address these data gaps. The data gaps identified by the AECOM Summary Report included the extent of subsurface soil impacts in the suspected source area, the extent of TPH impacts in the vicinity of MW-6, the extent of site-wide shallow soil dioxin/furan contamination, the current groundwater quality, and groundwater hydraulic properties.

3.1.4 Former Seattle City Light Sunnydale Substation

In 2001, Herrera Environmental Consultants completed a Phase I Environmental Site Assessment (ESA) of the Former Seattle City Light Sunnydale Substation property immediately south of the LL Apartments Parcel (Herrera 2001). A Phase II ESA was then completed by Pinnacle GeoSciences in 2009. The Port purchased this property from Seattle City Light in 2011. The property formerly contained a 4-kilovolt electrical substation. In 2003, based on Phase I ESA results, Seattle City Light completed an excavation to remove residual contaminated soil. Soil was excavated to a depth of about 4 feet at the southeastern corner of the former concrete slab (refer to Figure 2.3 for approximate location). The 2009 Phase II ESA evaluated Recognized Environmental Conditions identified during the Phase I ESA, including both contamination originating on the property and potential contamination originating from past LL Apartments Parcel operations. Phase II ESA sampling results were presented in a Summary Report of Phase II Studies dated August 24, 2009 (Pinnacle GeoSciences 2009).

The Phase II ESA consisted of 11 direct-push Geoprobe borings and groundwater grab samples in 3 of those borings. Three borings, DP-1 through DP-3, were advanced adjacent to the southern property fence of the LL Apartments Parcel and groundwater grab samples were collected from DP-2 and DP-3. The additional 6 borings were advanced in the area surrounding the former substation, between approximately 15 and 45 feet from the southwest property fence of the LL Apartments Parcel. Soil samples collected from the 11 locations and groundwater samples collected from the 3 Geoprobe locations were analyzed for TPH, PCBs, SVOCs, chlorinated herbicides and pesticides, metals, and dioxins/furans. Analytical results for 1 sample collected 1.5 feet bgs from Boring DP-3 resulted in a dioxin/furan toxicity equivalent (TEQ) greater than the selected project screening level of 11 pg/g (MTCA Method B, now updated to 13 pg/g). Boring DP-3 is located in the northeast corner of the Former Seattle City Light Sunnydale Substation property, adjacent to the AECOM Boring LL-08. Refer to Section 4.2.1.4 for additional details. No other soil or groundwater impacts associated with the LL Apartments Parcel were identified.

Data from the investigations conducted at the Former Seattle City Light Sunnydale Substation are discussed in this document only to assist in defining the nature and extent of contamination along the property line between the substation and the LL Apartments Parcel.

3.2 SUMMARY OF LORA LAKE APARTMENTS SITE INTERIM ACTIONS

The Port, in negotiation with WSDOE, agreed to two IAs under the existing AO prior to planning or executing additional RIs at the Site. Both IAs were carried out pursuant to WAC 173-340-430(1)(a). The IAs are described below:

- All remaining structures associated with the Lora Lake Apartments complex were demolished, and measures were implemented to prevent contaminant migration (i.e., surface covering).
- A stormwater system investigation was conducted to evaluate the chemical quality of stormwater, stormwater solids, and catch basin sediments in the existing on-property stormwater conveyance system that discharges to Lora Lake.

The following sections describe the IAs completed by the Port in 2009 and 2010.

3.2.1 Lora Lake Apartment Building Complex Interim Action

The apartment building demolition IA conducted in 2009 demolished 16 unoccupied apartment buildings that were vacated in 2008. The IA also removed all associated aboveground structures, such as parking canopies. Six additional apartment buildings were previously demolished as part of a construction effort in 2007 to comply with FAA flight path requirements for the STIA 3rd Runway expansion. The locations of the now demolished buildings are shown on Figure 2.5. No aboveground structures remain at the LL Apartments Parcel.

Following completion of aboveground building demolition activities, remaining intact foundation structures were secured with construction fencing. In-ground swimming pools were filled with gravel, and a small amount of soil was excavated in order to access and cut utility lines. In addition, all areas of exposed soil in landscape areas were covered with plastic and secured in place with sandbags. The existing stormwater system at the Site remains active, and drains all impervious surfaces, including parking areas and driveways; however, the building foundation drains were permanently plugged prior to building demolition. The LL Apartments Parcel is currently surrounded by a secure chain-link fence, which remains locked at all times.

The protective measures that were implemented during the IA for worker safety and control of contaminant migration are described below:

- **Soil Protective Measures.** During demolition activities storm drain catch basins were blocked and the water was captured and disposed of off-site, a silt fence was installed around construction areas, disturbed soil areas were covered to prevent erosion, and dust suppression activities were conducted.

- **Air Monitoring**. Both downwind and ambient air monitoring was conducted during demolition to evaluate the effectiveness of dust suppression measures.
- **Contaminated Soil Isolation and Worker Safety.** A barrier over unpaved areas was installed to prevent direct contact exposures, vehicular site access was restricted to paved surfaces only, and visual inspection of all vehicles entering and exiting the Site was conducted to prevent debris and/or soil transport off the property.

These protective measures are described in more detail in the Draft Interim Action Completion Report (AECOM 2009c).

3.2.2 Stormwater Investigation Interim Action

In response to concerns expressed by the Public in 2009, WSDOE requested that the Port conduct a Stormwater Interim Action (SWIA) pursuant to WAC 173-340-430(1)(a). As part of the SWIA, samples were collected and chemically analyzed to compare chemical concentrations in stormwater entering the LL Apartments Parcel to concentrations in stormwater leaving the LL Apartments Parcel. This comparison was conducted to evaluate the potential for contamination at the LL Apartments Parcel to be negatively impacting stormwater quality. The stormwater drainage system was also cleaned and inspected in order to determine the potential for contaminated groundwater and/or soil to seep into the LL Apartments Parcel stormwater drainage system through cracks or leaks in the system.

The results of the SWIA are summarized in the Stormwater Interim Action Data Report included as Appendix E. The SWIA consisted of stormwater whole water sampling, catch basin sediment sampling, system cleaning and inspection, and stormwater in-line solids sampling. Each of these activities is summarized in the following sections.

3.2.2.1 Stormwater Investigation

Storm flow monitoring and stormwater sample collection activities were completed at three locations to characterize stormwater quality of the inlet and outlet flows at the LL Apartments Parcel (Figure 3.2). Samples were collected from the Main Line Inlet Catch Basin, Main Line Outlet Catch Basin, and the Secondary Line Outlet Catch Basin. The Secondary Line Outlet Catch Basin collects stormwater from only within the LL Apartments Parcel, and connects to the main line system at Des Moines Memorial Drive. The Main Line system enters the Site on the west carrying flow from a large area of residential Burien. Figure 3.3 shows the approximate drainage area contributing flow to the Main Line system before it enters the LL Apartments Site.

Stormwater conditions were monitored at the LL Apartments Parcel during 10 distinct storm events (STEs) throughout the wet weather period between December 2009 and April 2010. Monitoring activities were completed over a range of representative storm sizes, rainfall intensities, and groundwater/soil water conditions (such as variation in groundwater elevation and soil saturation levels) at the LL Apartments Parcel. In addition, some STE sampling was conducted prior to system cleaning and inspection, and the remainder was conducted following system cleaning to evaluate the potential for contaminated catch basin sediments to be impacting stormwater quality. Groundwater table fluctuations were also measured during the monitored storms to characterize the potential subsurface contaminant transport through inflow and/or infiltration into the stormwater drainage system.

Two methods, grab sampling and flow-proportionate composite sampling, were used to collect stormwater samples from each of the three sampling locations shown in Figure 3.2. All stormwater samples were analyzed for the preliminary contaminants of concern (PCOCs) listed below in the SWIA Analytical Testing Program (Section 3.2.2.5). The results of the stormwater sampling events were statistically evaluated to determine what impact, if any, the LL Apartments Parcel has on the chemical quality of stormwater that leaves the Site. The results of the statistical evaluation determined that there was no statistical difference between the quality of stormwater entering the LL Apartments Parcel and the stormwater exiting the property.

3.2.2.2 Catch Basin Sediment Investigation

Catch basin sediment samples were collected at five locations to characterize PCOCs within the drainage systems beneath the LL Apartments Parcel in December 2009 and January 2010. Samples were collected at the Main Line Inlet Catch Basin, Main Line Outlet Catch Basin, two Main Line Interior Catch Basins, and the Secondary Line Outlet Catch Basin. Catch basin sediment sample locations are shown in Figure 3.2. Specific rationale for these locations is presented in the SWIA Data Report; however, in general, the locations were chosen to provide access to solids that may be introduced or influenced by on-property contaminant sources.

3.2.2.3 Stormwater Drainage System Cleaning and Inspection

3.2.2.3.1 Stormwater Drainage System Cleaning

Between January 4, 2010 and February 11, 2010, accumulated sediments were removed from the stormwater catch basins and storm drain conveyance pipes throughout the LL Apartments Parcel using vactor methods (high velocity vacuum truck). All segments of the drainage system were accessible and cleaned during this event.

3.2.2.3.2 Stormwater Drainage System Inspection

A system-wide TV in-line inspection was conducted on the LL Apartments Parcel storm drainage system between January 20, 2010 and February 8, 2010 to determine the integrity and physical condition of the storm drainage system piping and identify corrosion, cracks, or holes in the pipes that may allow for contaminant migration to or from the stormwater system. The inspection was conducted on 35 of the 36 storm drainage system pipe segments within the LL Apartments Parcel (Appendix E). The inspection was video-recorded and includes narration by the operator, who described distance markings and real-time visual observations. The inspection recordings were reviewed by the Port to verify operator observations and to further evaluate pipe conditions. The visual observations documented by the operator and by the Port included the condition of pipe joints, presence of pipe deposits, and interior pipe wall conditions.

3.2.2.4 Stormwater In-line Solids Investigation

In-line sediment traps, designed to collect stormwater solid samples, were installed at four catch basin locations at the LL Apartments Parcel to assess the chemical quality of solids introduced from or influenced by on-property sources, and potentially transported from the LL Apartments Parcel. Samples were collected from in-line sediment traps at the Main Line Inlet Catch Basin, Main Line Outlet Catch Basin, a Main Line Interior Catch Basin, and the Secondary Line Outlet Catch Basin. The collection locations of the in-line solids samples were selected to coincide with the storm flow monitoring, stormwater sampling, and catch basin sediment sampling locations to the maximum extent possible. The traps were installed after the stormwater drainage system cleanout activities were completed, and inspected after the tenth stormwater monitoring event in April 2010. It was determined that the sediment traps had not accumulated a sufficient volume of sediment and that the traps were left in place until December 2010 when the stormwater solids samples were collected for analyses. Stormwater in-line solids were analyzed for the site PCOCs listed below, where sufficient sediment sample volume was available.

3.2.2.5 SWIA Analytical Testing Program

Stormwater samples collected during the 10 monitoring events were analyzed for the following parameters, as specified in the SWIA Work Plan (Floyd|Snider and Taylor Associates 2009):

- TSS
- Arsenic (total and dissolved)
- TPH (diesel range and oil range)
- Polycyclic aromatic hydrocarbons (PAHs)
- PCP
- PCE, TCE, cis-1,2-dichloroethene and trans-1,2-dichloroethene (1,2-DCE isomers), and 1,2-DCA
- Dioxins/furans

In addition, the pH of all stormwater composite samples was measured at the Port's Stormwater Laboratory prior to delivery of samples to the analytical laboratory.

Stormwater in-line solids samples and catch basin sediment samples were analyzed for the following parameters, as specified in the SWIA Work Plan:

- Total solids
- TOC
- Arsenic and lead

- TPH (diesel and oil range)
- PAHs
- PCP
- Dioxins/furans

In addition to the parameters listed above, the catch basin sediment samples were also analyzed for VOCs including PCE, TCE, 1,2-DCE isomers, and 1,2-DCA.

3.3 2010 TO 2011 REMEDIAL INVESTIGATION ACTIVITIES

From 2010 to 2011, additional RI activities were conducted by the Port, in accordance with the site AO, to provide additional information on the nature and extent of contamination at the Site, and to close existing data gaps identified by previous investigation activities. The RI activities investigated soil and groundwater contamination at the LL Apartments Parcel, but also extended to the east and evaluated sediment quality in Lora Lake, and soil and groundwater quality in the DMCA. The following sections describe the RI activities conducted by the Port from 2010 to 2011.

3.3.1 Preliminary Contaminants of Concern and Analytical Testing Program

Previous investigations at the LL Apartments Parcel analyzed a number of soil and groundwater samples for a range of contaminants including VOCs, BTEX, SVOCs, PAHs, PCBs, dioxins/furans, TPH, and metals. These investigations identified several contaminants in soil and/or groundwater at concentrations greater than the most stringent MTCA Method A or B cleanup levels, which were selected at the time of these investigations as screening levels. As documented in the WSDOE-approved LL Apartments Parcel RI/FS Work Plan (Floyd|Snider 2010a), these contaminants were carried forward as PCOCs for the LL Apartments Parcel RI. PCOCs at the LL Parcel and the DMCA were determined to be effectively the same as the PCOCs for the LL Apartments Parcel, since investigation in these areas was conducted to investigate the potential for contaminants on the LL Apartments Parcel to have migrated to the LL Parcel, or the DMCA. Analytical methods for these PCOCs were selected to generate the lowest technically reliable practical quantitation limits (PQLs), thereby minimizing the possibility that the PQLs would be greater than the future cleanup levels. The PCOCs listed by media are presented below, and are consistent for all investigation areas.

An overview of dioxin/furan analytical methods and associated analysis limits (e.g., reporting limits, detection limits, etc.) is provided as an insert into the laboratory data reports associated with the RIs (Appendices F, G, and H).

3.3.1.1 Soil PCOCs

As discussed above, several contaminants were previously detected in soil at the LL Apartments Parcel that exceeded previous investigation screening levels. Based on these findings, the following constituents were analyzed in soil samples collected during RI activities:

- Dioxins/furans
- cPAHs
- Arsenic
- Lead
- Diesel range and heavy oil range TPH
- Gasoline range TPH
- PCP
- VOCs (PCE, TCE, and 1,2-DCA)
- BTEX (discussed below)
- cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-dichloroethene (trans-1,2-DCE; discussed below)
- TOC (discussed below)

The soil collected as part of the LL Apartments Parcel, the LL Parcel, and the DMCA RI efforts was analyzed for TOC to assist with any potential site-specific groundwater and transport pathway modeling. The soil collected as part of the RI efforts was analyzed for BTEX to determine the appropriate gasoline range TPH cleanup level. Additional analyses were also conducted for the PCE and TCE breakdown products cis-1,2-DCE and trans-1,2-DCE to provide complete characterization of the chlorinated ethene compounds.

3.3.1.2 Groundwater

Several contaminants were previously identified in groundwater at the LL Apartments Parcel that exceeded previous investigation screening levels. Based on these findings, the following constituents were analyzed as part of additional RI characterization in groundwater:

- Dioxins/furans
- cPAHs
- Arsenic
- Diesel range and heavy oil range TPH
- Gasoline range TPH
- PCP

- VOCs (PCE, TCE, and 1,2-DCA)
- Lead (discussed below)
- BTEX (discussed below)
- cis-1,2-DCE, trans-1,2-DCE (discussed below)
- TSS
- pH

In addition to contaminants observed at concentrations greater than screening levels in historical groundwater samples, groundwater samples collected as part of the LL Apartments Parcel, the LL Parcel, and the DMCA RI efforts were also analyzed for lead, because of the detections of lead observed in soil and the retention of lead as a soil PCOC. To assist in evaluating the groundwater analytical data, groundwater was also analyzed for physical parameters, including TSS and pH.

As in the soil analytical testing program, groundwater collected as part of the RI efforts was analyzed for BTEX to determine the appropriate gasoline range TPH cleanup level. Additional analyses were conducted for the PCE and TCE breakdown products cis-1,2-DCE and trans-1,2-DCE to provide complete characterization of the chlorinated ethene compounds.

3.3.1.3 Sediment

The LL Parcel sediment PCOCs are effectively the same as the LL Apartments Parcel PCOCs; however, the analytical testing program for sediment varied slightly from this PCOC list due to sampling methodology, and is discussed further below. The constituents analyzed for RI characterization in sediment included the following:

- Dioxins/furans
- cPAHs
- Arsenic
- PCP
- VOCs (PCE, TCE, and 1,2-DCA; cis-1,2-DCE, and trans-1,2-DCE in surface sediments only)
- TOC (discussed below)
- Total solids, grain size (discussed below)
- Ammonia and sulfide (discussed below)

Analyses of conventional parameters (in addition to TOC) were also performed on the sediment samples, including total solids, grain size, ammonia, and sulfide. The total solids and grain size analyses were used to provide additional information on the physical properties of the sediments. The results from analysis of ammonia and total sulfides were used to provide information on the biological testing sediment conditions.

The sediment analytical testing program generally matched the soil and groundwater analytical testing program with the addition of the sediment-specific conventional parameters listed above, and the elimination of petroleum hydrocarbons (diesel range, heavy oil range, and gasoline range) and BTEX. Consistent with typical sediment analytical programs, PAHs were used as indicator chemicals for the petroleum hydrocarbon compounds, due to the highly volatile nature of gasoline petroleum and BTEX compounds, as well as their ability to readily undergo biodegradation in surface sediments.

Freeze coring was used to collect the subsurface sediment samples within Lora Lake primarily because of the difficulty in sampling the loose, unconsolidated, peaty sediment present in the lake. Because the freeze-coring sampling method potentially releases VOCs during freezing and thawing, the subsurface sediment samples were not analyzed for VOCs, including BTEX. Additionally, grain size was not performed on the subsurface sediment samples, because the freezing and thawing of the sediment cores can potentially alter the grain size distribution and the water content of the samples. Freeze coring can also potentially alter the water content of the samples, thereby impacting the total solids analyses; however, the total solids analyses of all sediment samples were performed in order to determine the dry weight contaminant concentrations. Therefore, the results of the total solids analyses are presented in the LL Parcel data tables, but are approximate for the subsurface sediment samples collected with the freeze-coring methodology. Surface sediment grab samples, collected by divers using a hand corer, were co-located with the subsurface sediment samples, and were analyzed for the chlorinated VOCs listed above, grain size, and total solids.

3.3.2 Lora Lake Apartments Parcel Investigation

In accordance with the WSDOE-approved Lora Lake Apartments RI/FS Work Plan (Floyd|Snider 2010a), the Port performed a soil investigation at the property to further characterize the horizontal and vertical extent of contamination, as identified in the previous investigations. The LL Apartments Parcel phase of the 2010 to 2011 RI sampling efforts included a Shallow Soil Dioxin/Furan Investigation, a Central and Eastern Source Area Soil Investigation, a Northeast Corner Petroleum Soil Investigation, a Deep Groundwater Investigation, and a Site-wide Groundwater Quality Investigation.

This sampling program collected and analyzed soil from 46 soil borings and installed groundwater monitoring wells at 6 of those boring locations. RI soil sampling locations are shown on Figure 3.4. Investigation activities are described in the following sections according to their location within the Site, and purpose for completion. Investigation activities are discussed in further detail in the LL Apartments Parcel Data Report (Appendix F).

3.3.2.1 Shallow Soil Dioxin/Furan Investigation

In order to further define the lateral and vertical extents of potential dioxin/furan contamination, a total of 8 Geoprobes (PSB-1 through PSB-8) and 10 hand auger borings (SSB-1 through SSB-10) were initially advanced in locations spatially distributed throughout the LL Apartments Parcel and off-property along its perimeter (Figure 3.4).

Consistent with the Lora Lake Apartments RI/FS Work Plan, soil samples were analyzed in a tiered approach, with the two most shallow depth intervals analyzed immediately and deeper samples held in archive. Based on preliminary analytical results, archived samples were selected to further define the vertical extents of dioxins/furans in areas unbounded by the initial samples. In addition to the initial 10 hand auger boring locations, 3 hand auger locations (LLA-HA1 through LLA-HA3) were advanced in accordance with the Additional Shallow Dioxin Soil Sampling Technical Memorandum (Floyd|Snider 2011b), to laterally and vertically bound dioxins/furans in the southeast corner of the LL Apartments Parcel that was not bound by the initial investigation activities.

3.3.2.2 Central and Eastern Source Area Investigation

In order to further define the extents of PCOCs in the Central and Eastern Source Area, 17 Geoprobe borings (PSB-9 through PSB-21 and PSB-25 through PSB-27) were installed as shown in Figure 3.4. Soil samples were collected from each boring at various depths, in accordance with the sampling program as defined in the LL Apartments Work Plan (Floyd|Snider 2010a). Collected soil samples were analyzed for site PCOCs.

3.3.2.3 Northeast Corner Petroleum Soil Investigation

Three Geoprobe borings (PSB-22 through PSB-24) and three hollow-stem auger borings (MW-12 through MW-14) were installed to determine the extents of potential petroleum contamination in the northeastern portion of the LL Apartments Parcel. Previous groundwater investigations identified petroleum hydrocarbons in the northeast corner that were not bound by existing data, or attributable to a known source. Soil samples were collected from each new boring at various depths, in accordance with the Work Plan (Floyd|Snider 2010a). Collected soil samples were analyzed for site PCOCs. Groundwater monitoring wells were also installed in the hollow-stem auger borings following soil sampling.

3.3.2.4 Deep Groundwater Quality Investigation

In response to comments received on the Draft RI/FS Work Plan during the public comment process, WSDOE requested that a deep well investigation be conducted as part of RI activities. This investigation was developed to provide further information regarding subsurface geologic and hydrogeologic conditions at the LL Apartments Parcel, and to also identify if dense non-aqueous phase liquid (DNAPL) contamination has formed at depths below the vertical extents of previous LL Apartments Parcel investigations.

Three deep monitoring wells were installed in August 2010, within the Central and Eastern Source Area, by sonic drilling methods (Floyd|Snider 2010b). Drilling proceeded until contact with confining soils was made. Monitoring wells were screened at the interval immediately above the first encountered confining unit. Groundwater samples were collected (following well development) during three groundwater monitoring events in the summer/fall 2010, winter 2011, and spring 2011, and were analyzed for the groundwater PCOCs listed above with, the exception of metals and dioxins/furans. The goal of the deep well installation was to observe DNAPL contaminants that may have migrated through the groundwater aquifer to the first confining geologic unit, therefore metals and dioxins/furans were not analyzed, as these PCOCs do not have the characteristics of a DNAPL.

3.3.2.5 Site-wide Groundwater Quality Investigation

In addition to the deep well sampling discussed above, and in accordance with the LL Apartments RI/FS Work Plan, the entire monitoring well network was developed or redeveloped, then sampled for all site PCOCs during three separate monitoring events. These samples were collected to determine current groundwater quality conditions, and to provide a consistent site-wide dataset for FS evaluations. Previous historical groundwater sampling events did not sufficiently document sample methods and protocols for groundwater quality stabilization prior to sampling. In addition, constituents measured in each well, and the number of wells included in previous rounds of monitoring varied from event to event. The RI groundwater quality investigation was conducted to provide a complete dataset for all wells, and all PCOCs with documented sample collection methods, and groundwater stabilization parameters.

The shallow monitoring well network (MW-1 through MW-14) was sampled during the same three quarterly monitoring events listed above for the deep monitoring wells, by low-flow sampling methods. All groundwater monitoring well locations are shown on Figure 2.14.

3.3.3 Lora Lake Parcel Investigation

The RI on the LL Parcel was performed to determine if contamination from the LL Apartments Parcel had migrated onto the LL Parcel. The potential contamination transport pathways from the LL Apartments Parcel to the LL Parcel that were evaluated as part of this LL Parcel investigation included the potential discharge of impacted groundwater, stormwater, and storm drain sediments from the LL Apartments Parcel to Lora Lake and the potential transport of impacted soil from the LL Apartments Parcel to the LL Parcel via historical overland flow/migration. The investigations conducted at the LL Parcel sampled surface and subsurface sediment, collected geographic data (i.e., documented lake features and shoreline conditions), and sampled shallow soil along the western property boundary along Des Moines Memorial Drive (which also assisted with defining the area of elevated shallow dioxin/furan concentrations observed along the roadway during RI activities). LL Parcel sampling locations are shown on Figure 3.5. Investigation activities are summarized below, and discussed in further detail in the LL Parcel Data Report (Appendix G).

3.3.3.1 Sediment Investigation

Sediment investigation activities on the LL Parcel collected and analyzed both subsurface sediment cores and surface sediment grab samples. The subsurface and surface sediment sampling procedures were performed in accordance with the LL Parcel RI/FS Work Plan and Sampling and Analysis Plan/Quality Assurance Project Plan (SAP/QAPP), as well as WSDOE's *Sediment Sampling and Analysis Plan Appendix* and Puget Sound Estuary Program (PSEP) Guidelines (Floyd|Snider 2011a, WSDOE 2008, PSEP 1997).

Sediment sample locations are shown on Figure 3.5. The sampling efforts are summarized in the following sections.

3.3.3.1.1 Subsurface Sediment Investigation

To investigate potential historical and/or long-term contributions of contaminants to Lora Lake resulting from activities at the LL Apartments Parcel, or the stormwater drainage system that discharges runoff to Lora Lake, the quality of the subsurface sediments was evaluated through the collection and analysis of three subsurface sediment cores. Coring activities were conducted in March 2011. Subsurface sediment cores were collected from Lora Lake using freeze coring sampling techniques. Core locations were selected within the lake as near as possible to: the stormwater outfall into the lake, the discharge point where the lake connects to Miller Creek, and the deepest point within the lake. Cores ranged in depth from 2.2 to 5.5 feet. The cores were split into sample intervals, and analyzed for the sediment PCOCs.

3.3.3.1.2 Surface Sediment Investigation

To evaluate whether the surface sediments within Lora Lake and Miller Creek have been impacted from discharges via groundwater and/or stormwater migration from the LL Apartments Parcel, as well as from other stormwater discharge sources, surface sediment samples from within both Lora Lake and Miller Creek were collected and analyzed. A total of 5 surface sediment samples (3 co-located with the subsurface sediment cores) were collected to a depth of 15 cm from Lora Lake by diver-assisted hand core. Three surface sediment samples were collected to a depth of 10 cm from Miller Creek with a stainless-steel spoon. Surface sediment sample locations are shown in Figure 3.5.

Both subsurface and surface sediment samples were chemically analyzed for the sediment PCOCs. Additionally, biological testing was performed on seven of the surface sediment samples—four from Lora Lake and three from Miller Creek. Biological testing methods included the following:

- *Hyalella azteca* 10-day acute mortality testing
- *Chironomus dilutus* (formerly *C. tentans*) 10-day acute mortality testing
- *C. dilutus* 20-day chronic growth testing
- 15 minute Microtox® bacteria (*Vibrio fischeri*) bioluminescence test

3.3.3.2 Soil Investigation

In accordance with the WSDOE-approved LL Parcel RI/FS Work Plan (Floyd|Snider 2011a), a shallow soil investigation was performed within the LL Parcel between Des Moines Memorial Drive and Lora Lake. The sample locations were selected in coordination with WSDOE to meet the project objectives and address public comments regarding potential transport pathways from the LL Apartments Parcel to the LL Parcel. Additionally, the sample locations were selected to assist with defining the horizontal extent of shallow dioxin/furan contamination identified along the eastern edge of the

LL Apartments Parcel during the LL Apartments Parcel RI activities. Soil sample locations are shown on Figure 3.5.

Shallow soil samples were collected at six locations (LL-SB1 through LL-SB6) directly downgradient to the southeast and parallel to Des Moines Memorial Drive on the LL Parcel. These borings were installed using a hand auger to a depth of 4 feet, and were analyzed for the soil PCOCs.

3.3.3.3 Surveys and Water Level Monitoring

In addition to sediment and soil investigation activities on the LL Parcel, various activities to characterize the physical conditions of Lora Lake were conducted in accordance with the WSDOE-approved LL Parcel RI/FS Work Plan (Floyd|Snider 2011a). These activities consisted of the following:

- Survey of Lora Lake's physical drainage features
- Visual inspections of the shoreline of Lora Lake
- Completion of surface water and groundwater level measurements
- Completion of a bathymetric survey of Lora Lake

3.3.3.3.1 Survey of Physical Drainage Features

The two known physical drainage features associated with Lora Lake are the City of Burien storm drain outfall and a drainage culvert located along the southeastern side of Lora Lake that connects the lake to Miller Creek (Figure 2.16). Survey data of these features were collected for comparison to Lora Lake and Miller Creek surface water elevations, and to assist with development of the CSM for the LL Apartments and LL Parcels. The diameters and bottom elevations of these drainage features were surveyed by the Port in fall 2010, in accordance with the requirements specified in the AO.

3.3.3.3.2 Visual Inspection of the Lora Lake Shoreline

Two visual inspections of the Lora Lake shoreline were conducted in fall 2010 and spring 2011 to identify any unknown current and/or historical input sources to Lora Lake. The fall 2010 inspection did not identify any inputs; however, vegetation was overgrown along the shoreline making identification of additional inputs difficult. For this reason, an additional inspection was conducted in spring 2011. During this inspection, water was observed to be entering Lora Lake from two additional locations: from the nearby wetlands located to the south of the lake, and from a drainage channel in the southwest corner of the lake. Additionally, another outfall adjacent to the City of Burien storm drain outfall was observed during the inspection. No water appeared to be discharging from the outfall at the time of the inspection. All visual observations of the Lora Lake shoreline are shown in Figure 2.16.

3.3.3.3.3 Lora Lake, Miller Creek, and Groundwater Water Level Monitoring

Three rounds of water level measurements in fall 2010, winter 2011, and spring 2011 were completed at one location in Lora Lake, three locations in Miller Creek, a piezometer located between Lora Lake and Miller Creek (HPA1-1), and four existing groundwater monitoring wells located along Des Moines Memorial Drive (MW-8 through MW-11), between the LL Apartments Parcel and the LL Parcel. All water level monitoring locations were surveyed by the Port compliant with the survey requirements specified in the AO.

3.3.3.3.4 Lora Lake Bathymetric Survey

A bathymetric survey of Lora Lake was performed in March 2011 to gain a general understanding of the bathymetry and to determine the deepest location within the lake, which was subsequently used as one of the sampling locations during the surface and subsurface sediment investigations. The bathymetric survey was performed by collecting water depth measurements by lead line from an inflatable raft at regular intervals along multiple transects throughout the lake. Based on the water depth measurements, an interpolated Lora Lake bathymetry map was prepared using ArcGIS and is presented in Figure 3.6.

3.3.4 1982 Dredged Material Containment Area Investigation

Through historical research conducted as part of the RI/FS process for the Site, records obtained documented that material from Lora Lake was dredged, and placed on an adjacent Port-owned property in 1982 (the DMCA). Based on historical aerial photos and dredge plan documents, the DMCA is estimated to occupy an approximately 120,000-square-foot area underlying the ALS for the STIA 3rd Runway. The dredging event was managed by the King County Department of Public Works and involved removal (via hydraulic dredge) and placement of dredged material from Lora Lake into the constructed DMCA. This activity was conducted in response to complaints from lake residents of excess siltation. Investigation activities at the DMCA were performed in accordance with the WSDOE-approved DMCA Characterization memorandum (Floyd|Snider 2011c). These investigation activities are described below and discussed in further detail in the DMCA Data Report (Appendix H).

3.3.4.1 Dredged Material Containment Area Soil Test Pit Investigation

In April 2011, the Port excavated six test pits located throughout the estimated dredge spoil placement area to determine the depth, thickness, and extent of dredged material and to determine the nature and extent of potential contamination within this material. Test pits were spatially distributed within the estimated historic extents of the DMCA, and limited by vegetative growth in the eastern and northeastern portion of the area. Test pit locations are shown on Figure 3.7. As described in Appendix H, samples were collected of the likely dredge materials when observed, and at the water table. Samples were analyzed for the soil PCOCs.

3.3.4.2 Dredged Material Containment Area Groundwater Investigation

To evaluate the potential for contaminated dredge material to be impacting groundwater quality beneath and downgradient of the DMCA, groundwater samples were collected from existing wells surrounding the DMCA (refer to Figure 3.7). Three existing shallow aquifer monitoring wells (B310 through B312) located in the potential downgradient areas of the DMCA perimeter to the east, south, and west were redeveloped approximately 1 week prior to groundwater sample collection. These wells were previously installed as part of wetland monitoring activities conducted by the Port. Groundwater samples were collected from each of the three wells and analyzed for the groundwater PCOCs. Results of groundwater analyses are discussed in the DMCA Data Report (Appendix H) and Section 4.4.

4.0 Environmental Investigation and Interim Action Findings

The following sections discuss analytical results for chemicals identified in the RI/FS Work Plan as PCOCs, and detected during all environmental investigations conducted at the Site. Results of the SWIA are discussed below, followed by discussion of investigation results for the three separate parcels of the Site, subdivided by media and area of the Site, as applicable. For the purposes of this discussion, “detect” refers to a target analyte detected at a concentration greater than or equal to the method reporting limit, and “non-detect” refers to a target analyte not detected at a concentration greater than or equal to the method reporting limit. Specific analytical method reporting limits are presented in the data reports provided in Appendices E, F, G, and H.

4.1 STORMWATER DRAINAGE SYSTEM INTERIM ACTION FINDINGS

The SWIA collected stormwater, stormwater solids, and catch basin sediment samples from the LL Apartments Parcel over multiple sampling events. The results of this investigation are presented below, and detail on sampling activities, methods, and analytical results are contained in Appendix E. The SWIA sampling locations are shown in Figure 3.2.

The storm drain system catch basins range in depth from approximately 1 to 4 feet bgs. During the stormwater monitoring events the water table, as measured in on-site wells, ranged from 11 to 17 feet bgs and approximately 6 feet bgs at MW-2 in the northwest corner of the Site. During the TV in-line inspection the inspection report in Appendix C of the SWIA Report (Appendix E) notes that the pipe segments were in general 1 to 6 feet bgs, some at 8 and 11 feet bgs, and a few locations at 14 to 16 feet bgs. Therefore, the storm drain system is largely in the vadose zone; however, there may be some potential for groundwater intrusion during the wet season.

4.1.1 Stormwater Conveyance System Integrity

TV in-line inspection activities conducted at the LL Apartments Parcel were performed to evaluate where PCOCs may enter the LL Apartments Parcel storm drain system and the potential for contaminated groundwater and/or soil to seep into the stormwater drainage system. Approximately 50 percent (1,278 feet) of the LL Apartments Parcel pipe segments were observed to be in good condition and no pipe integrity cracks were identified during the inspection. In the remaining pipe segments, approximately 44 feet of pipe contained visible corrosion. Isolated areas of degradation were also observed in the remaining pipe segments, in the form of isolated cracks or holes, and soil and roots were observed to have entered the storm system at select pipe joints. It may be possible for stormwater or soil to enter or exit the conveyance system through these cracks and joints.

4.1.2 Catch Basin Sediment Quality

Catch basin sediment samples were collected at five locations to characterize PCOCs within the drainage systems beneath the LL Apartments Parcel (Figure 3.2). Samples were collected at the Main Line Inlet Catch Basin, Main Line Outlet Catch Basin, two Main Line Interior Catch Basins, and the Secondary Line Outlet Catch Basin. Specific rationale for these locations is presented in the SWIA Data Report; however, in general, the locations were selected to be able to assess the solids introduced or influenced by on-property sources. Stormwater in-line solids were analyzed for the site PCOCs. The catch basin sediment analytical findings are summarized below and discussed in detail in the SWIA Data Report (Appendix E).

4.1.2.1 Conventionals

4.1.2.1.1 Total Suspended Solids

The highest TSS content was measured at both the Main Line Inlet to the LL Apartments Parcel (83.2 percent) and the Main Line Outlet from the parcel (85.1 percent). The lowest total solids percentages of 23.5 percent and 20.6 percent were measured in sediments collected from the two Main Line Interior Catch Basins (CS/CB-19 and CB-12, respectively).

4.1.2.1.2 Total Organic Carbon

The highest TOC contents, 40.7 percent and 44.6 percent, were measured in sediment collected from the two Main Line Interior Catch Basins (CS/CB-19 and CB-12). The lowest TOC percentage of 1.29 percent was measured in sediments collected from the Main Line Outlet.

4.1.2.2 Arsenic and Lead

Arsenic was not detected in sediment collected from the five sampled catch basins at detection limits of 6 mg/kg in the Main Line Inlet and Outlet, and 20 mg/kg in the Main Line Interior Catch Basins (CS/CB-19 and CB-12) and Secondary Line Outlet (CB4555 [CS/CB-2]).

Lead was detected in each of the five catch basin sediment sampling locations. The highest lead concentration, 322 mg/kg, was measured in sediments collected from the Secondary Line Outlet (CB4555 [CS/CB-2]). The lowest concentration of lead was measured in sediments collected from the Main Line Inlet to the LL Apartments Parcel (31 mg/kg).

4.1.2.3 Total Petroleum Hydrocarbons

Diesel range and heavy oil range TPH were detected in each sample collected at the five catch basin sediment sampling locations.

4.1.2.3.1 Diesel Range Total Petroleum Hydrocarbons

The highest diesel range TPH concentrations were measured in sediments collected from the 2 Main Line Interior Catch Basins (CS/CB-19 and CB-12), ranging from a maximum of 4,200 mg/kg at CB-19 to 1,300 mg/kg at CB-12.

The lowest detected concentrations of diesel range TPH were measured at the Main Line Outlet Catch Basin (19 mg/kg) and at the Main Line Inlet Catch Basin (54 mg/kg for the parent sample and 31 mg/kg for the duplicate sample).

4.1.2.3.2 Heavy Oil Range Total Petroleum Hydrocarbons

Consistent with the diesel range TPH concentrations, the heavy oil range TPH concentrations were highest for sediments collected from the two Main Line Interior Catch Basins (CS/CB-19 and CB-12). Heavy oil range TPH concentrations ranged from 6,600 mg/kg at CB-12 to 18,000 mg/kg at CB-19.

The lowest detected concentration of heavy oil range TPH was at the stormwater Main Line Outlet (160 mg/kg).

The highest of the summed diesel range and heavy oil range TPH concentrations were measured in sediments collected from the two Main Line Interior Catch Basins (CB-12 and CS/CB-19) with concentrations of 7,900 mg/kg and 22,200 mg/kg, respectively.

4.1.2.4 Semivolatile Organic Compounds

4.1.2.4.1 Polycyclic Aromatic Hydrocarbons

<u>Low Molecular-Weight Polycyclic Aromatic Hydrocarbons</u>

In sediments collected from the five catch basin locations, the majority of low molecular-weight polycyclic aromatic hydrocarbons (LPAHs) were not detected, with one or two LPAH analytes detected in each sample. Phenanthrene was the one LPAH detected in all sediment samples.

The highest detected LPAH concentration was phenanthrene at 1,000 µg/kg in sediments collected from Catch Basin CS/CB-19. This catch basin is located directly downgradient of the Main Line Inlet. Further downgradient in the other Main Line Interior Catch Basin (CB-12), a phenanthrene concentration of 460 µg/kg was detected.

The lowest LPAH concentration was phenanthrene (36 µg/kg), which was detected in sediments collected from the Main Line Outlet Catch Basin.

<u>High Molecular-Weight Polycyclic Aromatic Hydrocarbons</u>

High molecular weight polycyclic aromatic hydrocarbons (HPAHs) were detected in all catch basin samples. The highest HPAH concentrations were detected in sediments collected from a Main Line Interior Catch Basin (CS/CB-19). HPAHs measured in sediments collected from the Main Line Interior Catch Basin (CS/CB 19) range from non-detect for benzo(g,h,i)perylene and dibenzo(a,h)anthracene to a concentration of 3,200 µg/kg for pyrene.

The lowest HPAH concentrations were measured in sediments sampled from the Main Line Outlet; these concentrations ranged from non-detect for dibenzo(a,h)anthracene to 73 µg/kg for fluoranthene.

Carcinogenic Polycyclic Aromatic Hydrocarbon Toxicity Equivalent Values

The highest cPAH TEQ concentration (calculated using one-half of the method reporting limit for non-detections) was 1,510 µg/kg, measured in sediments collected from the Main Line Interior Catch Basin (CS/CB-19). The lowest cPAH TEQ concentration was measured in sediments sampled the furthest downgradient at the Main Line Outlet (59 µg/kg).

4.1.2.4.2 Pentachlorophenol

PCP was detected at two of the five catch basin locations: the Main Line Inlet to the LL Apartments Parcel and the Main Line Outlet from the LL Apartments Parcel.

The highest PCP concentration was measured in the field duplicate collected at the Main Line Inlet. The PCP concentration for the parent sample collected at the Main Line Inlet was 25 µg/kg, and the duplicate sample was 84 µg/kg. PCP was measured at a concentration of 71 µg/kg in sediments collected from the Main Line Outlet. PCP was not detected in sediments collected from the Main Line Interior catch basins or the Secondary Line Outlet Catch Basin (CB4555 [CS/CB-2]).

4.1.2.5 Volatile Organic Compounds

None of the analyzed VOCs were detected during the sediment sampling event, including PCE, TCE, breakdown products cis-1,2-DCE and trans-1,2-DCE, and 1,2-DCA.

4.1.2.6 Dioxins/Furans

The results discussed below include dioxins/furans TEQ values calculated using the World Health Organization 2005 Toxic Equivalency Factors (Van den Berg et al. 2006), and one-half of the detection limit for non-detected congeners. Dioxin/furan congeners were detected in each sample collected at the five catch basin sediment sampling locations. The highest dioxins/furans TEQ concentration measured in sediments collected from the Main Line Interior Catch Basin (CB-12) was 143.1 pg/g. The lowest dioxin/furan TEQ concentration (13.4 pg/g) was measured in sediments collected at the Main Line Outlet.

4.1.3 Stormwater Quality

Storm flow monitoring and stormwater sample collection activities were completed at three locations to characterize the inlet and outlet flows at the LL Apartments Parcel; the Main Line Inlet Catch Basin, Main Line Outlet Catch Basin, and the Secondary Line Outlet Catch Basin. Stormwater conditions were monitored during 10 distinct STEs and monitoring activities were completed over a range of representative storm sizes, rainfall intensities, and groundwater/soil water conditions. All stormwater samples were analyzed for site PCOCs. The stormwater analytical findings are summarized below and discussed in detail in the SWIA Data Report (Appendix E).

4.1.3.1 Conventionals

4.1.3.1.1 Total Suspended Solids

The highest TSS concentration was detected at the Main Line Inlet location at a concentration of 59 mg/L. The highest detection occurred during STE 2. The lowest TSS detection of 3.4 mg/L was measured at the Secondary Line Outlet (CB-1) during STE 9.

4.1.3.1.2 pH

Measurements of pH during the STEs ranged from 6.22 at the Main Line Inlet during STE 10, to 7.09 measured at the Main Line Outlet during STE 9.

4.1.3.2 Arsenic (Total and Dissolved)

Total and dissolved arsenic were detected in each of the samples collected during the STEs at the three stormwater sampling locations.

The highest dissolved arsenic concentration was measured in the sample collected at the Secondary Line Outlet (CB-1) during STE 3, at a concentration of 1 µg/L. The highest detected total arsenic concentration of 1.3 µg/L was also measured at the Secondary Line Outlet (CB-1) during STE 3.

The lowest dissolved arsenic concentration of 0.2 µg/L was observed during STE 8 at the Secondary Line Outlet (CB-1). The lowest detected total arsenic concentration of 0.3 µg/L was also measured at the Secondary Line Outlet (CB-1) during STE 8.

Dissolved arsenic concentrations for the 10 monitored STEs at the Main Line Inlet and Main Line Outlet ranged from 0.3 µg/L to 0.6 µg/L. Total arsenic concentrations at the Main Line Inlet and the Main Line Outlet ranged from 0.5 µg/L to 1.2 µg/L over the 10 STEs.

4.1.3.3 Total Petroleum Hydrocarbons

Diesel range and heavy oil range TPH were detected in samples taken from 2 of the 3 stormwater sampling locations during the 10 STEs. Diesel range and heavy oil range TPH were not detected in samples collected at the Secondary Line Outlet (CB-1).

4.1.3.3.1 Diesel Range Total Petroleum Hydrocarbons

The highest detected concentration of diesel range TPH was 1.6 mg/L, measured at the Main Line Inlet during STE 1. Diesel range TPH was detected at the Main Line Inlet during 5 monitored STEs, with concentrations ranging from 0.3 mg/L to 1.6 mg/L.

Diesel range TPH was detected in samples taken from the Main Line Outlet during STE 1 and STE 3, with concentrations of 0.43 mg/L and 0.29 mg/L, respectively.

4.1.3.3.2 Heavy Oil Range Total Petroleum Hydrocarbons

The highest detected concentration of heavy oil range TPH was 7.5 mg/L measured at the Main Line Inlet during STE 1.

Heavy oil range TPH was detected in all but 1 sample collected at the Main Line Inlet, with concentrations ranging from 0.5 mg/L to 7.5 mg/L. Heavy oil range TPH was detected in 5 of the 10 sampling events at the Main Line Outlet, with concentrations ranging from 0.57 mg/L to 2.4 mg/L.

4.1.3.4 Semivolatile Organic Compounds

4.1.3.4.1 Polycyclic Aromatic Hydrocarbons

Low Molecular-weight Polycyclic Aromatic Hydrocarbons

LPAHs were detected in each of the samples collected at the 3 sampling locations during the 10 STEs.

The highest total LPAH concentration observed, 0.2 µg/L, was measured at the Main Line Inlet during STE 1. Total LPAH concentrations at the Main Line Outlet ranged from 0.01 µg/L to 0.17 µg/L.

High Molecular-weight Polycyclic Aromatic Hydrocarbons

HPAHs were detected in all stormwater samples collected from two of the three sample locations. HPAHs were not detected in samples collected from the Secondary Line Outlet Catch Basin (CB-1).

The highest total HPAH concentration of 0.75 µg/L was measured in stormwater at the Main Line Inlet during STE 2. Total HPAH concentrations measured at the Main Line Outlet ranged from 0.04 µg/L to 0.54 µg/L.

Carcinogenic Polycyclic Aromatic Hydrocarbon Toxicity Equivalent Values

The results discussed below are cPAH TEQ values calculated using one-half of the reporting limit for non-detects. The highest cPAH TEQ concentration of 0.071 µg/L was measured from the Main Line Inlet during STE 2. TEQ concentrations measured at the Main Line Outlet ranged from non-detect to 0.046 µg/L. cPAHs were not detected in any samples taken from the Secondary Line Outlet (CB-1) during the 10 STEs.

4.1.3.4.2 Pentachlorophenol

PCP was detected in samples collected at two of the three sampling locations. PCP was not detected in samples collected from the Secondary Line Outlet (CB-1) location.

The highest detected PCP concentration was 1.5 µg/L in a sample collected at the Main Line Inlet during STE 5.

PCP concentrations in samples collected from the Main Line Outlet ranged from non-detect to 1.3 µg/L, measured during STE 7.

4.1.3.5 Volatile Organic Compounds

VOCs were not detected in samples collected during the 10 monitored STEs from the 3 monitoring locations. Analyzed VOCs consisted of: PCE, TCE, breakdown products cis-1,2-DCE and 1,2-DCE, and 1,2-DCA.

4.1.3.6 Dioxins/Furans

Dioxin/furan TEQs were calculated for stormwater samples using one-half of the detection limit for non-detected congeners. Dioxins/furans were detected in all stormwater samples collected from the three monitoring locations. The highest dioxin/furan TEQ concentration measured for stormwater was 37.2 pg/g, and was collected from the Main Line Inlet during STE 7.

The lowest dioxin/furan TEQ concentration was measured at the Secondary Line Outlet (CB-1) at 1.3 pg/g, during STE 6.

4.1.4 Stormwater Statistical Evaluation

This section summarizes the results of a statistical evaluation of stormwater sample data collected as part of LL Apartments Parcel SWIA. The purpose of this statistical analysis was to compare the quality of stormwater entering the LL Apartments Parcel to the quality of stormwater leaving the LL Apartments Parcel. The analysis also identifies statistically significant changes in analyte concentrations between the stormwater entering and exiting the property.

4.1.4.1 Summary of Methods

Statistical analysis and calculation of summary statistics were performed using the software program ProUCL, Version 4.00.04, recommended by the U.S. Environmental Protection Agency (USEPA). Additional required statistical methods (comparison of means and graphical box plots) that are not available with ProUCL were conducted using the software program, Minitab, Version 15.

The calculation of means for datasets that include multiple non-detect results often requires the use of a more sophisticated mean calculation to account for the non-detect detection limits, rather than assigning the non-detect results a value of zero or one-half the reporting limit. Therefore, means were calculated as either arithmetic means or Kaplan-Meier means, as appropriate for the data.

The testing of statistically significant variations in the dataset was performed using comparison of means in one-way analysis of variance (ANOVA) or Kruskal-Wallis nonparametric comparison of means tests.

4.1.4.2 Summary of Statistical Evaluation Results

The highest analyte concentrations were generally observed in stormwater that was collected from the Main Line Inlet; however, the mean analyte concentrations were comparable between the Main Line Inlet and Main Line Outlet. The analytes cPAH, TPH, and PCP were not detected in the stormwater collected from the Secondary Line Outlet. All other analyte concentrations, with the exception of total and dissolved arsenic, are substantially lower and exhibit less variability at the Secondary Line Outlet when compared to the Main Line Inlet and Main Line Outlet. For dioxins/furans, arsenic, PCP, and TSS, there were no significant temporal trends in the data for any of the three locations. Heavy oil range TPH and cPAH TEQ concentrations, however, were statistically significantly lower in stormwater from the Main Line Inlet and Main Line Outlet following vactor drainage system cleaning when compared to the sampled STEs before the drainage system was cleaned. Diesel range TPH concentrations were also statistically significantly lower in stormwater from the Main Line Inlet following drainage system vactor cleaning. This suggests that catch basin sediments may have been contributing cPAH, diesel range and heavy oil range TPH to stormwater.

Overall, the statistical analysis of site-wide variability shows that there are no statistically significant changes in analyte concentrations as stormwater is conveyed across the LL Apartments Parcel. Detailed results, including statistic summary tables and box plots, can be found in the SWIA Data Report (Appendix E).

4.1.5 Stormwater In-line Solids Quality

In-line sediment traps, designed to collect stormwater solid samples, were installed at four catch basin locations at the LL Apartments Parcel to assess the chemical quality of solids in stormwater introduced from or influenced by on-property sources, and potentially transported from the LL Apartments Parcel. Samples were collected from in-line sediment traps at the Main Line Inlet Catch Basin, Main Line Outlet Catch Basin, a Main Line Interior Catch Basin, and the Secondary Line Outlet Catch Basin. Stormwater in-line solids were analyzed for site PCOCs. The stormwater in-line solids analytical findings are summarized below and discussed in detail in the SWIA Data Report (Appendix E).

Because there was limited sample volume, the Secondary Line Outlet sample (CB-2) was not analyzed for TOC, arsenic, lead, TPH, or PCP. Sufficient in-line solids sample volumes were collected from all other sampling locations allowing for analyses of all PCOCs.

4.1.5.1 Conventionals

4.1.5.1.1 Total Suspended Solids

The highest TSS content of 70.2 percent was measured at the sediment trap in the Main Line Outlet to the LL Apartments Parcel (CB4857). The lowest TSS percentage of 21.4 percent was measured in in-line solids collected from the trap at the Secondary Line Outlet (CB-2).

4.1.5.1.2 Total Organic Carbon

The highest percentages of TOC, 9.97 percent and 9.42 percent, were measured in in-line solids collected from the Main Line Interior trap (CB5945) and the Main Line Inlet trap (CB-31A), respectively. The lowest TOC percentage of 5.28 percent was measured from the in-line solids collected from the trap in the Main Line Outlet (CB4857). Because of insufficient sample volume, TOC was not analyzed in the sample collected at the Secondary Line Outlet (CB-2).

4.1.5.2 Arsenic and Lead

Arsenic was not detected in samples collected from the Main Line Inlet, Main Line Outlet, or Main Line Interior trap at detection limits of 7 mg/kg, 7 mg/kg, and 9 mg/kg, respectively. As stated above, because of insufficient sample volume, metals were not analyzed in the sample collected at the Secondary Line Outlet (CB-2).

Lead was detected in the three samples that were analyzed for metals. The highest lead concentration, 208 mg/kg, was measured in the sample collected from the Main Line Interior trap (CB5945). The lowest concentration of lead was measured in the sample collected at the Main Line Inlet to the LL Apartments Parcel (64 mg/kg in CB-31A).

4.1.5.3 Total Petroleum Hydrocarbons

Diesel range and heavy oil range TPH were detected in three of the four in-line solids samples. The fourth trap, located at the Secondary Line Outlet (CB-2), was not analyzed for TPH because of insufficient sample volume.

4.1.5.3.1 Diesel Range Total Petroleum Hydrocarbons

The highest diesel range TPH concentration was measured in in-line solids collected from the Main Line Interior trap (CB5945) at a concentration of 590 mg/kg. The lowest detected concentration of diesel range TPH was measured at the Main Line Outlet trap (CB4857) at a concentration of 200 mg/kg.

4.1.5.3.2 Heavy Oil Range Total Petroleum Hydrocarbons

Consistent with the diesel range TPH concentrations, the highest heavy oil range TPH concentration was measured in in-line solids collected from the Main Line Interior trap (CB5945) at a concentration of 2,000 mg/kg. The concentrations detected at the other 2 traps, the Main Line Inlet trap (CB-31A) and the Main Line Outlet trap (CB4857), were both 1,200 mg/kg.

The highest of the summed diesel range and heavy oil range TPH concentrations was measured at the Main Line Interior trap (CB5945) with a concentration of 2,590 mg/kg.

4.1.5.4 Semivolatile Organic Compounds

4.1.5.4.1 Polycyclic Aromatic Hydrocarbons

Low Molecular-weight Polycyclic Aromatic Hydrocarbons

In in-line solids collected from the four sediment trap locations, phenanthrene was the only detected LPAH.

The highest detected phenanthrene concentration was 690 µg/kg in in-line solids collected from the trap located in the Main Line Interior (CB5945). The lowest detected concentration was measured in the in-line solids collected from the Main Line Outlet (230 µg/kg) trap.

High Molecular-weight Polycyclic Aromatic Hydrocarbons

HPAHs were detected in all four of the in-line solids sediment trap samples. Total HPAH concentrations ranged from 2,010 µg/kg in the samples collected from the Main Line Interior trap (CB5945) to 6,570 µg/kg in the samples collected from the Secondary Line Outlet trap (CB-2). The total HPAH concentrations detected in the samples collected from the sediment traps at the Main Line Outlet (CB4857) and Main Line Inlet (CB-31A) were 2,550 µg/kg and 3,290 µg/kg, respectively.

Carcinogenic Polycyclic Aromatic Hydrocarbon Toxicity Equivalent Values

The highest cPAH TEQ concentration (calculated using one-half of the reporting limit for non-detections) was 801 µg/kg in the sample collected from the Main Line Interior trap (CB5945). The lowest TEQ concentration was 328 µg/kg in the sample collected at the Main Line Outlet (CB4857).

4.1.5.4.2 Pentachlorophenol

The in-line solids collected from the trap at the Secondary Line Outlet (CB-2) were not analyzed for PCP because of insufficient sample collection volume; however, PCP was analyzed and detected in each of the other three in-line solids sediment trap samples.

The highest PCP concentration was measured in the sample collected at the Main Line Outlet (CB4857). The concentration at this location was 79 µg/kg. The lowest concentrations of PCP were measured in the samples collected at the Main Line Interior (CB5945) and Main Line Inlet (CB-31A) sediment traps. The concentrations at these locations were 55 µg/kg and 50 µg/kg, respectively.

4.1.5.5 Dioxins/Furans

Dioxin/furan TEQs were calculated for in-line solids samples using one-half of the detection limit for non-detected congeners. Dioxin/furan congeners were detected in each sample collected at the four in-line solids sampling locations. The highest dioxin/furan TEQ concentration was measured in the Main Line Interior sediment trap (CB5945). The

TEQ value at this location was 181 pg/g. The lowest dioxin/furan TEQ concentration of 44 pg/g was measured in in-line solids collected at the Secondary Line Outlet trap (CB-2).

4.1.6 Summary of Stormwater Interim Action Findings

4.1.6.1 Catch Basin Sediment Quality

Catch basin sediment samples were collected and analyzed to evaluate potential PCOC concentrations that may be present within the LL Apartment Parcel storm drain system. TOC measurements were consistent with field observations that sediment accumulations in catch basins located within the interior of the LL Apartments Parcel were organic rich and unconsolidated. High TOC, organic-rich sediments from the two Main Line Interior Catch Basins also contained the highest analyte concentrations. TPH, lead, SVOC, and dioxin/furan concentrations detected in catch basin sediments at these locations were elevated relative to catch basin sediments sampled at the Main Line Inlet and the Main Line and Secondary Line Outlet (CB4555 [CS/CB-2]) catch basins. These compounds are typically characterized by high organic carbon coefficients and/or low water solubility. The lowest analyte concentrations (including lead, TPH, PAHs, and dioxins/furans) were observed in catch basin sediments sampled from the Main Line Inlet and the Main Line Outlet. The main line sediments also had the lowest TOC concentration and the greatest concentration of TSS.

4.1.6.2 Stormwater Quality

The statistical evaluation of the stormwater monitoring data demonstrates that there are no statistically significant changes in analyte concentrations as stormwater is conveyed across the LL Apartments Parcel. Therefore, the stormwater entering the Site at the Main Line Inlet, or collected on-property in the Secondary Line, is not adversely impacted as it is conveyed through the LL Apartments Parcel and leaves the Site at the Main Line Outlet and/or Secondary Line Outlet (CB-1). In general, the highest PCOC concentrations were detected in stormwater from the Main Line Inlet. The lowest PCOC concentrations and the least overall variability in the data were observed in stormwater from the Secondary Line Outlet (CB-1).

Several PCOCs (cPAHs, diesel range and heavy oil range TPH, and PCP) were not detected in stormwater collected from the Secondary Line Outlet (CB-1), and dioxins/furans and TSS were detected at lower concentrations relative to the Main Line Inlet and Main Line Outlet locations. The results of the SWIA indicate that the Secondary Line does not contribute elevated PCOC concentrations or degrade stormwater quality from the LL Apartments Parcel.

4.1.6.3 In-line Solids Sediment Quality

In-line stormwater solids samples were collected and analyzed to evaluate potential chemical concentrations that may be present within the LL Apartment Parcel storm drain system as solids move through the storm system. The highest analyte concentrations for the in-line solids (including lead, TPH, PAHs, and dioxins/furans) were observed in the in-line solids that were collected from the sediment trap in the Main Line Interior. When the analyte concentrations from the Main Line Inlet trap are compared to the Main Line Outlet trap, the concentration of TPHs, PAHs, and dioxins/furans were either the same or lower in the Main Line Outlet trap. The concentrations of lead and PCP were higher for the Main Line Outlet trap in-line solids compared to the Main Line Inlet trap. With a few exceptions (TEQs for cPAHs), the concentrations of all analytes in the Secondary Line Outlet trap in-line solids were lower than all other in-line solids sampling locations.

4.2 LORA LAKE APARTMENTS PARCEL INVESTIGATIONS

RI activities conducted to date on the LL Apartments Parcel include the collection and analysis of surface and subsurface soil samples, the installation of shallow and deep groundwater monitoring wells, and the monitoring of groundwater levels and chemical conditions during multiple monitoring events. The following sections describe the results of all soil and groundwater quality analyses conducted at the LL Apartments Parcel.

Investigation results and associated data are organized in the following sections according to media type and focus area (which include the Central and Eastern Source Areas, Northeast Corner, Shallow Site-wide Dioxins/Furans, Other Area Soil [from AECOM investigation only], Site-wide Shallow Groundwater Quality, and Deep Groundwater Quality). The analytical program conducted for each historical investigation varied by event, as described in Section 3.0. Appendix D presents the historical GeoScience Management and AECOM analytical data, while the LL Apartments Parcel Data Report (Appendix F) presents the 2010 to 2011 RI Data. Summary data, including frequency of detection and maximum concentrations for all PCOCs, are presented in Tables 4.1 and 4.2 for soil and groundwater, respectively, and are discussed in the following sections.

4.2.1 Lora Lake Apartments Parcel Soil Quality

4.2.1.1 Central and Eastern Source Areas

The 2007 GeoScience Management investigation (GeoScience Management 2008) collected and analyzed subsurface soil samples from six boring locations (MW-1 and LLP-2 through LLP-6) in the suspected source area near the location of the former drum cleanout pond (Figure 3.1). Soil samples from LLP-2 through LLP-6 were analyzed for all 2010 to 2011 RI PCOCs excluding dioxins/furans. MW-1 soil samples were also analyzed for the RI PCOCs, including dioxins/furans. Each location was sampled at approximately 6.5 feet bgs and between 14.5 to 17 feet bgs, except at LLP-5, which was only analyzed in the deeper interval.

The 2008 AECOM investigation advanced an additional three shallow soil borings in the former drum cleanout pond area (LL-01, LL-10, and LL-11), located adjacent to MW-1, and to the north and south of the former Recreation Building (ENSR|AECOM 2008a). These borings were advanced to a depth of 2 feet bgs, and no field evidence of contamination was observed. AECOM sampled shallow soil (at 0–0.5 foot bgs and 1.5--2 feet bgs) and subsurface soil between 6.5 and 15.5 feet bgs during the installation of Wells MW-4 and MW-5 in the eastern portion of the source area located between the Central Source Area (Recreation Building) and the eastern property boundary (Eastern

Source Area). Multiple PCOCs were detected in both borings, with the highest concentrations occurring in the 0–0.5 foot bgs interval and decreasing in subsurface intervals. Soil analytical samples were not collected during installation of Wells MW-8 through MW-11 as part of the Supplemental Groundwater Investigation (ENSR|AECOM 2008b).

As part of the 2010 to 2011 RI activities, 8 Geoprobe soil borings were advanced in the Central Source Area to depths ranging from 9.5 to 25 feet bgs (PSB-9 through PSB 12, PSB-9A, and PSB-25 through PSB-27). PSB-9 was sampled for all 2010 to 2011 RI PCOCs except dioxins/furans and VOCs. PSB 9A, PSB-10, PSB-11 and PSB-12 were sampled for all 2010 to 2011 RI PCOCs. PSB-25, PSB-26, and PSB-27 were analyzed for metals and TPH only to further delineate the extents of these PCOCs. In addition, 1 Roto-sonic soil boring (MW-16) was also advanced to a depth of 47.5 feet bgs in the Central Source Area.

An additional nine Geoprobe soil borings and two Roto-sonic deep soil borings were advanced to further delineate the lateral and vertical extents of contamination in the Eastern Source Area. Borings PSB-13, PSB-14, PSB-15, PSB-17, MW-15, and MW-17 were located in the Eastern Source Area, and Borings PSB-16, PSB-18, PSB-19, PSB-20 and PSB-21 were located outside of the LL Apartments Parcel property fence along Des Moines Memorial Drive (Figure 3.4). Consistent with the prior AECOM investigation, the highest PCOC concentrations detected in the Eastern Source Area, within the vicinity of MW-4 and MW-5, occurred at the surface of PSB-15 and PSB-16.

4.2.1.1.1 Arsenic and Lead

GeoScience Management analyzed for arsenic in Borings LLP-2 through LLP-5 in the Central Source Area and reported no detections. AECOM also analyzed all borings in the Central Source Area for arsenic and reported a maximum arsenic concentration of 11.1 mg/kg in the sample collected from the 0–0.5 foot bgs interval of LL-10, with all other arsenic concentrations less than 5 mg/kg. In the eastern source area, AECOM detected concentrations of arsenic ranging from 2.2 mg/kg in the sample collected from the 14--15 feet bgs interval of MW-4 to 10.2 mg/kg in the sample collected from the 0--0.5 foot bgs interval of MW-5.

In soil samples analyzed as part of the 2010 to 2011 RI activities, arsenic was detected in the Central Source Area at a concentration of 8 mg/kg in the sample collected from the 0–0.5 foot bgs interval of PSB-9A and at 7 mg/kg in the samples collected from the 8.5–10 feet bgs interval of PSB-10 and the 1.5–2 feet bgs interval of PSB-11. In the Eastern Source Area, detected arsenic concentrations ranged from 5 mg/kg in the sample collected from the 0–0.5 foot bgs interval of PSB-21 and 0–1 foot bgs interval of PSB-19 to 11 mg/kg in the sample collected from the 0–0.5 foot bgs interval of PSB-13. Maximum detected arsenic concentrations from all investigations are presented in Figure 4.1.

GeoScience Management only analyzed for lead in the samples collected from a depth of 14.5 feet bgs in LLP-4 and a depth of 15.5 feet bgs in LLP-5, with detections of 47 mg/kg and 6 mg/kg, respectively. AECOM analyzed all borings in the Central Source Area for lead, with the highest concentration of lead (265 mg/kg) detected in the sample collected from the 1.5–2 feet bgs interval of LL-01, located adjacent to MW-1. All other lead concentrations in the Central Source Area ranged from 2.05 to 91.6 mg/kg. In the Eastern Source Area, detected lead concentrations ranged from 2.98 mg/kg in the sample collected from the 14–14.5 feet bgs interval of MW-4 to 370 mg/kg in the sample collected from the 0–0.5 foot bgs interval of MW-4.

In soil samples analyzed as part of the 2010 to 2011 RI activities, lead was detected in all samples from the Central Source Area. The highest detected lead concentration was in the sample collected from the 2–4 feet bgs interval of PSB-11 with a maximum lead concentration of 2,880 mg/kg. The remainder of the sample results ranged from 2 mg/kg in the samples collected from the 8.5–9.5 feet bgs interval of PSB-9 and the 14--15 feet bgs interval of PSB-10, to 304 mg/kg in the sample collected from the 1.5--2 feet bgs interval of PSB-11. In the Eastern Source Area, lead concentrations ranged from 3 mg/kg in samples (collected from multiple locations and depths) to 245 mg/kg in the sample collected from the 0–0.5 foot bgs interval of PSB-15. Metals were not analyzed in soil samples collected from the deep Roto-sonic borings for Wells MW-15 through MW-17. Maximum detected lead concentrations from all investigations are presented in Figure 4.2.

4.2.1.1.2 Total Petroleum Hydrocarbons

<u>Gasoline Range Total Petroleum Hydrocarbons</u>

In the 2007 GeoScience Management investigation, the maximum TPH detections in soil occurred in a gravel layer with oil-like staining and a petroleum odor (at approximately 14 feet bgs) in the Central Source Area (LLP- 4 and MW-1). Maximum gasoline range hydrocarbons in LLP-4 and MW-1 were 1,900 mg/kg and 1,000 mg/kg, respectively. Oily staining was not encountered in the LLP-5 boring immediately to the east of LLP-4 and MW-1 and gasoline range TPH were not detected at this location. In the Central Source Area, AECOM borings showed gasoline range TPH concentrations ranging from 2.4 mg/kg in the sample collected from the 0–0.5 foot bgs interval of LL-01 to 17 mg/kg in the sample collected from the 1.5–2 feet bgs interval of LL-10. In the Eastern Source Area, gasoline range TPH were detected only in the sample collected from the 11.5--13 feet bgs interval of MW-5 at a concentration of 14 mg/kg.

Seven soil borings advanced in the Central Source Area during the 2010 to 2011 RI were analyzed for gasoline range TPH. Gasoline range TPH were detected in concentrations ranging from 8.2 mg/kg in the sample collected from the 4–6 feet bgs interval of PSB-11 to 150 mg/kg in the sample collected from the 1.5–2 feet bgs interval of PSB-11. In the eastern source area, gasoline range TPH were detected at concentrations ranging from 3.3 mg/kg in the samples collected from the 4–6 feet bgs and 13–15 feet bgs intervals of PSB-16 to 20 mg/kg in the sample collected from the 0–0.5 foot bgs interval of PSB-16. Gasoline range TPH were not analyzed in soil samples collected from the deep Roto-sonic borings for Wells MW-15 through MW-17. The maximum detected gasoline range TPH concentrations from all investigations are presented in Figure 4.3.

Diesel Range Total Petroleum Hydrocarbons

In the 2007 GeoScience Management investigation, diesel range TPH concentrations ranged from 39 mg/kg in the sample collected from 15.5 feet bgs in LLP-5 to 8,900 mg/kg in the sample collected from 14 feet bgs in MW-1. In the Central Source Area, the results from AECOM borings showed diesel range TPH concentrations ranging from 1.6 mg/kg in the sample collected from the 1.5–2 feet bgs interval of LL-11 to 37 mg/kg in the sample collected from the 1.5-2 feet bgs interval of LL-10. In the Eastern Source Area, diesel range TPH ranged from 1.5 mg/kg in the sample collected from the 9–10.5 feet bgs interval of MW-4 to 1,100 mg/kg in the sample collected from the 11.5–13 feet bgs interval of MW-5.

In soil samples analyzed as part of the 2010 to 2011 RI activities, diesel range TPH were detected in samples from the Central Source Area with concentrations ranging from 6 mg/kg in the sample collected from the 2–4 feet bgs interval of PSB-12 to 440 mg/kg in the sample collected from the 2–4 feet bgs interval of PSB-11. In the Eastern Source Area, diesel range TPH were detected at concentrations ranging from 5.4 mg/kg in the sample collected from the 1.5–2 feet bgs interval of PSB-13 to 110 mg/kg in the sample collected from the 1–2 feet bgs interval of PSB-16. Diesel range TPH were not detected in the deep Roto-sonic borings for Wells MW-15 through MW-17. Maximum detected diesel range TPH concentrations from all investigations are presented in Figure 4.4.

Heavy Oil Range Total Petroleum Hydrocarbons

In the 2007 GeoScience Management investigation, heavy oil range TPH concentrations ranged from 160 mg/kg in the sample collected from 15.5 feet bgs in LLP-5 to 17,000 mg/kg in the sample collected from 14.5 feet bgs in LLP-4. In the Central Source Area, sample results from AECOM borings showed heavy oil range TPH concentrations ranging from 53 mg/kg in the sample collected from the 0–0.5 foot bgs interval of LL-11 to 230 mg/kg in the sample collected from the 1.5–2 feet interval of LL-10. In the Eastern Source Area, diesel range TPH were detected in the samples collected from the 0--0.5 foot bgs intervals of MW-4 and MW-5 at a concentration of 480 mg/kg in both samples, and in the sample collected from the 11.5–13 feet bgs interval of MW-5 at a concentration of 810 mg/kg.

In soil samples analyzed as part of the 2010 to 2011 RI activities, heavy oil range TPH were detected in samples from the Central Source Area in concentrations ranging from 12 mg/kg in the sample collected from the 1.5–2 feet bgs interval of PSB-12 to 2,700 mg/kg in the sample collected from the 2–4 feet bgs interval of PSB-11. In the Eastern Source Area, heavy oil range TPH were detected in concentrations ranging from 12 mg/kg in the sample collected from the 2–4 feet bgs interval of PSB-15 to 930 mg/kg in the sample collected from the 2–4 feet bgs interval of PSB-13. Heavy oil range TPH were not detected in the deep Roto-sonic borings for Wells MW-15 through MW-17. Maximum detected heavy oil range TPH concentrations from all investigations are presented in Figure 4.5.

In soil samples analyzed as part of the 2010 to 2011 RI activities, summed diesel range and heavy oil range TPH were detected in samples from the Central and Eastern Source

Areas at concentrations ranging from 36.3 mg/kg in the sample collected from the 4-6 feet bgs interval of PSB-16 to 3,140 mg/kg in the sample collected from the 2–4 feet bgs interval of PSB-11.

4.2.1.1.3 Semivolatile Organic Compounds

Carcinogenic Polycyclic Aromatic Hydrocarbon Toxicity Equivalent Values

In the Central Source Area, cPAHs were only analyzed in subsurface soil samples collected by GeoScience Management. The highest cPAH TEQs (calculated with non-detect results equal to zero) were detected in samples collected at depths of 14.5 feet bgs and 14 feet bgs in LLP-4 and MW-1. The cPAH TEQs in these samples were 760 µg/kg and 870 µg/kg, respectively.

AECOM detected cPAHs in at least 1 depth interval of all borings in the Central Source Area, with a maximum cPAH TEQ (calculated with non-detect results equal to one-half the reporting limit) of 77.3 µg/kg in the sample collected from the 0–0.5 foot bgs interval of LL-10. In the Eastern Source Area, AECOM reported cPAH TEQs in the 0–0.5 foot bgs intervals of MW-4 and MW-5 as 149 µg/kg and 243 µg/kg, respectively. The deeper 11.5-13 feet bgs soil interval of MW-5 also had a cPAH TEQ of 144 µg/kg.

Generally during the 2010 to 2011 RI, the highest cPAH concentrations (calculated with non-detect results equal to one-half the reporting limit) in the Central Source Area were encountered in the vicinity of the GeoScience Management LLP-2 and LLP-4/MW-1 borings, at PSB-10 and PSB-11. The cPAH TEQ concentrations were highest at PSB-11, with a maximum TEQ of 150 µg/kg in the sample collected from 1.5–2 feet bgs. In the samples collected from PSB-9 or PSB-9A, cPAHs were not detected. In the Eastern Source Area, the maximum detected cPAH TEQ was 350 µg/kg in the sample collected from the 0–0.5 foot bgs interval of PSB-20. The majority of cPAH TEQs in the Eastern Source Area ranged from 13 µg/kg (detected in multiple locations and depths) to 120 µg/kg detected in the sample collected from 0–0.5 foot bgs interval of PSB-15. cPAHs were not detected in the deep boring Roto-sonic locations (MW-15 through MW-17). Maximum detected cPAH TEQ concentrations for each soil boring location are presented in Figure 4.6.

Pentachlorophenol

In the GeoScience Management investigation, PCP was detected at 110 µg/kg in the sample collected from the 7 feet bgs interval of MW-1. PCP was detected in all AECOM samples from the Central Source Area with concentrations ranging from 29 µg/kg in the sample collected from the 1.5–2 feet bgs interval of LL-11 to 1,900 µg/kg in the sample collected from the 1.5–2 feet bgs interval of LL-10. PCP was also detected in the Eastern Source Area, with the highest concentrations (15,000 µg/kg and 2,700 µg/kg) detected in the samples collected from the 0–0.5 foot bgs intervals of MW-4 and MW-5, respectively. All other PCP concentrations in these locations were less than 130 µg/kg.

During the 2010 to 2011 RI, the highest PCP concentrations in the Central Source Area were encountered in PSB-10 and PSB-11. The maximum PCP concentration was

2,400 µg/kg in the sample collected from the 1.5–2 feet bgs interval of PSB-11. Aside from PSB-10 and PSB-11, PCP concentrations ranged from 13 µg/kg in the sample collected from the 2–4 feet bgs interval of PSB-9A to 38 µg/kg in the sample collected from the 0–0.5 foot bgs interval of PSB-9A. The maximum detected PCP concentrations for each soil boring location are presented in Figure 4.7.

4.2.1.1.4 Volatile Organic Compounds

During the GeoScience Management investigation, VOCs were analyzed in samples collected from LLP-4 and LLP-5 in the Central Source Area. At LLP-4, xylenes, toluene, and ethylbenzene were detected in the sample collected from 14.5 feet bgs at concentrations of 12,500 µg/kg, 620 µg/kg, and 1,400 µg/kg, respectively. Chlorinated VOCs were not detected in soil borings from the Central Source Area during the GeoScience Management Investigation. In 2008, AECOM detected 1 or more of the compounds ethylbenzene, xylenes, and toluene in the Central Source Area, with detected concentrations ranging from 0.23 µg/kg for m,p-xylene in the sample collected from the 1.5–2 feet bgs interval of LL-01 to 1.8 µg/kg for toluene in the sample from the 0–0.5 foot bgs interval of LL-01. In the Eastern Source Area, xylenes and toluene were detected in soil samples collected from MW-4 and MW-5 at concentrations ranging from 0.23 µg/kg to 0.73 µg/kg and 0.33 µg/kg to 1.5 µg/kg, respectively.

During the 2010 to 2011 RI, the chlorinated VOCs TCE and PCE were detected in the Central Source Area at concentrations of 0.8 µg/kg in the sample taken from 1.5–2 feet bgs at PSB-11. PCE was also detected at a concentration of 0.6 µg/kg in the sample collected from the 14–16 feet bgs interval of PSB-11. BTEX was not detected in the Central Source Area. Ethylbenzene, xylenes, and toluene were detected in the Eastern Source Area. Ethylbenzene was detected in 2 samples with a maximum concentration of 10 µg/kg detected in the sample collected from the 4–6 feet bgs interval of PSB-21. Toluene was detected in 3 samples with a maximum concentration of 240 µg/kg detected in the sample collected from the 4–6 feet bgs interval of PSB-21. Xylenes were detected in 7 samples with concentrations ranging from 1.4 µg/kg in the sample collected from the 13–15 feet bgs interval of PSB-16 to 1,400 µg/kg detected in the sample collected from the 2–4 feet bgs interval of PSB-20. Figure 4.8 presents all maximum detected VOC results for soil boring locations.

4.2.1.1.4 Dioxins/Furans

GeoScience Management analyzed soil samples collected from MW-1 for dioxins/furans, with resulting TEQ concentrations (calculated with non-detect results equal to zero) of 1,290 pg/g and 302 pg/g in samples from the 7 and 14 feet bgs intervals, respectively. No other soil samples were analyzed for dioxins/furans during the GeoScience Management event. In 2008, AECOM analyzed for dioxins/furans in all borings in the Central Source Area, with maximum dioxin/furan TEQs (calculated using one-half of the method reporting limit for non-detected congeners [ENSR|AECOM, 2008a]) of 493 pg/g and 1,807 pg/g in the samples from the 0–0.5 foot and 1.5–2 feet intervals of LL-01, and 155 pg/g and 2,603 pg/g in samples from the same depth intervals of LL-10. Soil samples collected from the Eastern Source Area as part of the AECOM investigations contained dioxins/furans in all samples from MW-4 and MW-5, with TEQs ranging from 6.43 pg/g in the sample collected from the 14–15.5 feet bgs interval of MW-4 to 3,098 pg/g in the sample collected from the 0–0.5 foot bgs interval of MW-5.

During the 2010 to 2011 RI, dioxin/furan concentrations (calculated with non-detect results equal to one-half the detection limit) were highest in the Central Source Area at PSB-11, with a maximum TEQ of 21,200 pg/g in the sample collected from the 1.5–2 feet bgs interval. Similar to the AECOM LL-01 boring, the sample with the highest dioxin/furan concentrations encountered during the 2010 to 2011 RI were found in a stained, gravelly layer from approximately 2–4 feet bgs in PSB-11. Dioxins/furans were analyzed for and detected to a depth of 14–16 feet bgs in PSB-11 with a TEQ of 2,050 pg/g. The detections associated with this area appear to be highly localized, with concentrations decreasing markedly in the other samples collected in the Central Source Area. Dioxin/furan TEQs ranged from 0.653 pg/g in the sample collected from the 14–15 feet bgs interval of PSB-10 to 1,650 pg/g in the sample collected from the 1.5–2 feet bgs interval of PSB-27. The dioxins/furans in samples collected from the Eastern Source Area during the 2010 to 2011 RI were highest in surface soil within the vicinity of MW-5. In samples collected from the 0–0.5 foot bgs intervals of PSB-15 and PSB-16, dioxin/furan TEQs were 2,260 pg/g and 205 pg/g respectively. Maximum dioxin/furan concentrations in soil are shown in Figure 4.9.

4.2.1.2 Northeast Corner Petroleum

As part of the 2008 soil and groundwater investigation by AECOM, one soil boring was advanced in the Northeast Corner of the LL Apartments Parcel, and completed as Monitoring Well MW-6. During installation, shallow soil above 2 feet bgs and deeper soil below 11 feet bgs were sampled for all of the 2010 to 2011 RI PCOCs, plus additional metals, VOCs, and SVOCs. Subsequent groundwater monitoring by AECOM identified the presence of TPH in MW-6; therefore, as part of the 2010 to 2011 RI, additional soil borings and monitoring wells were installed upgradient of MW-6 to identify potential sources of TPH to MW-6.

During the 2010 to 2011 RI, 3 Geoprobe borings (PSB-22 through PSB-24) and 3 hollow-stem auger borings (MW-12 through MW-14) were advanced in the Northeast Corner, to depths ranging between 17 and 25 feet bgs. Groundwater monitoring wells were installed in the three hollow-stem auger borings. Soil from MW-12 through MW-14 was analyzed for dioxins/furans in shallow intervals above 4 feet bgs and for the full PCOC list (excluding dioxins/furans) below 4 feet bgs, in accordance with the LL Apartments Parcel RI/FS Work Plan (Floyd|Snider 2010a). PSB-22 through PSB-24 soil was analyzed for all PCOCs in shallow intervals above 2 feet bgs excluding chlorinated VOCs, as these chemicals had not previously been detected in this area of the LL Apartments Parcel. Dioxins/furans were not analyzed for in intervals below 2 feet bgs and VOCs were analyzed in the two deepest samples collected from each boring, with depths corresponding to just above and below the water table.

4.2.1.2.1 Arsenic and Lead

In 2008, AECOM analyzed arsenic in MW-6 soil, with a maximum concentration of 9.2 mg/kg detected in the sample collected from the 0–0.5 foot bgs interval.

During the 2010 to 2011 RI, arsenic detections ranged from 6 mg/kg in the sample collected from the 2–4 feet bgs interval of PSB-23 to a maximum of 9 mg/kg in the sample collected from the 0–0.5 foot bgs interval of PSB-24. Maximum detected concentrations of arsenic in soil are shown in Figure 4.1.

AECOM analyzed lead in MW-6, with a maximum concentration of 51.1 mg/kg detected in the sample collected from the 0–0.5 foot bgs interval. During the 2010 to 2011 RI, lead concentrations ranged from 3 mg/kg (collected from multiple locations and depths) to a maximum of 49 mg/kg in the sample collected from the 0–0.5 foot bgs interval of PSB-23. Maximum detected concentrations of lead in soil are shown in Figure 4.2.

4.2.1.2.2 Total Petroleum Hydrocarbons

In 2008, AECOM detected concentrations of diesel range and heavy oil range TPH less than 200 mg/kg in MW-6 soil. During the 2010 to 2011 RI, only heavy oil range TPH was detected in soil collected from borings within the Northeast Corner. Heavy oil range TPH was detected in samples from the 0–0.5 foot bgs intervals of PSB-23 and PSB-24, both at a concentration of 18 mg/kg. Maximum detected concentrations of diesel range TPH are shown in Figure 4.4, and maximum concentrations of heavy oil range TPH are shown in Figure 4.5.

4.2.1.2.3 Semivolatile Organic Compounds

Carcinogenic Polycyclic Aromatic Hydrocarbon Toxicity Equivalent Values

In the 2008 AECOM investigation cPAHs were detected in MW-6 with a maximum TEQ (calculated with non-detect results equal to one-half the reporting limit) of 11.3 µg/kg in the sample collected from the 0–0.5 foot bgs interval. Concentrations in MW-6 soil were present at similar concentrations in samples collected to 13 feet bgs and non-detect at 19 feet bgs. In the 2010 to 2011 RI, cPAHs were detected in samples from the 0-0.5 foot bgs intervals of PSB-23 and PSB-24, both with a cPAH TEQ of 14 µg/kg. Maximum detected cPAH TEQ concentrations for each soil boring location are presented in Figure 4.6.

Pentachlorophenol

In the 2008 AECOM investigation PCP was detected in the 0–0.5 foot bgs interval of MW-6 only, at a concentration of 65 µg/kg. In the 2010 to 2011 RI, PCP was detected in samples from the 0–0.5 foot bgs intervals of PSB-23 and PSB-24, both at a concentration of 14 µg/kg. Maximum detected PCP concentrations for each soil boring location are presented in Figure 4.7.

4.2.1.2.4 Volatile Organic Compounds

During the 2008 AECOM investigation, toluene was the only 2010 to 2011 RI PCOC VOC detected in Northeast Corner soil. Toluene was detected in MW-6 at concentrations ranging from 0.22 µg/kg in the sample collected from the 11.5–13 feet bgs interval to 0.66 µg/kg in the sample collected from the 0–0.5 foot bgs interval. In the 2010 to 2011

RI, the only VOC detected was PCE, at a concentration of 0.9 µg/kg in the sample collected from the 5.5–7.5 feet bgs interval of MW-12. Figure 4.8 presents all maximum detected VOC results for soil boring locations.

4.2.1.2.5 Dioxins/Furans

In the 2008 AECOM investigation, dioxins/furans were detected in MW-6 with a maximum TEQ (calculated with non-detect results equal to one-half the detection limit) of 9.92 µg/kg in the sample collected from the 0–0.5 foot bgs interval. In the 2010 to 2011 RI, dioxin/furan TEQs were detected at a maximum of 26.2 pg/g in the surface soil from MW-13. Throughout the Northeast Corner sample locations, dioxin/furan TEQs (aside from the maximum TEQ) ranged from 0.893 pg/g in the sample collected from the 4--5.5 feet bgs interval of MW-12 to 24.8 pg/g in the sample collected from the 1.5–2 feet bgs interval of MW-13, with the highest TEQs generally occurring in the 0–0.5 and 1.5--2 feet bgs intervals. Maximum detected dioxin/furan TEQ concentrations for each soil boring location are presented in Figure 4.9.

4.2.1.3 Site-wide Shallow Dioxins/Furans

Results of the previous investigations at the Site identified the presence of dioxin/furan contamination in the shallow surface soil (from 0 foot bgs to 4 feet bgs) at the LL Apartments Parcel. To better define the extent of this contamination, additional shallow borings were installed across the Site as part of the 2010 to 2011 RI and analyzed for dioxins/furans. Dioxin/furan data for shallow soil are available from 48 boring locations across the LL Apartments Parcel. Of these 48 locations, detected concentrations of dioxins/furans are near or less than the investigation screening level of 5 pg/g in 14 of those locations. These borings are located mainly along the northern and southern-most portions of the property. The following section discusses the results of dioxin/furan analyses in shallow soil samples collected from the surface to 4 feet bgs. Concentrations of dioxins/furans that exceed the investigation screening levels are generally located in the Eastern Source Area along the eastern property line, in the Central Source Area, and extending west through the center of the property. The shallow borings installed as part of the 2010 to 2011 RI for investigation of shallow dioxin/furan contamination are shown on Figure 2.7. Figure 4.10 presents the dioxin/furan TEQ concentrations observed in samples collected from the 0–0.5 foot bgs interval. Figure 4.11 presents dioxin/furan TEQ concentrations from site borings in the 0.5–2 feet bgs interval, and Figure 4.12 presents dioxin/furan TEQ concentrations at the 2–4 feet depth interval. As seen in the figures, the majority of elevated dioxin/furan concentrations (greater than the 2010 to 2011 RI screening level of 5 pg/g) occur in these shallow soil intervals.

The maximum detected concentration for each boring installed at the LL Apartments Parcel occurs within the top 4 feet of soil at the Site. All of the maximum detections shown on Figure 4.9 occur in either the surface (0 to 0.5 foot) interval, the 0.5-to-2-foot interval or the 2-to-4-foot interval, as shown in Figures 4.10 through 4.12. Dioxin/furan TEQs in the top 2 feet of soil in the Northeast Corner (including MW-6, MW-13, PSB-23, and PSB-24) typically ranged from 7.21 pg/g (PSB-23) to 26.2 pg/g (MW-13). The maximum dioxin/furan TEQ concentration observed in MW-13 of 26.2 pg/g was in the sample collected from the 0-to-0.5-foot interval. All other concentrations of dioxin/furan TEQs greater than the 5 pg/g screening level in the Northeast Corner were observed in the 0.5-to-2-foot interval.

Extending from the Northeast Corner towards the northwest corner of the Site, dioxin/furan concentrations in borings were around the investigation screening level of 5 pg/g. The maximum dioxin/furan TEQ concentration in borings installed along the northern portion of the LL Apartments Parcel from the Northeast Corner to the central portion (including LL-09, MW-14, PSB-05, PSB-07, PSB-22, and SSB-10) was 12.8 pg/g in the sample collected from 1.5–2 feet bgs interval at PSB-5. The remainder of the sample results was all generally less than 5 pg/g. This area incorporates approximately 20 percent of the Site where dioxin/furan concentrations are around the investigation screening level of 5 pg/g.

Concentrations of dioxins/furans greater than the 5 pg/g screening level were observed in borings between the Central and Eastern Source Areas and the Northeast Corner in Borings PSB-13, PSB-21, and MW-12 at TEQ concentrations ranging from 7.78 pg/g (PSB-21) to 187 pg/g (PSB-13). Dioxins/furans in these 3 locations were primarily observed between the surface and 4–6 feet bgs. In PSB-21 and MW-12, TEQ concentrations reduce to less than 3 pg/g in the 4–6 feet bgs interval. At PSB-13, dioxin/furan TEQ concentrations drop to 2.5 pg/g in the sample collected from 11–13 feet bgs. No samples were analyzed between 6 feet and 11 feet in PSB-13.

Moving from the Central and Eastern Source Areas to the northwest corner of the LL Apartments Parcel, dioxins/furans were detected in borings in the western and northwestern portions of the property in Borings LL-11, LL-12, PSB-3, PSB-4, PSB-9A, and MW-2. In these locations, dioxins/furans were detected in the surface samples collected from 0–0.5 foot bgs interval, and ranged in TEQ concentration from 11.6 pg/g (PSB-9A) to 234 pg/g (LL-12). In each location, samples collected from the 1.5–2 feet bgs depth interval contained substantially lower concentrations of dioxin/furan TEQs, ranging from 0.10 pg/g (MW-2) to 5.28 pg/g (LL-12). Dioxin/furan concentrations in the northwest corner of the Site are also bound to the west and north by Borings SSB-1 and SSB-4, which contained concentrations of dioxin/furan TEQs at 3.93 pg/g and 2.81 pg/g, respectively, in the 0–0.5 foot bgs interval.

Soil borings in the southwest corner of the LL Apartments Parcel (LL-07, LL-08, PSB-1, PSB-2, PSB-6, SSB-2, SSB-3 and SSB-5) generally contained detected concentrations of dioxin/furan TEQs to depths of 2 feet bgs ranging from 0.53 pg/g (SSB-05) to 33.8 pg/g (LL-07) with the exceptions of PSB-6 and LL-08. These two borings, located along the southern property line towards the central portion of the property, contained higher concentrations of dioxins/furans than the other borings in this area. In these 2 locations, elevated concentrations of dioxins/furans were detected to 2 feet bgs at location PSB-6, and to 4 feet bgs in LL-08. The maximum detected TEQ concentration in these 2 borings was 702 pg/g in the sample collected from the 1.5–2 feet bgs interval of PSB-6. The sample collected immediately below this elevated concentration from a depth interval of 2–4 feet bgs contained a dioxin/furan TEQ concentration of 0.94 pg/g. In Boring LL-08, the sample collected from 2–4 feet bgs contained a dioxin/furan TEQ of 650 pg/g. The next sample collected from this location was from a depth interval of 13–15 feet bgs, and contained a dioxin/furan TEQ of 0.78 pg/g. The horizontal extent of this elevated dioxin/furan contamination is bound to the south by borings located on the Former Seattle City Light Sunnydale Substation property, and is discussed in greater detail in Section 4.2.1.4 below.

In the southern and southeastern corner of the LL Apartments Parcel, in the vicinity of boring locations HA-1, HA-3, MW-3, PSB-17 and PSB-8, dioxin/furan TEQ concentrations ranged from 0.37 pg/g (HA-1, 0–0.5 foot) to 17.7 pg/g (HA-3) with the majority of samples between 0.37 pg/g and 3.15 pg/g (HA-1, 1.5–2 feet). The sample collected from HA-3 from the 0-to-0.5-foot interval with a TEQ concentration of 17.7 pg/g was the only sample exceeding this range. This area of the Site comprises an approximate 10 percent of the property where dioxin/furan contamination is not present in soil at concentrations greater than the range of 0 to 17.7 pg/g, as shown in Figure 4.9.

Surface soil dioxin/furan concentrations in the Central and Eastern Source Areas were generally greater than the 5 pg/g screening level, ranging in TEQ concentration from 7.93 pg/g (PSB-17) to 21,200 pg/g (PSB-11).

4.2.1.4 Other Area Soil

The 2008 soil investigation by AECOM advanced several soil borings around the Site in areas that were not further investigated during the 2010 to 2011 RI because the detected contaminant concentrations in these areas generally did not exceed investigation screening levels for the PCOCs identified in the RI/FS Work Plan (Floyd|Snider 2010a). Areas of the LL Apartments Parcel outside of the main source areas discussed in the previous sections where contaminant concentrations exceed screening levels based on historical data are described in the sections below. The following borings are located outside the main source areas:

- LL-07 located in the southwest corner of the property
- LL-08 located on the LL Apartments Parcel adjacent to the northeast corner of the Former Seattle City Light Sunnydale Substation
- MW-2 and MW-3 located in the northwest and southwest corners of the property
- LL-09 located near the Northeast Corner
- LL-12 located to the west of the Central Source Area

During previous investigations, soil samples in these locations were collected and analyzed to a depth of approximately 15 feet bgs, with the exception LL-07 where samples were collected to a depth of only 2 feet bgs. Samples were analyzed for all of the 2010 to 2011 RI PCOCs, plus additional metals, VOCs, and SVOCs.

4.2.1.4.1 Arsenic and Lead

AECOM detected arsenic in all samples collected from the Other Area soil borings. Arsenic detections ranged from 0.89 mg/kg in the sample collected from the 13–15 feet bgs interval of LL-12 to a maximum of 11.2 mg/kg in the sample collected from the

0--0.5 foot bgs interval of MW-2. Maximum detected concentrations of arsenic in soil are shown in Figure 4.1.

AECOM detected lead in all samples collected from the Other Area soil borings. Lead detections ranged from 1.82 mg/kg in the sample collected from the 6.5–8 feet bgs interval of MW-2 to a maximum of 108 mg/kg in the sample collected from the 2–4 feet bgs interval of LL-08. Maximum detected concentrations of lead in soil are shown in Figure 4.2.

4.2.1.4.2 Total Petroleum Hydrocarbons

AECOM detected gasoline range TPH in two samples only in their investigation of the Other Areas. Gasoline range TPH was detected at concentrations of 5.4 mg/kg and 0.65 mg/kg in the samples collected from the 2–4 feet bgs interval of LL-08 and the 0--0.5 foot bgs interval of MW-3, respectively.

Both diesel range and heavy oil range TPH were detected more frequently than gasoline range TPH. Diesel range TPH was detected in Borings LL-07, LL-08, LL-09, and LL-12 at concentrations ranging from 1.4 mg/kg in the sample collected from the 13–15 feet bgs interval of LL-08 to 160 mg/kg in the sample collected from the 2–4 feet bgs interval of LL-08. Heavy oil range TPH was detected in at least 1 sample from all borings except MW-3 at concentrations ranging from 27 mg/kg in the sample collected from the 0--0.5 foot bgs interval of LL-09 to 610 mg/kg in the sample collected from the 2–4 feet bgs interval of LL-08. The maximum summed diesel range and heavy oil range TPH concentration of 770 mg/kg was detected in the sample collected from the 2–4 feet bgs interval of LL-08.

Maximum detected concentrations of gasoline range TPH are shown in Figure 4.3, diesel range TPH in Figure 4.4, and heavy oil range TPH in Figure 4.5.

4.2.1.4.3 Semivolatile Organic Compounds

Carcinogenic Polycyclic Aromatic Hydrocarbon Toxicity Equivalent Values

In the 2008 AECOM investigation cPAHs were detected in at least 1 sample from all Other Area boring locations with a cPAH TEQ (calculated with non-detect results equal to one-half the reporting limit) ranging from 4.1 µg/kg in the sample collected from the 1.5–2 feet bgs interval of LL-12 to 156 µg/kg in the sample collected from the 2–4 feet bgs interval of LL-08. This maximum detection was the only cPAH exceedance of the investigation screening level of 137 µg/kg. This slight exceedance is located in an area that also contains concentrations of dioxins/furans at similar depths that exceed the investigation screening levels for dioxins/furans.

During the 2009 Pinnacle GeoSciences investigation of the Former Seattle City Light Sunnydale Substation property, cPAHs were analyzed in Borings DP-3 and DP-8. Resultant cPAH TEQs (calculated with non-detect results equal to one-half the reporting limit) ranged from 0.1 µg/kg in multiple samples collected from DP-8, to 13 µg/kg in the sample collected at 1.5 feet bgs from DP-3. Maximum detected cPAH TEQ concentrations for each soil boring location are presented in Figure 4.6.

Pentachlorophenol

AECOM detected PCP in boring locations LL-07, LL-08, LL-12, and MW-2 with concentrations ranging from 38 µg/kg in the sample collected from the 0–0.5 foot bgs interval of LL-07 to 340 µg/kg in the sample collected from the 2–4 feet bgs interval of LL-08. The maximum detected PCP concentrations for each soil boring location are presented in Figure 4.7.

4.2.1.4.4 Volatile Organic Compounds

During the 2008 AECOM investigation, toluene was the most commonly detected 2010 to 2011 RI PCOC. Toluene was detected at concentrations ranging from 0.22 µg/kg in the sample collected from the 14–15.5 feet bgs interval of MW-3 to 3.1 µg/kg in the sample collected from the 0–0.5 foot bgs interval of LL-12. Ethylbenzene and xylenes were also detected, with maximum concentrations of 0.46 µg/kg and 1.6 µg/kg, respectively, in the sample collected from the 0–0.5 foot bgs interval of LL-12. Figure 4.8 presents all maximum detected VOC results for soil boring locations.

4.2.1.4.5 Dioxins/Furans

AECOM detected dioxins/furans in all Other Area samples with a dioxin/furan TEQ (calculated with non-detect results equal to one-half the detection limit) ranging from 0.034 pg/g in the sample collected from the 13–15 feet bgs interval of LL-09 to 650 pg/g in the sample collected from the 2–4 feet bgs interval of LL-08.

During the 2009 Pinnacle GeoSciences investigation of the Former Seattle City Light Sunnydale Substation property, dioxins/furans were detected in samples collected from Locations DP-1, DP-2, DP-3, and DP-9. A maximum dioxin/furan TEQ (calculated with non-detect results equal to one-half of the detection limit) of 56 pg/g was detected in the sample collected at 1.5 feet bgs from DP-3 located in the Northeast Corner of the property. The underlying sample collected at 3 feet bgs from DP-3 had a dioxin/furan TEQ of 0.01 pg/g, and samples collected from Boring DP-2 to the west and Boring DP-9 to the south had maximum dioxin/furan TEQs of 1.61 pg/g and 4.29 pg/g, respectively in samples collected from 1.0 foot bgs.

Maximum detected dioxin/furan TEQ concentrations for each soil boring location (including the Former Seattle City Light Sunnydale Substation locations) are presented in Figure 4.9.

4.2.2 Groundwater Quality

Groundwater quality has been assessed at the Site throughout the environmental investigations completed to date, including the 2010 to 2011 RI. As part of the 2007 GeoScience Management investigation, qualitative groundwater samples were collected on the LL Apartments Parcel from Geoprobe Borings LLP-2 through LLP-6 and LLP-8 though LLP-9. As part of the 2008 AECOM investigation, groundwater samples were collected from shallow aquifer Monitoring Wells MW-1 through MW-11 on the LL Apartments Parcel and downgradient at the western edge of the LL Parcel. As part of the 2010 to 2011 RI, groundwater samples were collected from shallow aquifer Monitoring Wells MW-1 through MW-14 at the LL Apartments Parcel and downgradient, and three wells at the DMCA (B-310 through B-312). Groundwater samples were also collected from the newly installed deep Monitoring Wells MW-15, MW-16, and MW-17.

Typically, groundwater samples collected from Geoprobe locations are used qualitatively to inform identification of source areas, and to generally identify the presence or absence of groundwater contamination. Groundwater samples collected from Geoprobe locations are collected directly from the subsurface without filtration through a sand pack or purging, which often results in high sample turbidity. In addition, sample results are not reproducible as the borings are temporary, and backfilled immediately following sampling. Geoprobe groundwater data are discussed below, but are not included in the RI evaluation of current groundwater quality at the Site due to these qualitative limitations. The existing permanent monitoring well network provides adequate coverage of the Site, and allows for data collection according to standard groundwater sampling techniques (including purging and water quality monitoring prior to sample collection). Since monitoring well data are available throughout the Site, and given the limitations on applicability of Geoprobe water data, the Geoprobe groundwater data are included in the discussions below of historical sampling results, for qualitative identification of the presence of PCOCs, but are not used in the quantitative definition of the nature and extent of site groundwater contamination.

Groundwater sampling conducted by AECOM from 2007 to 2008 targeted specific wells and specific analytes during each monitoring event, and did not analyze all wells or PCOCs during any single event. Therefore, the resulting dataset does not provide a complete snapshot of groundwater quality conditions throughout the Site at any given time. In addition, sampling methods were not well documented, and turbidity information is unavailable. Given the hydrophobic nature of the site PCOCs, turbidity information is critical, as elevated contaminant concentrations in groundwater samples may be associated with solids content rather than dissolved-phase contamination. The groundwater data from these AECOM investigations are discussed in the following sections only as a qualitative source of information to identify the presence of potential contamination, and are not carried forward into the determination of nature and extent of groundwater contamination at the Site.

4.2.2.1 Site-wide Shallow Aquifer Groundwater Quality

Shallow aquifer groundwater has been monitored in nine separate sampling events since 2007. GeoScience Management collected Geoprobe groundwater samples from the Central Source Area in July 2007, and then subsequently sampled groundwater from MW-1 twice, in November and December 2007. AECOM sampled on-site wells MW-1 through MW-6 in March 2008, and re-sampled MW-3 through MW-5, as well as newly installed off-property wells MW-8 through MW-11 in August 2008. AECOM also conducted a third, targeted sampling event in December 2008. This event collected a representative upgradient sample from MW-2, a sample from MW-6, which was dry during the August event, a sample from newly-installed MW-7 and a sample from MW-10, which had the highest dioxin/furan concentration during the August event. As part of the 2010 to 2011 RI, Wells MW-1 through MW-14 were sampled during three monitoring events in

August 2010, January 2011, and April 2011 (with the exception of MW-6, which was not sampled in August 2010 due to insufficient groundwater for sample collection).

4.2.2.1.1 Arsenic and Lead

In the 2007 GeoScience Management investigation, Geoprobe groundwater samples from LLP-4, LLP-5, LLP-8, and LLP-9 were analyzed for dissolved arsenic. Concentrations of 65 µg/L and 8.1 µg/L were detected in LLP-4 and LLP-9, respectively. In 2008, AECOM analyzed samples collected from MW-1 through MW-11 (except MW-7) for total arsenic. Concentrations ranged from 0.22 µg/L to 10.5 µg/L, detected in MW-1.

Detected concentrations of dissolved arsenic in groundwater during the 2010 to 2011 RI monitoring events ranged from 0.2 µg/L to 11.9 µg/L in MW-1 during the January 2011 sampling event. During the April 2011 sampling event, the groundwater sample collected from MW-1 was analyzed for total arsenic with a detected concentration of 14.2 µg/L. Maximum detections of arsenic in groundwater from the 2010 to 2011 RI sampling events are shown in Figure 4.13.

In 2007, the same Geoprobe samples that were analyzed for arsenic were also analyzed for lead. Dissolved lead was only detected once at a concentration of 1.2 µg/L in LLP-4. In 2008, AECOM detected total lead at concentrations ranging from 0.017 µg/L to 0.324 µg/L in MW-6.

Lead was not detected in any of the shallow aquifer monitoring wells during the 2010 to 2011 RI monitoring events.

4.2.2.1.2 Total Petroleum Hydrocarbons

<u>Gasoline Range Total Petroleum Hydrocarbons</u>

In the 2007 GeoScience Management investigation, Geoprobe groundwater samples from LLP-4, LLP-5, LLP-8, and LLP-9 were analyzed for gasoline range TPH. Additionally, two samples from MW-1, one in November 2007 and one in December 2007, were also analyzed. Concentrations of 2.0 mg/L and 0.22 mg/L were detected in Geoprobe samples LLP-4 and LLP-5, respectively. Gasoline range TPH was also detected in MW-1 at concentrations of 2.1 mg/L and 0.21 mg/L, respectively, during the November and December sampling events. In 2008, AECOM analyzed samples collected from MW-1 through MW-6 for gasoline range TPH. Concentrations ranged from 0.017 mg/L to 0.39 in MW-1.

During the 2010 to 2011 RI monitoring events, gasoline range TPH was detected at concentrations of 0.4 mg/L and 0.46 mg/L in MW-1. Gasoline range TPH was not detected in samples collected from other wells during the 2010 to 2011 RI sampling events.

<u>Diesel Range Total Petroleum Hydrocarbons</u>

During the 2007 GeoScience Management investigation, all Geoprobe groundwater samples were analyzed for diesel range TPH, as well as the two groundwater samples from MW-1. All Geoprobe samples except LLP-8 and LLP-9 had detected concentrations of diesel range TPH. Concentrations ranged from 0.28 mg/L to 6.7 mg/L in LLP-2. Diesel range TPH was also detected in MW-1 at concentrations of 11.0 mg/L and 2.3 mg/L during the November 2007 and December 2007 sampling events, respectively. In 2008, AECOM analyzed samples collected from MW-1 through MW-11 (except MW-7) for diesel range TPH. Concentrations of 6.3 mg/L and 7.3 mg/L were detected in MW-1 and MW-6, respectively.

During the 2010 to 2011 RI monitoring events, diesel range TPH was detected at a concentration of 0.18 mg/L in both MW-1 and MW-6 during the January 2011 and April 2011 sampling events, respectively. Diesel range TPH was not detected in samples collected from other wells during the 2010 to 2011 RI.

Heavy Oil Range Total Petroleum Hydrocarbons

In the 2007 GeoScience Management investigation, all Geoprobe groundwater samples were analyzed for heavy oil range TPH, as well as the two groundwater samples collected from MW-1 in 2007. All Geoprobe samples except LLP-8 and LLP-9 had detected concentrations of heavy oil range TPH. Concentrations ranged from 0.69 mg/L to 7.8 mg/L in LLP-2. Heavy oil range TPH was also detected in MW-1 at concentrations of 4.8 mg/L and 2.5 mg/L during the November and December sampling events, respectively. In 2008, AECOM analyzed samples collected from MW-1 through MW-11 (except MW-7) for heavy oil range TPH. Concentrations of 8.3 mg/L and 0.89 mg/L were detected in MW-1 and MW-6, respectively.

During the 2010 to 2011 RI monitoring events, heavy oil range TPH was only detected in MW-1 at a concentration of 0.53 mg/L. Heavy oil range TPH was not detected in samples collected from other wells during the 2010 to 2011 RI.

4.2.2.1.3 Semivolatile Organic Compounds

Carcinogenic Polycyclic Aromatic Hydrocarbon Toxicity Equivalent Values

In the 2007 GeoScience Management investigation, cPAHs were analyzed in Geoprobe samples taken from LLP-4, LLP-5, LLP-8, LLP-9, and also from MW-1. The cPAH TEQ concentrations (calculated using non-detects equal to zero) in samples collected from Geoprobe locations ranged from 0.004 µg/L to 0.136 µg/L in LLP-4. The maximum detected cPAH TEQ concentration was observed in MW-1 at 0.407 µg/L. In 2008, AECOM analyzed for cPAHs in all monitoring wells with the exception of MW-7. In MW-1 cPAH TEQ concentrations ranged from 0.06 µg/L to 1.0 µg/L.

In sampling conducted as part of the 2010 to 2011 RI, cPAHs were only detected in samples collected from MW-1 during the January 2011 and April 2011 monitoring events, with cPAH TEQ concentrations of 0.028 µg/L and 0.011 µg/L, respectively. Maximum detections of cPAHs in groundwater from the 2010 to 2011 RI sampling events are shown in Figure 4.14.

Pentachlorophenol

In the 2007 GeoScience Management investigation, PCP was analyzed in Geoprobe samples taken from LLP-4, LLP-5, LLP-8, LLP-9, and also from MW-1. PCP was detected at the highest concentrations observed in groundwater in samples collected from the LLP-4 Geoprobe location and MW-1 during the November 2007 event, with concentrations of 120 and 150 µg/L, respectively; however, the PCP concentration in MW-1 decreased to 5.7 µg/L in December 2007.

During the 2010 to 2011 RI sampling events, PCP was detected in samples collected from Wells MW-1, MW-5, and MW-9 at concentrations ranging from 0.29 µg/L in MW-9 to 1.4 µg/L in MW-5. PCP was not detected in any other groundwater samples during the 2010 to 2011 RI. Maximum detections of PCP in groundwater from the 2010 to 2011 RI sampling events are shown in Figure 4.15.

4.2.2.1.4 Volatile Organic Compounds

During the 2007 GeoScience Management investigation, benzene, toluene, ethylbenzene, xylene, cis-1,2-DCE, trans-1,2-DCE, 1,2-DCA, TCE, and PCE were detected in the Geoprobe samples from LLP-4 and MW-1. With the exceptions of a xylene detection of 50 µg/L and a toluene detection of 8.1 µg/L in LLP-4, all other detections of these VOCs were less than 5.0 µg/L. These VOCs were not detected in any of the other groundwater sample locations. Analytical results from the 2008 AECOM investigations were similar to the results from the GeoScience Management investigation.

During the 2010 to 2011 RI, VOCs were primarily detected in samples collected from MW-1, at concentrations generally less than 5 µg/L. In a sample collected from MW-5 during the August 2010 event, 1,2-DCA and cis-1,2-DCE were detected at 0.07 and 0.028 µg/L, respectively. PCE was detected at 0.035 µg/L in the sample collected from MW-13 during the August 2010 event. Figure 4.16 presents all detected concentrations of VOCs in groundwater during the 2010 to 2011 RI monitoring events.

4.2.2.1.4 Dioxins/Furans

During the 2007 GeoScience Management investigation, only MW-1 was analyzed for dioxins/furans. The dioxin/furan TEQ concentration (calculated using one-half the detection limit for non-detects) was 105 pg/L. AECOM analyzed samples collected from MW-1 through MW-11 (except MW-7) for dioxins/furans. The dioxin/furan TEQ concentrations (detected in all locations) ranged from 0.52 pg/L to 234 pg/L in MW-1.

During the 2010 to 2011 RI sampling events, At least one dioxin/furan congener was detected in all wells except MW-14, which had no detections. Dioxin/furan concentrations in groundwater have consistently been highest in samples collected from MW-1, with dioxin/furan TEQs ranging from 18.8 pg/L in August 2010 to 38.3 pg/L in January 2011. Site-wide, dioxins/furans have been detected occasionally (except in MW-14), with TEQs typically ranging from 1.43 to 5.86 pg/L when excluding MW-1 detections. Maximum detections of dioxin/furan TEQs in groundwater from the 2010 to 2011 RI sampling events are shown in Figure 4.17.

4.2.2.2 Deep Groundwater Quality

Monitoring Wells MW-15 through MW-17 were installed during the 2010 to 2011 RI to evaluate groundwater conditions at the Site immediately above the first encountered confining unit. This was done to investigate the potential for historical operations to have released DNAPL contaminants at the Site that would have migrated down through the groundwater table until encountering a confining geologic unit. MW-15 through MW-17 were located in the Central and Eastern Source Areas. Wells were installed to depths ranging from 50 to 60 feet bgs. No DNAPL or indications of contamination were observed during the installation of these three wells. These deep wells were sampled three times, in September 2010, January 2011, and April 2011.

Deep monitoring wells were sampled for SVOCs, metals, TPH, and VOCs, with a single heavy oil range TPH detection of 0.2 mg/L in the sample collected from MW-15 in September 2010. No other analytes were detected in any well during any sampling event.

4.2.3 Lora Lake Apartments Parcel Physical Conditions

Generally, soil in the LL Apartments Parcel is composed of sands and silty sands deposited by glacial outwash, overlain by a fill layer of varying thickness composed primarily of well-graded sands and gravels. The thickest fill layers, which were observed from ground surface down to approximately 3 feet bgs in the northeast to 11 feet bgs in the southeast, were encountered in the Central Source Area during this investigation (refer to Attachments F.1, Soil Boring Logs, and F.2, Monitoring Well Installation Logs). The deepest portion of this fill was in the vicinity of stained gravels located at approximately 4 feet bgs and 14 feet bgs that exhibited a hydrocarbon odor and sheen, and to the east in the vicinity of MW-5. PCOC concentrations were positively correlated with the presence of fill, with the highest concentrations of dioxins/furans, cPAHs, PCP, and metals occurring in the top 4 feet of the PSB-11 soil boring in the southeast corner of the former Recreation Building, which had a stained gravelly layer at approximately 4 feet bgs. PCOC concentrations decreased below this layer, and were not strongly correlated with the presence of a second stained interval with a hydrocarbon odor at approximately 15 feet bgs. Consistent with the observations made by GeoScience Management and AECOM, the relatively higher PCOC concentrations above and around 4 feet bgs in this area suggest that it may be the former work surface during the era of barrel-washing operations on the parcel.

In the Eastern Source Area, fill soil increased in thickness, extending on average from ground surface to approximately 10 feet bgs. PCOC concentrations in this vicinity, though also correlated with the presence of fill, had the highest dioxin/furan, cPAH, and PCP concentrations occurring primarily in the top 2 feet of soils and decreasing markedly below.

Fill was absent in the Northeast Corner of the Site, and was not readily distinguishable in borings to the west in the likely upgradient direction. Similarly, PCOCs were generally encountered in lower concentrations in these locations.

Groundwater elevations were monitored during three separate events for this investigation, in fall 2010, and winter and spring 2011. Generally, groundwater elevations followed the topography of the LL Apartments Parcel, with elevations fluctuating seasonally between 295 and 298 feet (North American Vertical Datum of 1988 [NAVD88]) in MW-2 in the Northwest Corner. Elevations in MW-1, MW-3, and MW-16 in the center of the parcel ranged between approximately 285 and 290 feet, and decreased to 278 to 280 feet in the MW-4 and MW-5 farther east. Northeast corner wells had similar groundwater elevations to the wells in the Eastern Source Area.

The downgradient wells across Des Moines Memorial Drive ranged from minimum elevations of 278 down to 270 feet, and maximum elevations of 280 down to 275 feet. Groundwater elevations in this area were lowest in MW-9 and increased to the north and south. Taken together with groundwater elevation data on the LL Apartments Parcel data, this suggests a primarily west-east hydraulic gradient, with groundwater moving generally from the northwest and southwest to the east.

4.3 LORA LAKE PARCEL INVESTIGATIONS

Investigation activities at the LL Parcel included surface and subsurface sediment quality evaluation and bioassay testing. In addition, shallow soil quality investigation activities were conducted along the western property boundary to assist with defining the nature and extent of chemicals in shallow soil, and to evaluate potential connectivity of contaminants in shallow soil at the LL Parcel to shallow soil at the LL Apartments Parcel. Results of the sediment quality and shallow soil investigation activities are summarized in the following sections, and discussed in detail in the LL Parcel Data Report (Appendix G).

4.3.1 Lora Lake and Miller Creek Sediment Quality

Sediment investigation activities on the LL Parcel collected and analyzed three subsurface sediment cores in Lora Lake and eight surface sediment grab samples in Lora Lake and Miller Creek. The sediment sampling locations are shown on Figure 3.5. Both subsurface and surface sediment samples were chemically analyzed for the sediment PCOCs. PCOC detections in surface sediments are shown in Figure 4.18, and PCOC detections in subsurface sediments are shown in Figure 4.19. Additionally, biological testing was performed on seven of the surface sediment samples—four from Lora Lake and three from Miller Creek. Bioassay results are shown in Figure 4.20, while Tables 4.3 through 4.6 provide a summary of the Lora Lake and Miller Creek sediment analytical results (frequency of detections) and biological testing results. These results are summarized below.

4.3.1.1 Surface and Subsurface Sediment Analytical Results

4.3.1.1.1 Conventionals

TOC percentages, total solids percentages, sulfide concentrations, and grain size distributions varied widely between the sediment samples collected within Lora Lake, the Lora Lake surface sediment sample collected from the sediment settling basin, and the Miller Creek surface sediment samples.

TOC levels in the Lora Lake surface sediment samples from LL-SED1 through LL-SED4 ranged from 5.8 to 10.6 percent, while the LL-SED5 sample, from the lake's sediment settling basin, showed TOC at 0.90 percent. The TOC levels in the Lora Lake subsurface sediment samples ranged from 4.2 to 26.1 percent. The highest TOC level was detected in the 56–112 cm sampling interval from the LL-SED2 core. TOC levels in the Miller Creek surface sediment samples, MC-SED1 through MC-SED3, ranged from 0.15 to 0.54 percent.

Total solids in the LL-SED1 through LL-SED4 surface sediment samples ranged from 15.4 to 20.7 percent. The LL-SED5 sample was 81.6 percent total solids and the Miller Creek surface sediment samples ranged between 77.2 and 85.2 percent total solids.

Surface sediment samples from LL-SED1 through LL-SED4 had sulfide concentrations ranging between 984 mg/kg and 2,670 mg/kg. The highest concentration was detected in the LL-SED2 surface sediment sample. Sulfide was analyzed in 2 Lora Lake subsurface sediment samples where peat was observed (LL-SED3 core samples from 36–141 cm and 141–167 cm), but was not detected in either sample. The surface sediment sample from LL-SED5 had sulfide detected at a concentration of 31.4 mg/kg. Sulfide was only detected in 1 of the Miller Creek surface sediment samples, the sample from MC-SED1, at a concentration of 48.6 mg/kg.

Generally, grain size in the surface sediment samples collected within Lora Lake corresponded with field observations of silty sediment. These Lora Lake surface sediment samples, with the exception of the sample from LL-SED1, were greater than 70 percent fines. The surface sediment sample from LL-SED1 had a lower percentage of fines, at approximately 50 percent, also reflective of the sandier sediment materials observed in the field at this location. The surface sediment sample from LL-SED5, collected from the settling basin, was predominately sand (greater than 62.5 microns) with some gravel. The grain size distribution of the Miller Creek surface sediment samples reflected the gravelly nature of these sediments. Generally, over 95 percent of the Miller Creek surface sediment samples consisted of materials greater than 250 µm in diameter, with greater than 50 percent of the sample consisting of gravel.

4.3.1.1.2 Arsenic and Lead

Arsenic was detected in all of the Lora Lake surface and subsurface sediment samples with the exception of the sample interval from 36–141 cm in the LL-SED3 core. Arsenic concentrations ranged from 7 mg/kg in the surface sample from LL-SED5 to 80 mg/kg in all three sample intervals from the LL-SED2 core. Arsenic was detected in only 1 of the

Miller Creek surface sediment samples, the sample from MC-SED1, with a concentration of 8 mg/kg. Detected concentrations of arsenic in surface and subsurface sediments are shown in Figures 4.18 and 4.19.

Lead was detected in all of the Lora Lake surface sediment samples and only in the top sample intervals of the three subsurface sediment cores. Concentrations of lead ranged from 29 mg/kg in the 0–56 cm sample interval from the LL-SED1 core to 492 mg/kg in the surface sample from LL-SED4. Lead concentrations in the 3 surface sediment samples from Miller Creek were less than the concentrations detected in the Lora Lake surface sediment samples, with a maximum concentration of 12 mg/kg in the sample from MC-SED1. Detected concentrations of lead in surface and subsurface sediments are shown in Figures 4.18 and 4.19.

4.3.1.1.3 Semivolatile Organic Compounds

<u>Carcinogenic Polycyclic Aromatic Hydrocarbon Toxicity Equivalent Values</u>

cPAHs were detected in all of the Lora Lake surface sediment samples and in the top sample intervals from the three subsurface sediment cores. Generally, minimal to no cPAHs were detected in the deeper sediment core samples. The maximum TEQ (calculated with non-detect results equal to one-half the reporting limit) for cPAHs observed in sediment core samples was 580 µg/kg in the 0–56 cm sample interval from the LL-SED2 core. The maximum cPAH TEQ for the Lora Lake surface sediment samples was 180 µg/kg, detected in the sample from LL-SED1. No cPAHs were detected in the Miller Creek surface sediment samples. Detected concentrations of cPAHs in surface and subsurface sediments are shown in Figures 4.18 and 4.19.

<u>Pentachlorophenol</u>

PCP was detected in 2 of the Lora Lake surface sediment samples, the LL-SED1 and LL-SED5 samples, at concentrations of 50 µg/kg and 33 µg/kg, respectively. PCP was not detected in any of the Lora Lake subsurface sediment samples or the Miller Creek surface sediment samples. Detected concentrations of PCP in surface sediments are shown in Figure 4.18.

4.3.1.1.4 Volatile Organic Compounds

PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and 1,2-DCA were not detected in any of the Lora Lake surface sediment samples, or the Miller Creek surface sediment samples.

4.3.1.1.5 Dioxins/Furans

All of the subsurface and surface sediment samples collected from Lora Lake and Miller Creek had at least one dioxin/furan congener detected. Dioxin/furan TEQs were similar in concentration for the surface sediment samples collected within the lake (samples from LL-SED1 through LL-SED4) and the top sample intervals in the cores from LL-SED2 and LL-SED3. Results from these samples ranged from 149 pg/g in the surface sediment sample from LL-SED4 to 217 pg/g in the top interval of the core from LL-SED2. The deeper sample intervals in the cores from LL-SED2 and LL-SED3 had lower dioxin/furan TEQs, with the maximum TEQ of 1.30 pg/g (calculated with non-detect results equal to one-half the detection limit) in the 56–112 cm sample interval from the LL-SED2 core. The 0–56 cm sample interval from the LL-SED1 core had a dioxin/furan TEQ of 23.2 pg/g. LL-SED5, collected from the sediment settling basin had a dioxin/furan TEQ of 7.55 pg/g.

The lowest dioxin/furan TEQs overall were calculated for the Miller Creek surface sediment samples, with the TEQs for these samples ranging from 0.327 pg/g to 0.442 pg/g. Detected concentrations of dioxin/furan TEQs in surface and subsurface sediments are shown in Figures 4.18 and 4.19.

4.3.1.2 Biological Testing Results

According to the evaluation methods developed in consultation with WSDOE, biological test results for the surface sediment samples collected in Lora Lake and Miller Creek were evaluated by comparing test data to the criteria presented in the *Sediment Evaluation Framework for the Pacific Northwest* (RSET 2009) and the Draft Freshwater Benthic Sediment Quality Value technical report prepared for WSDOE (Avocet Consulting 2010). However, since that initial evaluation was performed, the Sediment Management Standards (SMS) Rule (Chapter 173-204 WAC) was revised to include Freshwater Sediment Cleanup Objectives (SCO) and Cleanup Screening Level (CSL) Biological Criteria. Therefore, the Lora Lake and Miller Creek biological test results were also evaluated using the SMS criteria. The RSET freshwater decision criteria approach is generally consistent with the SMS Rule. For both the SMS and RSET approaches, comparisons to reference results were replaced with comparison to the negative control results since areas to collect freshwater reference sediments are not currently identified. Additionally, both the SMS and RSET decision criteria consist of two levels of observed response in the test organisms. Under SMS, these are referred to as exceedances of the CSL and SCO, while under RSET these are referred to as “one-hit” or “two-hit” failures. A CSL exceedance (or one-hit failure) is a marked response in any one biological test. A SCO exceedance (or two-hit failure) is a lower intensity of response. The CSL criterion is also exceeded when two or more biological tests for the test sediment are greater than the SCO. Table 4.6 and Figure 4.20 presents results of the bioassay testing conducted in Lora Lake and Miller Creek for all testing locations.

4.3.1.2.1 10-day Acute Amphipod (Hyalella azteca) for Mortality

Mortality in the Lora Lake and Miller Creek sediment samples ranged from 0 to 8.8 percent, compared with 3.8 percent in the control for the 10-day acute mortality test. None of the samples were significantly different from the control; therefore, none of the samples fail the CSL or SCO criteria for survival.

4.3.1.2.2 20-day Chronic Midge (Chironomus dilutus) for Mortality and Growth

Mortality in the Lora Lake and Miller Creek sediment samples ranged from 20.8 to 77.1 percent, compared with 7.3 percent in the control for the 20-day chronic mortality and growth test. All of the sediment samples, except the samples from sampling stations LL-SED1 and MC-SED2, were significantly different from the control and had percent mortalities greater than 15 percent compared to the control, failing the SCO criterion for survival. The LL-SED2 sediment sample had a percent mortality greater than 25 percent compared to the control and was significantly different from the control; therefore, failing the CSL criterion for survival.

Growth in the samples ranged from 0.75 to 1.41 mg/individual Ash-Free Dry Weight (AFDW), compared with 0.41–0.81 mg/individual AFDW in the controls. As all samples were greater than the control, the samples did not fail the CSL or SCO criteria for growth.

4.3.1.2.3 15 minute Microtox® bacteria (Vibrio fischeri) bioluminescence test

The Microtox® bioluminescence test is a measure of the change in light output from bioluminescent bacteria over a 15 minute interval. Light output is measured initially, at 5 minutes, and at 15 minutes—the 5- and 15-minute outputs are then compared against the initial output. Change in light output in the samples at 15 minutes ranged from 82 to 90 percent of the initial output, compared with 83 and 89 percent of the initial output in the controls. No samples were significantly different from the controls; therefore, none of them fail the RSET one- or two-hit criteria for luminescence.Criteria for the Microtox® test are not included in SMS.

4.3.1.3 Interpretation of Sediment Biological Testing Results

The biological toxicity tests performed on the Miller Creek and Lora Lake surface sediments were used to assess the overall potential toxicity to benthic organisms from the chemicals present within the surface sediments. Surface sediment samples from sampling locations LL-SED1 and MC-SED2 did not have any CSL or SCO failures. The LL-SED3, LL-SED4, MC-SED1, and MC-SED3 sediment samples failed one criterion of the SCO criterion for midge survival; however, as these samples did not have a second failure in the midge growth, the amphipod mortality, or Microtox® tests, these samples are considered unlikely to cause adverse impacts to ecological receptors. Overall, the biological toxicity testing in both Lora Lake and Miller Creek indicated that the surface sediments are unlikely to cause adverse impacts to ecological receptors, with the exception of one location within Lora Lake, LL-SED2. The LL-SED2 sediment sample failed the CSL criterion for midge survival; however, this failure is most likely associated with sulfides, and is discussed in greater detail below and in Appendix G.

The LL-SED2 surface sediment sample was collected from the deepest location within the lake, at a depth of 15.2 feet below the water surface. The LL-SED2 surface sediment sample had chemical concentrations within the range of the other Lora Lake surface sediment samples (samples from locations LL-SED1 through LL-SED4); however, the LL-SED2 sample had the highest concentrations of TOC and total sulfides. The LL-SED2 sample TOC percentage was 10.6 percent, while TOC percentages in the other Lora Lake surface sediment samples ranged from 5.8 to 8.7 percent. The most noticeable difference, however, in the LL-SED2 surface sediment sample relative to the other non-toxic lake bioassay samples was that the sulfides concentration was much higher, with sulfide measured in LL-SED2 surface sediment sample at 2,670 mg/kg. This concentration is two to three times greater than the concentrations measured in the other lake surface sediment samples that were similar in physical composition and were tested for benthic toxicity.

Total sulfide (sulfides) is a conventional parameter that is recommended to be measured in sediment because it is potentially toxic and often indicative of anaerobic conditions not conducive to habitat quality for benthic organisms (PSEP 1986). Total sulfide measurements represent the amount of acid-soluble hydrogen sulfide (H_2S), bisulfide (HS^-), and sulfide (S^{2-}) in a sample. The biological effects of sulfide in sediments are poorly understood, yet can be important in determining sediment toxicity to a wide range of organisms (Wang and Chapman 1999). Sulfide is produced by anaerobic decomposition of organic matter and can be an abundant constituent of aquatic sediments. Sulfide has been viewed as more toxic than ammonia under certain conditions (Lapota et al. 2000). Sulfide influences sediment toxicity in three ways: by producing toxic effects itself, by reducing metal toxicity via the formation of insoluble metal sulfide solids or metal sulfide complexes, and by affecting animal behavior (Wang and Chapman 1999). Even in freshwater sediments, where sulfide concentrations are generally not elevated, the potential contribution of sulfide to toxicity cannot be ignored because freshwater benthic organisms are more sensitive than marine organisms to sulfide (Wang and Chapman 1999).

Toxicity thresholds are often difficult to establish for benthic organisms for sulfides because of the difficulty to obtain a reasonable dose-response relationship. This is due to sulfide's volatile nature, making it difficult to maintain a constant concentration during toxicity testing. Additionally, lowered oxygen levels generally accompany increased sulfide levels, which can then contribute as a confounding effect. Still, effects data reveal a strong potential for sulfide to cause toxicity in many sediments (Lapota et al. 2000). SMS contains a SCO criterion for total sulfides of 39 mg/kg and a CSL criterion of 61 mg/kg. The total sulfides concentrations in surface sediment samples LL-SED1, LL-SED2, LL-SED3, and LL-SED4, ranging from 984 mg/kg to 2,670 mg/kg were all considerably greater than the SCO and CSL criteria. The SCO is based on a no observable effects level to the benthic community, and the CSL adds an allowable degree of minor adverse effects.

Therefore, based on the similar range of chemical concentrations detected in the LL-SED2 surface sediment sample relative to the other lake sediment samples tested for benthic toxicity, and the slightly higher TOC content coupled with the elevated levels of sulfide, it is probable that the CSL-level failure at LL-SED2 is associated with the physical conditions and sulfide abundance at the bottom of lake, rather than specific chemical concentrations. It is likely that the deeper portion of the lake does not experience significant sediment overturning or exchange of aerobic surface water and is an anaerobic, sulfide-rich environment.

The biological testing results generally show that the surface sediment samples taken from Lora Lake and Miller Creek are unlikely to cause adverse impacts to ecological receptors. Only the surface sediment from LL-SED2 indicates the potential for adverse impacts to ecological receptors; however, as discussed above, this is likely the result of other factors, such as elevated sulfide levels, rather than due to elevated chemical concentrations in the surface sediment at this location. Under the SMS Rule

(Chapter 173-204 WAC), results of bioassay testing are definitive and "trump" comparison of chemical concentrations to chemical criteria in determining toxicity of sediments to benthic organisms.

4.3.2 Lora Lake Parcel Soil Quality

Soil investigation activities on the LL Parcel collected and analyzed shallow soil samples collected at six locations (LL-SB1 through LL-SB6) directly downgradient of the LL Apartments Parcel and parallel to Des Moines Memorial Drive. The soil sample locations are shown on Figure 3.5. Soil samples were generally collected from 3 depth intervals (as allowed by field conditions) including 0–0.5 foot, 1.5–2.0 feet, and 2–4 feet bgs. Samples were chemically analyzed for the soil PCOCs. The soil analytical findings are presented in frequency of detection Table 4.7 and summarized below.

4.3.2.1 Conventionals

Total solids were found to be fairly consistent across all soil samples, with percentages of total solids ranging from 74.0 to 92.9 percent. The majority of the percentages fell in the 88 to 92 percent range. TOC among the soil samples was slightly more variable, with percentages ranging from 0.072 percent in the sample collected from 2–3.5 feet bgs in LL-SB2 to 8.78 percent in the sample collected from 0–0.5 foot bgs in Boring LL-SB5.

4.3.2.2 Arsenic and Lead

Arsenic was detected in 13 of the 18 collected soil samples. Arsenic concentrations ranged from 6 mg/kg in the samples collected from the 1.5–2 feet bgs interval in Borings LL-SB1 and LL-SB3 to 13 mg/kg in the samples collected from the 0–0.5 foot bgs sample interval in Borings LL-SB2 and LL-SB4. Maximum detected concentrations of arsenic in soil for each boring location are shown in Figure 4.1.

Lead was detected in all but one of the collected soil samples. Lead concentrations ranged from 2 mg/kg (multiple locations and depths) to 64 mg/kg in the sample collected from the 0–0.5 foot bgs interval in Boring LL-SB5. Maximum detected concentrations of lead in soil for each boring location are shown in Figure 4.2.

4.3.2.3 Total Petroleum Hydrocarbons

Gasoline range TPH was detected in only 1 LL Parcel soil sample, at 12 mg/kg in the sample collected from 1.5–2 feet bgs in Boring LL-SB2. Diesel range TPH was detected in 2 samples at concentrations of 6.1 mg/kg and 13 mg/kg in the 0–0.5 foot bgs samples from Borings LL-SB4 and LL-SB5, respectively. Heavy oil range TPH was detected in 7 of the soil samples with a maximum concentration of 150 mg/kg in the sample interval from 0–0.5 foot bgs from Boring LL-SB5. The maximum summed diesel and heavy oil TPH concentration of 163 mg/kg was detected in the sample interval from 0–0.5 foot bgs from Boring LL-SB5. Maximum detected concentrations of gasoline range, diesel range, and heavy oil range TPH in soil for each boring location are shown in Figure 4.3 through Figure 4.5.

4.3.2.4 Semivolatile Organic Compounds

4.3.2.4.1 Carcinogenic Polycyclic Aromatic Hydrocarbon Toxicity Equivalent Values

cPAHs were detected in 9 of the 19 LL Parcel shallow soil samples. Detections of cPAHs were observed in the 0–0.5 foot bgs sampling interval for all sample locations, with the exception of location LL-SB1. Location LL-SB5 was the only boring with cPAHs detected in the 1.5–2 feet bgs sample interval. Detections of cPAHs were reported in the 2–4 feet bgs sample interval from Borings LL-SB1, LL-SB5, and LL-SB6. For the soil samples collected from the 0–0.5 foot bgs interval, the maximum TEQ (calculated with non-detect results equal to one-half the reporting limit) was 26 µg/kg from Boring LL-SB5. The maximum cPAH TEQ value observed in the 1.5–2 feet bgs and 2–4 feet bgs intervals was 7.7 µg/kg from Boring LL-SB5 (1.5–2 feet bgs interval). Maximum detected concentrations of cPAH TEQs in soil for each boring location are shown in Figure 4.6.

4.3.2.4.2 Pentachlorophenol

PCP was detected in only 1 of the LL Parcel shallow soil samples, at a concentration of 24 µg/kg in the sample interval from 0–0.5 foot bgs in Boring LL-SB6. Maximum detected concentrations of PCP in soil for each boring location are shown in Figure 4.7.

4.3.2.5 Volatile Organic Compounds

Chlorinated VOCs including PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and 1,2-DCA were not detected in any of the LL Parcel shallow soil samples. Additionally, benzene, toluene, ethylbenzene, and xylenes were also not detected in any of the LL Parcel shallow soil samples.

4.3.2.6 Dioxins/Furans

All of the LL Parcel soil samples had at least one dioxin/furan congener detected. The minimum dioxin/furan TEQ (calculated with non-detect results equal to one-half the detection limit) was 0.31 pg/g in the sample interval from 2–4 feet bgs in Boring LL-SB4. The maximum TEQ was 40.4 pg/g in the sample interval from 0–0.5 foot bgs in Boring LL-SB6. Dioxin/furan concentrations in shallow soil are shown in Figures 4.10, 4.11, and 4.12 for the 0–0.5 foot bgs, 0.5–2 feet bgs, and 2–4 feet bgs intervals.

4.3.3 Lora Lake Parcel Physical Conditions

In addition to sediment and soil investigation activities on the LL Parcel, various activities were conducted to characterize the physical conditions of Lora Lake. Findings of these characterization activities are summarized below.

4.3.3.1 Visual Inspection of the Lora Lake Shoreline

Two visual inspections of the Lora Lake shoreline were conducted in fall 2010 and spring 2011 to identify any unknown current and/or historical input sources to Lora Lake. During the spring 2011 inspection, water was observed to be entering Lora Lake from two additional locations: from the nearby wetlands located to the south of the lake, and from a drainage channel in the southwest corner of the lake. Additionally, another outfall, adjacent to City of Burien storm drain outfall, was observed during the inspection. No water appeared to be discharging from the outfall at the time of the inspection. All visual observations of the Lora Lake shoreline are shown on Figure 2.16.

4.3.3.2 Lora Lake, Miller Creek, and Groundwater Water Level Monitoring

Three rounds of water level measurements in fall 2010, winter 2011, and spring 2011 were completed at one location in Lora Lake, three locations in Miller Creek, a piezometer located between Lora Lake and Miller Creek, and four existing groundwater monitoring wells located along Des Moines Memorial Drive, between the LL Apartments Parcel and the LL Parcel. All water level monitoring locations were surveyed by the Port, and are shown in Figure 3.5. In addition, the invert elevations of the drainage pipe entering the lake, and the drainage pipe connecting Lora Lake to Miller Creek were also measured. The surveyed elevations were used to translate lake and creek water level measurements into surface water elevations for each of the three monitoring events. Surface water elevations at these monitoring locations indicate that during the three events, water flowed from Lora Lake to Miller Creek, but that during the winter seasons, water may have been exchanging in both directions between Lora Lake and Miller Creek.

4.3.3.3 Lora Lake Bathymetric Survey

A bathymetric survey was performed by collecting water depth measurements by lead line from an inflatable raft at regular intervals along multiple transects throughout the lake. Based on the water depth measurements, an interpolated Lora Lake bathymetry map was prepared using ArcGIS and is presented in Figure 3.6. The bathymetric survey data were used to help select the sediment sampling locations within Lora Lake. The bathymetric survey shows that the deepest point in the lake is located in the southern area, and was measured at 15.2 feet deep. The majority of the lake is shallower with depths ranging from 1.2 feet to 14.8 feet.

4.4 DREDGED MATERIAL CONTAINMENT AREA INVESTIGATION

4.4.1 Dredged Material Containment Area Soil Quality

Soil investigation activities in the DMCA excavated six test pits distributed spatially throughout the DMCA. Soil samples were collected for chemical analysis from Test Pits TP-1 through TP-6 from a range of depth intervals, as described in the DMCA Data Report (Appendix H). Because of Lora Lake's history as a peat mining source, a dark brown layer of peaty, silty sand encountered in TP-1 through TP-5 was identified in the field as the potential hydraulic dredge material from Lora Lake. Sampling locations are shown on Figure 3.7. Soil samples were analyzed for the soil PCOCs. The soil analytical results are summarized below and in the frequency of detection Table 4.8, and are discussed in detail in the DMCA Data Report (Appendix H).

4.4.1.1 Conventionals

TOC content in the DMCA soil samples ranged from 0.168 percent to 11.2 percent, with the minimum TOC occurring in the sand layer of TP-5 (2–3 feet bgs) and the maximum TOC occurring in the silty sand/peat layer of TP-5 (1.5–2 feet bgs).

Total solids were generally reported between 30 and 50 percent in the silty sand/peat layers, and between 80 to 90 percent in sandy and gravelly intervals.

4.4.1.2 Arsenic and Lead

Arsenic and lead were detected in soil samples collected from all test pit locations.

Arsenic concentrations were less than 15 mg/kg in samples collected from TP-1, TP-2, and TP-6. The maximum detected arsenic concentrations were 50 mg/kg in TP-3 (at 3–4 feet bgs) and TP-5 (at 1.5–2 feet bgs), and 60 mg/kg in TP-4 (at 0–1.5 feet bgs).

Concentrations of lead in TP-3 ranged from 3 mg/kg at 5–6 feet bgs to 165 mg/kg at 3–4 feet bgs. Concentrations of lead in other samples were generally less than 20 mg/kg, with the exceptions of 119 mg/kg in the surface interval of TP-4 and 160 mg/kg in TP-5 at 1.5–2 feet bgs.

The maximum detected concentrations of arsenic and lead in soil for each test pit location are shown on Figures 4.1 and 4.2, respectively.

4.4.1.3 Total Petroleum Hydrocarbons

Gasoline range TPH was detected in TP-2 at 5.9 mg/kg from 3–4 feet bgs and in TP-5 at 23 mg/kg from 1.5–2 feet bgs. Gasoline range TPH was not detected in any other DMCA soil sample.

Diesel range TPH was detected in TP-3 at 16 mg/kg in the 3–4 feet bgs interval, in TP-4 at 14 mg/kg in the 0–1.5 feet bgs interval, and in TP-5 at 21 mg/kg in the 1.5–2 feet bgs interval. Diesel range TPH was not detected in any other DMCA soil sample.

Heavy oil range TPH was detected in TP-1, TP-2, TP-3, TP-4, and TP-5. Concentrations ranged from 18 mg/kg in the 2–3 feet bgs interval of TP-3 to 120 mg/kg in the 1.5–2 feet bgs interval of TP-5.

The maximum summed diesel and heavy oil range TPH concentration of 141 mg/kg was detected in the 1.5–2 feet bgs interval of TP-5.

The maximum detected concentrations of TPH in soil for each test pit location are shown on Figures 4.3, 4.4, and 4.5.

4.4.1.4 Semivolatile Organic Compounds

cPAH TEQs (calculated with non-detect results equal to one-half the reporting limit) were detected in TP-1, TP-2, TP-3, and TP-4 ranging between 3.2 µg/kg from the 1.5–3 feet bgs interval of TP-2 to 21 µg/kg from the 1.5–2 feet bgs interval of TP-5. cPAH TEQs were not detected in any samples collected from TP-6. Maximum detected concentrations of cPAH TEQs in soil for each test pit location are shown in Figure 4.6.

PCP was detected in TP-5 at 39 µg/kg in the 1.5–2 feet sample interval, and in TP-3 at 24 µg/kg in the 3–4 feet bgs sample interval. Maximum detected concentrations of PCP in soil for each test pit location are shown in Figure 4.7.

4.4.1.5 Volatile Organic Compounds

Chlorinated VOCs were not detected in any of the DMCA test pit soil samples. The only VOCs were detected in soil samples were toluene and ethylbenzene.

Toluene was detected in 4 of the 15 collected soil samples. The maximum concentration of toluene was detected in TP-5 at 6,500 µg/kg from 1.5–2 feet bgs; however, excluding this elevated concentration, toluene was detected at concentrations ranging from 32 µg/kg in TP-2 from 1.5–3 feet bgs to 71 µg/kg in TP-3 from 3–4 feet bgs.

Ethylbenzene was detected at only 1 location, TP-1 at 50 µg/kg from 1.5–3 feet bgs. VOCs were not detected in any samples collected from TP-4 or TP-6.

4.4.1.6 Dioxins/Furans

Dioxin/furan congeners were detected in soil samples collected from all DMCA test pit locations. Dioxin/furan TEQ concentrations (calculated with non-detect results equal to one-half the detection limit) were greater than 7.5 pg/g in only three locations: TP-3 at 41.1 pg/g from 3–4 feet bgs, the surface interval of TP-4 at 64.5 pg/g, and TP-5 at 71.9 pg/g from 1.5–2 feet bgs. These elevated concentrations were associated with the layer of silty sand and peat identified in the field as the potential Lora Lake dredge material.

The remainder of dioxin/furan TEQ concentrations were less than 7.5 pg/g. The maximum detected concentrations of dioxin/furan TEQs in soil for each test pit location are shown on Figure 4.9.

4.4.2 Dredged Material Containment Area Groundwater Quality

Three existing monitoring wells (HC00-B310, HC00-B311, and HC00-B312) located to the east, south, and west of the DMCA, were determined likely to represent all directions of potential downgradient groundwater flow based on area topography. These wells were redeveloped, sampled with low flow sampling techniques, and analyzed for the groundwater PCOCs. Monitoring well locations are shown on Figure 3.7. Table 4.9 summarizes groundwater analytical results frequency of detection for the DMCA; analytical results are summarized below and discussed in detail in Appendix H.

Arsenic and dioxins/furans were detected in the three groundwater samples collected. Total arsenic was detected at concentrations less than 1 µg/L in all samples. Maximum detected concentrations of arsenic in groundwater for each monitoring well location are shown on Figure 4.13.

A single dioxin/furan congener, octachlorodibenzo-p-dioxin, was detected in all three groundwater samples. The groundwater dioxin/furan TEQs (calculated with non-detect results equal to one-half the detection limit) ranged from 2.30 pg/L in B-310 to 2.56 pg/L in B-311. Dioxin/furan concentrations in groundwater are shown on Figure 4.17.

4.4.3 Summary of Dredged Material Containment Area Conditions

The DMCA is a relatively flat area, with the ground surface sloping slightly downward from the northwest and southwest to the east. The area under the STIA 3rd Runway ALS is covered with crushed gravel, with soil berms surrounding the gravel area. An additional soil berm, possibly related to the 2002 stormwater mitigation construction activities, is located within the vegetated area to the east of the runway lighting. Field personnel were not able to identify the original 1982 DMCA constructed soil berms based on current physical grade or topography, and it is unknown if the soil berms proposed for containment of the hydraulic dredge material in the DMCA were constructed as planned, or have since been regraded.

Fill soil in the DMCA generally consist of silty and gravelly sands, with several occurrences of large gravels. During test pit excavation, a dark brown layer of silty sand with peat was encountered underlying fill soil in all locations except TP-6, which was located the farthest to the east within the estimated DMCA extents. Soil samples collected from the peat-containing layer included the 4.5–5.5 feet bgs interval of TP-1, the 1.5--3 feet bgs interval of TP-2, the 3–4 feet bgs interval of TP-3, the 0–1.5 feet bgs interval of TP-4 and the 1.5–2 feet bgs interval of TP-5. This layer was identified in the field as the material most likely to be the hydraulically-dredged sediments from Lora Lake due to its bedded appearance, peat and silt content, as well as relatively uniform thickness of 0.5 to 1.5 feet. Underlying soil, of probable native material, consisted of coarse sands with very little silt.

Within the peat layer, TOC was elevated relative to the overlying fill materials and the underlying probable native materials. The average TOC of samples collected from the silty sand/peat material was 7.13 percent, as compared to 0.51 percent for the fill and native materials.

PCOC concentrations were also relatively higher in the silty sand/peat layer as compared to overlying fill and underlying native material. Average arsenic and lead detections in this layer were 60 mg/kg and 165 mg/kg, compared to average detections of 15 mg/kg and 18 mg/kg in all other samples. Average heavy oil range TPH concentrations in the silty sand/peat layer were 77.7 mg/kg, as opposed to 20.5 mg/kg in fill and native materials, and diesel range TPH was only detected in the silty sand/peat layer. Average cPAH TEQs were approximately 20 µg/kg in this layer, compared to approximately 10 µg/kg in all other samples. Additionally, PCP was only detected in samples collected from the silty sand/peat layer. The average dioxin/furan TEQ concentration was 36.5 pg/g in samples from this layer and 1.6 pg/g in all other samples. All PCOC concentrations declined markedly beneath the silty sand/peat layer, indicating that the detected chemical concentrations are relatively constrained to the likely dredged material.

Groundwater was observed in every test pit, with groundwater elevations ranging from approximately 275.5 feet (NAVD88) in the northernmost test pits (TP-1 and TP-4) to below 274 feet in the southernmost test pits (TP-3 and TP-6). This suggests a primarily north-northwest to south-southeast hydraulic gradient, consistent with earlier approximations based on topography. Groundwater elevations measured in the three DMCA monitoring wells prior to sampling also indicate an inferred flow direction of north-northwest to south-southeast, as described in the DMCA Data Report (Appendix H).

5.0 Exposure Pathways Analysis and Identification of Appropriate Cleanup Level Regulations

This section describes the analysis of exposure pathways and identification of the appropriate cleanup level regulations for the LL Apartments Site. The RIs, as outlined in the RI/FS Work Plans (Floyd|Snider 2010a, 2011a) were conducted to fill data gaps identified as part of the preliminary CSM with the goal of enabling a comprehensive understanding of the existing nature and extent of contamination at the Site. Public comments on data gaps in draft RI/FS Work Plans and SWIA reports were reviewed in consultation with WSDOE and considered during the finalization of the RI sampling programs. Port responses to public comments received during the project investigation stages are provided in Appendix I. In response to public input regarding potential contribution of dioxins/furans from the LL Apartments Parcel soil to stormwater, a Lora Lake Apartments stormwater dioxin/furan contribution evaluation was conducted and is presented in Appendix J.

Data generated during the RI enabled revisions of the preliminary CSM. The preliminary CSM is summarized below to provide context for the exposure pathway analysis. The revised CSM, described in Section 8.0, presents an updated and more accurate picture of site conditions, applicable transport pathways, and exposure routes. The following subsections update the exposure pathways analysis from the preliminary CSM based on the incorporation of RI data, and identify the appropriate regulations for the selection and/or calculation of site cleanup levels.

5.1 PRELIMINARY CONCEPTUAL SITE MODEL AND CONTAMINANTS OF CONCERN

A preliminary CSM was developed for the LL Apartments Parcel by AECOM on behalf of the Port in 2009 as part of the Summary Report (AECOM 2009b). This preliminary CSM was based on findings from previous investigations and remedial actions on the LL Apartments Parcel.

Contaminants in soil and groundwater at the LL Apartments Parcel have the potential to migrate through natural mechanisms that may result in exposure to human and ecological receptors. The primary migration pathways, as described by the 2009 preliminary CSM, consist of the following:

- **Vapor Migration:** Contaminants in soil and groundwater can volatilize into soil vapor and migrate up to the ground surface.
- **Soil to Groundwater:** Historical releases of contamination to the ground surface or to the subsurface during historical site operations at the LL Apartments Parcel can result in a continued release, or leaching, of contaminants entrained in soil to the groundwater table.
- **Groundwater to Surface Water:** Lora Lake is located to the southeast of the LL Apartments Parcel, across Des Moines Memorial Drive. Contaminated groundwater in the shallow water table beneath the LL Apartments Parcel has the potential to migrate through groundwater flow to Lora Lake surface water.

- **Stormwater to Surface Water:** Stormwater at the LL Apartments Parcel flows into a large City of Burien municipal storm drainage system that enters the LL Apartments Parcel from the west (upgradient) and collects runoff from Des Moines Memorial Drive after leaving the LL Apartments Parcel on the east, before discharging to Lora Lake.
- **Surface Soil to Surface Water:** Surface soil has the potential to reach surface water via direct runoff downslope or migration via the stormwater system. Prior to construction of the Lora Lake Apartments complex, the LL Apartments Parcel was largely unpaved, and presumably the majority of stormwater infiltrated through the ground surface. As part of the construction of the Lora Lake Apartments complex, new stormwater infrastructure was installed and the Site was regraded.

The sediment to surface water pathway was not specifically included in the AECOM 2009 preliminary CSM; however, this pathway is captured as an intermediate component of the groundwater and surface soil to surface water pathways that were included in the preliminary CSM and as described above.

The preliminary CSM identified potential receptors of contamination in soil, sediment, surface water, and groundwater at the Site to include both human and ecological receptors. Potential human receptors were identified as site workers, and ecological receptors were identified as aquatic receptors.

5.1.1 Preliminary Contaminants of Concern

Previous investigations at the LL Apartments Parcel analyzed a number of soil and groundwater samples for a range of contaminants including VOCs, BTEX, SVOCs, PAHs, PCBs, dioxins/furans, TPH, and metals, as summarized above in Section 3.1. These investigations identified several contaminants in soil and/or groundwater at concentrations greater than the most stringent MTCA Method A or B cleanup levels, which were selected at the time of these investigations as screening levels.

The following compounds were identified as PCOCs for additional characterization in the LL Apartments Parcel phase of the site RI based on the previous environmental investigations:

- cPAHs
- Dioxins/furans
- Arsenic
- Lead
- Diesel range and heavy oil range hydrocarbons
- Gasoline range hydrocarbons
- PCP
- VOCs (PCE, TCE, and 1,2-DCA)

In addition to analysis of these PCOCs, the soil and groundwater samples collected as part of the LL Apartments Parcel RI effort were analyzed for BTEX to determine the appropriate gasoline range hydrocarbon cleanup level in the RI/FS. Additional analyses were conducted for the PCE and TCE breakdown products cis-1,2-DCE and trans-1,2-DCE. Since the LL Apartments Parcel is one of the potential sources of contamination to the LL Parcel and the DMCA, the LL Parcel and DMCA PCOCs are effectively the same as the LL Apartments Parcel PCOCs.

5.2 UPDATED EXPOSURE PATHWAY ANALYSIS AND CLEANUP LEVEL REGULATION IDENTIFICATION

In overview, the primary cleanup regulations that apply to this Site are the MTCA Cleanup Regulation (Chapter 173-340 WAC) and the SMS Rule (Chapter 173-204 WAC). Surface water quality criteria (National Toxics Rule, 40 CFR 131.36 and Clean Water Act Section 304) were also considered in evaluating the leaching potential of Lora Lake and Miller Creek surface sediments, discussed further in the LL Parcel FS, Sections 18.0 through 20.0.

The following site-specific land use information is relevant to identifying the cleanup level regulations applicable to the Site:

- The Port's current objective for the Site is to complete the AO obligations, conduct appropriate remediation of site contamination, and redevelop the city block, of which the LL Apartments Parcel is a part, for airport-compatible commercial or light industrial use.
- The LL Apartments Parcel, the majority of the LL Parcel, and DMCA are all currently located within security fencing, monitored, and access-controlled by Port security as STIA property. A small portion of the LL Parcel, such as parcel soils adjacent to Des Moines Memorial Drive, outside of the secured fencing, is potentially accessible by the public.
- The FAA defines restrictions on allowable development and structures for runway and runway approach safety areas (AC/150 5300-13; USDOT FAA 1989). Figure 2.5 shows where the FAA's Runway Protection and Approach Transition Zones overlay the Site.
    - The northeast portion of the LL Apartments Parcel is located within the FAA RPZ-Controlled Activity Area.
    - The western portion of the LL Parcel is located within the FAA RPZ-Controlled Activity Area and the eastern portion is located within the FAA RPZ-Extended Object Free Area.
    - The DMCA is located entirely in the FAA RPZ-Extended Object Free Area.
- FAA restrictions prohibit any future development that is inconsistent with the area rules as long as STIA is an operating airport. The future site use at the LL Parcel is expected to remain consistent with current habitat use indefinitely, and the future use at the DMCA is expected to include development for use as a cleared vacant area, with a supportive of aviation uses such as construction equipment laydown, or temporary storage.

- LL Parcel is part of the Miller Creek/Lora Lake/Vacca Farm Wetland and Flood Plain Zone Mitigation Area required by the NRMP for STIA 3rd Runway construction (Parametrix 2001). Lora Lake and Miller Creek are both freshwater environments with public access restrictions surrounding Lora Lake and the adjacent portions of Miller Creek. Restrictive covenants prohibit any future development on the LL Parcel, which will be maintained as a protected wetland aquatic habitat area in perpetuity.
- WAC 173-201A-600(1), a section of the Water Quality Standards for Surface Waters of the state of Washington, requires that water quality in Lora Lake be protected for: salmonid spawning, rearing, and migration; primary contact recreation; domestic, industrial, and agricultural water supply; stock watering; wildlife habitat; harvesting; commerce and navigation; boating; and aesthetic values. In addition, Miller Creek, to which Lora Lake discharges, has been closed to consumptive use[2] since 1946 in order to protect flows for aquatic habitat (Water Resource Inventory Area 9, WAC 173-509-040).

5.2.1 Soil

Potential soil pathways have been identified in the preliminary CSM, and further evaluated based on information collected during the RI. The following soil pathways are considered for identification of applicable soil cleanup level regulations at the Site:

- Protection of human health via direct contact with contaminated soil.
- Protection of groundwater resources from contaminants leaching from soil.
- Protection of ecological receptors.
- Protection of indoor air from vapor intrusion from contaminated soil.

Each of these soil exposure pathways is discussed below.

5.2.1.1 Evaluation of Soil Cleanup Levels for the Protection of Human Health

Given the current and future land use restrictions, and anticipated future land uses of the three areas that are the subject of this RI, MTCA Method B unrestricted land use cleanup levels are applicable as soil cleanup levels for the LL Apartments Parcel and the LL Parcel, and MTCA Method C industrial land use cleanup levels are applicable as soil cleanup levels for the DMCA.

For the LL Apartments Parcel, MTCA Method B cleanup levels are protective of human health via worker direct contact exposure to site soil under future light industrial and/or commercial site development.

[2] WSDOE has determined that there are no waters available for further appropriation through the establishment of rights to use water consumptively, therefore since 1946 Miller Creek was one of the streams that was closed to further consumptive appropriations (i.e., no water can additionally be withdrawn or used from the creek). No additional water rights could be granted, and no additional withdrawal or use was allowed, except for domestic in-house use for a single residence and non-feed lot stock watering (WAC 173-509-070).

For the LL Parcel, the cleanup levels are protective for airport worker and possible public direct contact exposure. The majority of the LL Parcel is located within security fencing, and is monitored and access-controlled by Port security as STIA property. A small portion of the LL Parcel, such as parcel soils adjacent to Des Moines Memorial Drive, is outside of the secured fencing, and is potentially accessible by the public. Because of the potential for public access to this small portion of the LL Parcel, the Port has selected the unrestricted land use MTCA Method B soil cleanup levels for the protection of human health. The LL Parcel is also part of the Miller Creek/Lora Lake/Vacca Farm Wetland and Flood Plain Zone Mitigation Area.

For the DMCA, the MTCA Method C cleanup levels are protective for industrial use and airport worker direct contact exposure. As noted above, the DMCA is located entirely in the FAA RPZ-Extended Object Free Area, within security fencing that prevents public access. Port worker access is controlled by Port security. The DMCA is also commercially zoned as an area of Aviation Operations by the City of SeaTac. The planned future conditions of the DMCA will include an engineered compacted gravel or paved surface to be constructed concurrent with the LL Apartments Parcel remedial action that would support continued Port use consistent with FAA requirements and security zone use.

For site COCs where MTCA Method B or Method C soil cleanup levels, as appropriate, are not available and MTCA Method A soil cleanup levels exist, such as for petroleum hydrocarbons, the Method A levels are considered appropriate for use.

5.2.1.2 Evaluation of Soil Cleanup Levels for the Protection of Groundwater

The closest groundwater supply/extraction wells are located approximately 1 and 2 miles to the northeast of the Site (cross-gradient) and are occasionally used for drinking water supply in the summer months when the municipal supply is low. The groundwater supply/extraction wells are screened at depths greater than 200 feet bgs (approximate well screen elevations of 145 to 45 feet NAVD88, compared to the site well screened elevations of 299 to 266 feet NAVD88). There is no drinking water supply aquifer within the immediate vicinity of the Site; therefore, consumption of drinking water is not a current human health exposure pathway. Chapter 173-340-720(2) of MTCA, however, requires an assumption that shallow groundwater could potentially become a source of drinking water in the future. Therefore, for this RI, groundwater cleanup levels for potability are applicable.

Based on the observed soil contamination present at the LL Apartments Parcel, an assessment of soil cleanup levels based on the protection of groundwater is appropriate for the LL Apartments Parcel, the LL Parcel, and the DMCA.

5.2.1.3 Evaluation of Soil Cleanup Levels for the Protection of Ecological Receptors

The goal of the Terrestrial Ecological Evaluation (TEE) process in MTCA is to evaluate the potential for terrestrial ecological exposure to contaminated soil to cause significant adverse effects. The first step in the TEE process is determining if the Site qualifies for completion of a TEE, or if the Site is excluded from further evaluation based on site conditions or other factors. If a site meets one of the exclusion criteria outlined in MTCA, no additional evaluation is required, and cleanup levels for protection of terrestrial receptors are not required.

A preliminary TEE was conducted by AECOM as part of the Summary Report (AECOM 2009b). This evaluation indicated that the LL Apartments Parcel did not provide significant ecological habitat and that due to the proposed future land use and the exclusion criteria in MTCA (WAC 173-340-7491), no further ecological assessment was necessary (AECOM 2009b). This TEE was updated as part of this RI/FS. Consistent with the AECOM findings, the updated TEE also concluded that the LL Apartments Parcel is excluded from further consideration due to the planned future use as a commercial or light industrial property, and that impervious surfaces would comprise the vast majority of the LL Apartments Parcel. Additionally, future redevelopment at the LL Apartments Parcel must comply with FAA regulation AC/150 5300-13 for the portions of the property that fall within the FAA RPZ (USDOT FAA 1989; Figure 2.5). This regulation states that future site uses within these areas must not attract wildlife. Details on the TEE are provided in Appendix K.

The DMCA was also excluded from further consideration under the TEE process due to the current zoning of the property and the planned future use of the area. The planned future conditions of the DMCA will include an engineered compacted gravel or paved surface to be constructed concurrent with the LL Apartments Parcel remedial action. The constructed surface would prevent plant growth or animal burrowing and would support continued Port use consistent with FAA requirements and security zone use, as described in detail in Appendix K.

For the LL Parcel, the process for evaluation by or exclusion from the TEE process evaluated the area in consideration of the controlling documents—the FAA WHMP and the Port NRMP. The TEE process at this parcel is complex because although the property is a wetland aquatic habitat mitigation area, it has a limited defined use and application that does not include improving habitat for avian or wildlife species. The NRMP, which outlines the purpose and function of the wetland aquatic mitigation area, states that the area is developed to "restore wetland and stream buffer functions in a manner that avoids creating new avian wildlife hazards and reduces existing avian wildlife hazards." (Parametrix 2001). The NRMP also clearly states that all mitigation areas and functions are controlled by the requirements of the WHMP, which manages safety associated with bird and wildlife strike of aircraft during takeoff and landing. The FAA WHMP includes applicable, relevant, and appropriate requirements (ARARs) for MTCA decisions at the Site. Applicable remedial goals of the RI/FS must be evaluated in the context of these safety requirements that function as ARARs.

The LL Parcel, however, does not qualify for either an exclusion from the TEE process or a simplified TEE because the LL Parcel is managed as a wetland area where semi-native vegetation has been restored and because there are more than 10 acres of contiguous vegetated habitat in the area within and surrounding Lora Lake. Consequently, as required by WAC 173-340-7493, a site-specific TEE is appropriate to evaluate the potential for ecological risks for this area (Appendix K). Since the LL Apartments Parcel and DMCA are excluded from evaluation under the TEE process, no cleanup levels will be set for protection of terrestrial species at these parcels.

LL Parcel soil data were compared to site-specific ecological indicator soil concentrations (EICs) for avian and mammalian wildlife (WAC 173-340-900, Table 749-3). EICs are applicable as soil cleanup levels for the ecological COCs for the LL Parcel based on the TEE CSM (Appendix K). The applicability of EICs relative to Washington State background levels for dioxins/furans is discussed below in Section 6.1.

5.2.1.4 Evaluation of Soil Cleanup Levels for Protection of Indoor Air

A sub-slab vapor investigation was conducted by AECOM in 2008 that sampled and analyzed soil vapor for VOCs beneath eight buildings on the LL Apartments Parcel, including the former Recreation Building (designated REC. BLDG. on Figure 2.4; ENSR/AECOM 2008a). During data review and validation, select samples were eliminated due to poor data quality, as tracer gas presence in the samples indicated sample quality control limits had not been achieved. The remaining vapor sample results were compared to MTCA Method B screening levels for ambient air. Table 5.1 presents frequency of detection information for the soil gas samples collected by AECOM. Of the samples collected, low concentrations of dichlorofluoromethane and methylene chloride were found in three samples at levels less than the USEPA guidance screening levels for shallow soil vapor published in the 2002 *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils* (USEPA 2002). Results of the sub-slab soil vapor investigation conducted by AECOM determined that the concentrations of VOCs in soil gas at the LL Apartments Parcel are not at levels expected to affect indoor air quality.

There are currently no buildings on the LL Apartments Parcel as a result of building demolition conducted by the Port in August and September 2009, as described in the Interim Action Demolition Work Plan (AECOM 2009a). Any future building construction would be conducted after site remediation per the AO.

There are also no buildings present on the LL Parcel or DMCA. Because the LL Parcel is part of the Miller Creek/Lora Lake Upland Buffer and Flood Plain Zone Mitigation Area required by the NRMP for expansion of the STIA and construction of the 3rd Runway, no buildings will be constructed on this parcel in the future. The DMCA is located underneath the ALS for the STIA 3rd Runway within the FAA RPZ-Extended Object Free Area (Figure 2.5) and no buildings will be constructed in this area in the future.

5.2.1.5 Summary—Soil Exposure Pathways and Associated Cleanup Level Authorities

The following soil exposure pathways and associated cleanup level regulations are applicable to the Site:

- Protection of human health via direct contact with soil: MTCA Method B (or Method A where Method B is not available) Soil Cleanup Levels for the LL Apartments and LL Parcel, and MTCA Method C Soil Cleanup Levels for the DMCA.

- Soil leaching to groundwater, if empirical site data demonstrate that pathway is a concern: MTCA Equation 747-1 Calculation of Soil Cleanup Levels for the protection of groundwater resources from contaminants leaching from soil.
- Protection of terrestrial species: MTCA TEE Ecological Indicator Concentrations.
- Washington state natural background for dioxins/furans (WSDOE 2010) and arsenic (WAC 173-340-900, Table 740-1, footnote b).

5.2.2 Groundwater

The following potential pathways were identified in the preliminary CSM, and following evaluation of information collected as part of the RI. These pathways are considered for identification of applicable groundwater cleanup level regulations at the Site:

- Protection of human health via drinking water as potential future highest beneficial use.
- Protection of surface water resources, based on the discharge of groundwater to Lora Lake and Lora Lake surface water exchange with Miller Creek.
- Protection of indoor air from vapor intrusion from shallow contaminated groundwater.

Each groundwater pathway is discussed below.

5.2.2.1 Evaluation of Groundwater Cleanup Levels for the Protection of Human Health

Data generated from Wells MW-15, MW-16, and MW-17, screened at the bottom of the uppermost water-bearing zone below the Site (recessional outwash aquifer), confirmed that contamination associated with site soil and the shallow portion of the aquifer has not impacted deeper groundwater. In addition, no drinking water supply wells are within the immediate vicinity of the Site, or are screened in the shallow portion of the recessional outwash aquifer.

Nonetheless, WAC173-340-720(2) and 173-340-720(4)(b) require an assumption of potability for the potential future use as drinking water. Where the groundwater cleanup level is based on a drinking water beneficial use, standard MTCA Method B cleanup levels shall be at least as stringent as applicable state and federal laws. Therefore, groundwater cleanup levels will be identified based on the protection of human health via drinking water consumption, including state and federal maximum contaminant levels (MCLs), as applicable.

5.2.2.2 Evaluation of Groundwater Cleanup Levels for the Protection of Surface Water

Shallow groundwater at the LL Apartments Parcel flows downgradient to the LL Parcel, and is hydraulically connected to Lora Lake, which is hydraulically connected to Miller Creek.

Per WAC 173-340-720(4)(b)(ii),

> "Where the groundwater cleanup level is based on a drinking water beneficial use, standard MTCA Method B cleanup levels shall be at least as stringent as concentrations established in accordance with the methods specified in WAC 173-340-730 for protecting surface water beneficial uses *unless* it can be demonstrated that the hazardous substances are not likely to reach surface water. This demonstration must be based on factors other than the implementation of a cleanup action at the site."

Federal ambient surface water quality criteria applicable to Lora Lake and Miller Creek are based on human health risk associated with the consumption of aquatic organisms (e.g., fish and/or shellfish; National Toxics Rule, 40 CFR 131.36 and Clean Water Act Section 304)[3]. For all site COCs except dioxins/furans, groundwater cleanup levels based on drinking water beneficial use are more stringent than these surface water ARARs. Therefore, groundwater cleanup levels for all COCs except dioxins/furans will be based on beneficial use as drinking water.

For dioxins/furans, however, current groundwater concentrations are protective of surface water, and, therefore, dioxin/furan surface water ARARs are not applicable. This conclusion is consistent with WAC 173-340-720(4)(b)(ii), cited above. The multiple lines of evidence described below demonstrate that dioxins/furans present in groundwater at the LL Apartments Parcel are not likely to discharge from groundwater to Lora Lake surface water at concentrations greater than the applicable surface water quality criterion (0.0051 pg/L).

- **Chemical Properties of Dioxins/Furans—Rapid Attenuation to Soil Particles and, Therefore, Limited Groundwater Transport:** Dioxins/furans are large organic compounds with multiple chlorine atoms. Dioxins/furans, therefore, have extremely low water solubilities and high partitioning coefficients, making them extremely immobile compounds in groundwater. For example, an average soil organic carbon-water partitioning coefficient (Koc) for the dioxin congener 2,3,7,8-tetrachloro-dibenzo-p-dioxin (2,3,7,8-TCDD)[4] is 13,000,000 L/kg (refer to peer-reviewed literature, Appendix J, Worksheet 1 for Koc references). The 2,3,7,8-TCDD congener is the least chlorinated and, therefore, the most mobile dioxin/furan congener and would consequently have a lower Koc than the other more chlorinated congeners.
- **Historical Potential Release of Dioxins/Furans Occurred Over 60 Years Ago:** In the 1940s through the early 1950s, a barrel-washing facility operated on the LL Apartments Parcel in the Central Source Area. The barrels washed at the facility contained industrial chemicals prior to their designation for re-use or disposal. It is the industrial chemicals washed from the barrels more than 60 years ago that are suspected to be the potential source of the highest

[3] The surface water quality criterion based on human health risk associated with the consumption of aquatic organisms for dioxins/furans is 0.0051 pg/L and the criterion based on consumption of aquatic organisms plus the consumption of drinking water (National Toxics Rule, 40 CFR 131.36 and Clean Water Act Section 304) is 0.005 pg/L.

[4] 2,3,7,8-TCDD is the only congener with multiple peer-reviewed and published Koc values because it is the most toxic and well-studied dioxin congener (USEPA 2003).

dioxin/furan contamination in this area. Considering that the suspected source of contamination occurred over 60 years ago and that the highest concentration of dioxins/furans in groundwater is localized to the Central Source Area, it is likely that the dioxin/furan contamination has been transported as far as it will go and that it will not migrate any farther from the source area.

- **LL Apartments Parcel Empirical Site Groundwater Data Demonstration:** Existing groundwater data from the LL Apartments Parcel show that dioxin/furan groundwater concentrations rapidly decrease from the Central Source Area. For example, the maximum dioxin/furan TEQ concentration detected in MW-1 as part of the recent RI sampling is 38.3 pg/L. MW-4 and MW-5 are located within the Eastern Source Area; MW-4 is approximately 230 feet downgradient of MW-1, and MW-5 is approximately 160 feet downgradient of MW-1. The maximum dioxin/furan TEQ concentrations detected in groundwater during the recent RI sampling was 2.54 pg/L at MW-4 and 3.72 pg/L at MW-5, each an order of magnitude less than the MW-1 TEQ concentration. These empirical data further demonstrate the significant attenuation of dioxins/furans in groundwater at the Site and support the BIOSCREEN modeling results presented in Appendix L and summarized below.

- **DMCA and LL Parcel Empirical Site Groundwater Data Demonstration:** As described above, the dioxin/furan maximum concentrations observed in LL Apartments Parcel downgradient wells (MW-4 and MW-5) were 2.54 pg/L and 3.72 pg/L. Similarly, groundwater dioxin/furan TEQ concentrations detected in the four monitoring wells located on the downgradient LL Parcel (MW-8 through MW-11; Figure 2.14) and in the three monitoring wells located in the DMCA range from approximately 2.5 pg/L to 3 pg/L. This concentration range is also within the range of the dioxin/furan TEQ reporting limit, or the calculated TEQ result when no congeners are detected in a groundwater sample, and within the range of the dioxin/furan analytical method blanks that represent the ideal water matrix, free of interferences from the analysis. Therefore, the range is representative of the lowest achievable dioxin/furan TEQs (1 to 3 pg/L). These DMCA and LL Parcel empirical data also support the BIOSCREEN modeling results presented in Appendix L and summarized below, and provide an additional line of evidence that the upgradient LL Apartments Parcel dioxins/furans in groundwater attenuate to soil particles rapidly and are not transported in groundwater to downgradient parcels.[5]

- **Differences in the Dioxin/Furan Congener Distribution between the LL Apartments Parcel Source Area and Other Locations:** In addition to the LL Apartments Parcel, DMCA, and LL Parcel concentration-based empirical data demonstrations described above, existing groundwater data from the three parcels also indicate another difference between the source area and the

[5] As noted elsewhere in this report, dioxins/furans are ubiquitous in the urban environment. The data noted in this paragraph demonstrate that low levels of dioxins/furans detected at the Site, which is located in an urban environment, are not different from the range of concentrations that can reliably be seen with laboratory analytical tools, and not different from the range of concentrations detected in laboratory "clean" quality control samples.

other well locations. Within the Central Source Area, nearly all dioxin/furan congeners are detected in the groundwater samples collected from MW-1; however, in upgradient and downgradient wells located on the LL Apartments Parcel, the LL Parcel, and the DMCA, the detected congeners are limited to the most chlorinated congeners with seven or eight chlorines (1,2,3,4,6,7,8 HpCDD, 1,2,3,4,6,7,8-HpCDF, octachlorodibenzo-p-dioxin, and octachlorodibenzofuran). This observed difference between the groundwater congeners within the source area versus other areas or parcels provides another type of empirical data demonstration that the extent of dioxins/furans in groundwater associated with the LL Apartments Parcel historical operations is limited to the source area, and does not appear to be impacting downgradient groundwater. This conclusion is also supported by the fact that in the upgradient well MW-2 detected congeners are similar to and consistent with the congeners detected in samples from the LL Parcel and DMCA.

- **BIOSCREEN-AT Model Results Predict Site Dioxins/Furans do not Discharge to Surface Water at Concentrations greater than Surface Water Criteria:** BIOSCREEN-AT modeling evaluation provides another line of evidence in the demonstration that dioxins/furans are not likely to reach the surface water of Lora Lake at concentrations greater than the most stringent dioxin/furan surface water criterion for the protection of human health via consumption of organisms (0.0051 pg/L, Federal Clean Water Act Section 304).[6] The BIOSCREEN-AT model has been approved by WSDOE to evaluate attenuation and biodegradation processes of contamination in groundwater between a location and the adjacent surface water. The model is designed to use actual site concentrations to determine an attenuated concentration at a specified distance.

  For the purposes of this project and as recommended in the BIOSCREEN guidance (USEPA 1996), the BIOSCREEN-AT model was run for dioxins/furans to determine what concentrations are predicted to be present in downgradient groundwater over time and eventually discharge to surface water. The BIOSCREEN-AT model results show that the maximum dioxin/furan TEQ concentration of 38.3 pg/L detected at the LL Apartments Parcel during the RI at MW-1 within the Central Source Area, attenuates to less than the surface water criterion of 0.0051 pg/L between 90 and 150 feet downgradient of MW-1; well before the point of groundwater discharge to Lora Lake, even when the model is run for a time period of 100 years. Therefore, this modeling evaluation demonstrates that prior to any remedial action, with the existing site conditions, dioxins/furans are predicted to attenuate rapidly as the groundwater moves through soil and are not likely to reach the surface water of Lora Lake at concentrations greater than the surface water quality criterion. The

[6] The surface water quality criterion based on human health risk associated with the consumption of aquatic organisms for dioxins/furans is 0.0051 pg/L and the criterion based on consumption of aquatic organisms plus the consumption of drinking water is 0.005 pg/L (National Toxics Rule, 40 CFR 131.36 and Clean Water Act Section 304). Due to the small difference between the two criteria, the BIOSCREEN-AT modeling results are the same for both human health consumption criteria.

BIOSCREEN-AT model results, sensitivity analysis, and input parameters are presented in Appendix L.

These lines of evidence demonstrate that dioxins/furans in groundwater resulting from site contamination are not likely to reach surface water at concentrations exceeding the most stringent surface water ARARs for protection of human health. Per MTCA 173-340-720(4)(b), the concentrations of dioxins/furans observed in site groundwater are currently protective of surface water beneficial uses, and, therefore, dioxin/furan surface water ARARs are not applicable as site groundwater cleanup levels.

5.2.2.3 Evaluation of Groundwater Cleanup Levels for the Protection of Indoor Air

Results of the sub-slab soil vapor investigation indicate that the concentrations of VOCs in soil gas at the LL Apartments Parcel are not at levels expected to affect the indoor air quality at the LL Apartments Parcel (ENSR/AECOM 2008a). Any future building construction on the LL Apartments Parcel would be conducted after site remediation, per the AO.

Given future use restrictions that prevent construction of buildings in the LL Parcel and the DMCA, establishment of cleanup levels for the protection of indoor air in these areas is not required.

5.2.2.4 Summary—Groundwater Exposure Pathways and Associated Cleanup Level Regulations

The following groundwater exposure pathways and associated cleanup level regulations are applicable to the Site:

- Protection of human health via drinking water consumption: MTCA Method B (or Method A where Method B is not available) groundwater cleanup levels.
- Protection of human health via drinking water consumption: state and federal drinking water MCLs.

5.2.3 Sediment

Lora Lake and Miller Creek are both freshwater environments located downgradient from the LL Apartments Parcel and the LL Parcel. Public access restrictions surround Lora Lake and the adjacent portion of Miller Creek up to approximately 0.3 miles upstream and 1.3 miles downstream of the lake. The following pathways were considered to identify applicable sediment cleanup level regulations at the LL Parcel and in Miller Creek:

- Protection of ecological receptors in Lora Lake and Miller Creek.
- Protection of human health via consumption of aquatic organisms downstream of the Site in Miller Creek.

Each sediment pathway is discussed below.

5.2.3.1 Evaluation of Sediment Cleanup Levels for the Protection of Ecological Receptors

The protection of sediment ecological receptors in Lora Lake and Miller Creek was evaluated via surface sediment chemical quality and biological toxicity testing.

There are no promulgated sediment standards available for the protection of aquatic organisms (i.e., toxicity) for most VOCs, in part due to their chemical properties that prevent them from partitioning to sediments. Dioxins/furans have very low toxicity to aquatic organisms and, as a result, quantitative estimates of toxic concentrations have not been developed. Therefore, there are no available promulgated dioxin/furan sediment concentration standards for the protection of aquatic life. Sediment concentration standards that are protective of aquatic organisms in freshwater environments were recently promulgated for the remaining COCs under SMS (effective date: September 2013).

In the Washington State SMS (WAC 173-204), the SCO levels serve as the long-term goal for sediments of the state, and the lower end of the range within which cleanup standards for a site can be selected. The CSLs serve as the level above which cleanup sites are designated, and also serve as the upper end of the range within which cleanup standards for a site may be selected, based on balancing environmental protectiveness, cost, and technical feasibility. Thus, a cleanup standard for any given site may be set within a range of allowable adverse effects, from no effects to minor adverse effects, depending on site-specific considerations. The detected contaminant concentrations are also reviewed in conjunction with the results of the biological toxicity testing relative to the biological toxicity interpretive guidelines. Under the SMS, results of biological toxicity testing are definitive and “trump” comparison of chemical concentrations to chemical criteria.

The results of the Lora Lake and Miller Creek sediment bioassay tests were evaluated according to the biological toxicity interpretive criteria from the Sediment Evaluation Framework for the Pacific Northwest guidance document (RSET 2009) for the Microtox® bacteria test and the SMS Rule for the amphipod and midge toxicity tests.

Sediment freshwater cleanup levels based on the protection of ecological receptors via biological toxicity interpretive criteria are applicable for the Lora Lake and Miller Creek surface sediments. Chemical quality of the sediments will be compared to the freshwater sediment chemical criteria under SMS.

5.2.3.2 Evaluation of Sediment Cleanup Levels for the Protection of Human Health

There is not a current human health exposure pathway for surface water or sediment via direct contact in Lora Lake because access to Lora Lake is restricted.

A potential human health exposure pathway does exist at Miller Creek, however, via downstream recreational consumption of aquatic organisms (i.e., fish) that spend some period of time in Lora Lake and may bioaccumulate site COCs via surface water and sediment exposure before returning to Miller Creek. Public access to fishing in Miller Creek exists approximately 1.3 miles downstream from Lora Lake, at the point that Miller Creek exits the secured STIA fence. The drainage culvert that connects Lora Lake to Miller Creek may potentially allow for passage of fish from the creek into the lake and vice versa.

When the Site RI/FS was originally submitted in January 2012, SMS included narrative requirements for the protection of human health, but did not include specific procedures to develop cleanup levels addressing human health risk posed by the bioaccumulative exposure pathway. Sediment cleanup levels for the protection of human health were, therefore, not originally considered in the previously submitted RI/FS. The revised SMS Rule, however, now provides specific requirements for the establishment of sediment cleanup levels to address this exposure pathway (WAC 173-204-560). To comply with the revised SMS requirements, numerical cleanup levels protective of human health have been derived. The derivations of these sediment cleanup levels were provided in a technical memorandum submitted to WSDOE in December 2014 (Floyd|Snider 2014).

Additionally, surface water ARARs for the protection of human health via fish consumption are available and applicable for the Lora Lake and Miller Creek surface sediments via sediment contaminants leaching to surface water. The assessment of sediment leaching to surface water is included in the LL Parcel FS.

5.2.3.3 Summary—Sediment Cleanup Levels

The following sediment exposure pathways and associated cleanup level regulations are applicable to the LL Parcel and Miller Creek:

- Protection of benthic organisms: Freshwater biological and chemical criteria (SMS Chapter 173-204 WAC).
- Protection of human health, including human consumption of aquatic species: Risk-based cleanup levels (SMS Chapter 173-204 WAC).
- Protection of human health, including sediment leaching to surface water: Surface water organism only ARARs (National Toxics Rule, 40 CFR 131.36 and Clean Water Act Section 304).

5.3 SUMMARY OF LORA LAKE APARTMENTS PARCEL, LORA LAKE PARCEL, AND DMCA APPLICABLE CLEANUP LEVEL REGULATIONS

Table 5.2 summarizes the cleanup level regulations applicable to the LL Apartments Parcel, the LL Parcel, and the DMCA following evaluation of the pathways for each media. Numerical cleanup level values for site COCs are identified in Section 6.0 below.

6.0 Site-specific Cleanup Levels for Contaminants of Concern

As part of the LL Apartments Parcel RI/FS Work Plan, PCOCs were identified based on the results of previous environmental investigations conducted at the LL Apartments Parcel (Floyd|Snider 2010a). Previous investigations analyzed numerous soil and groundwater samples for SVOCs, PAHs, PCBs, dioxins/furans, TPH, VOCs, BTEX, and metals. Section 3.3.1 describes the RI analytical program for each PCOC in each potentially contaminated medium at the LL Apartments Parcel and the downgradient LL Parcel and DMCA.

In parallel with the LL Apartments Parcel soil and groundwater RI, an investigation was completed on the LL Parcel to identify soil conditions and the chemical quality of Lora Lake and Miller Creek sediments in order to evaluate the potential for LL Apartments Parcel contaminated soil to impact soil and/or sediments on the LL Parcel. A soil and groundwater investigation was also conducted within the DMCA. PCOCs at the LL Parcel and the DMCA were selected to be the same as the LL Apartments Parcel PCOCs, because the LL Apartments Parcel is one of the potential sources of contamination to the LL Parcel and because dredged sediments from Lora Lake were disposed of within the DMCA.

COCs were identified for the Site based on their frequency of detection in samples collected from the three investigation areas. For conservatism, if a contaminant was detected at an elevated frequency of detection (greater than 5 percent) in soil or groundwater at the LL Apartments Parcel, the LL Parcel, or the DMCA, the contaminant was identified as a site COC for that medium in all three areas, regardless of the frequency of detection in the other two areas. For surface sediments, if a contaminant was detected at an elevated frequency of detection (greater than 5 percent) in Lora Lake surface sediments, but was detected at a frequency less than 5 percent in Miller Creek surface sediments, the contaminant was identified as a sediment COC because Lora Lake is a potential source of contamination to Miller Creek.

Table 6.1 summarizes the site COCs described in the sections below for each medium. Table 6.2 identifies the groundwater ARARs for the protection of human health via drinking water beneficial uses. Table 6.3 provides the summary statistics and frequencies of detections for these PCOCs analyzed in groundwater samples collected as part of the RI.[7] Table 6.4 identifies the specific numerical cleanup levels, based on the applicable cleanup levels, as described in Section 5.0, by media for each specific COC. Table 6.5 presents the SMS freshwater sediment biological criteria.

[7] Pre-RI groundwater sampling results are influenced by suspended solids and are not likely representative of groundwater quality (Section 4.2.2). Therefore, the 2010 to 2011 RI groundwater data are used to evaluate site conditions.

6.1 SOIL

6.1.1 Final Contaminants of Concern

Soil samples collected during the RI conducted at the LL Apartments Parcel, the LL Parcel, and the DMCA were analyzed for the following chemical groups:

- Arsenic and lead by USEPA Method 6010
- TPH (diesel range and heavy oil range) by NWTPH-Dx
- TPH (gasoline range) by NWTPH-G
- cPAHs by USEPA Method 8270
- PCP by USEPA Method 8041
- PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and 1,2-DCA by USEPA Method 8260C
- BTEX by USEPA Method 8021
- Dioxins/furans by USEPA Method 1613

The summary statistics and frequencies of detections for these PCOCs analyzed in soil samples collected during all environmental investigations conducted at the Site are presented in Tables 4.1, 4.7, and 4.8. A review of these soil data indicates the following:

- **Arsenic and Lead:** Arsenic was detected in more than 5 percent of the soil samples collected from the LL Apartments Parcel, LL Parcel, and the DMCA and is retained as a site COC. Lead was detected in more than 5 percent of the soil samples collected from the LL Apartments Parcel, LL Parcel, and the DMCA and is retained as a site COC.
- **TPH:** Gasoline range, diesel range, and heavy oil range TPH were detected in soil samples collected from the LL Apartments Parcel, LL Parcel, and the DMCA at frequencies greater than 5 percent. Therefore, all three TPH ranges are retained as site COCs.
- **cPAHs:** cPAH TEQs were detected at a frequency of 35.4 percent in soil samples collected from the LL Apartments Parcel, 47.4 percent in soil samples collected from the LL Parcel, and 46.7 percent in soil samples collected from the DMCA. cPAHs are retained as site COCs.
- **PCP:** PCP was detected at a frequency of 43.9 percent in soil samples collected from the LL Apartments Parcel, 5.3 percent in soil samples collected from the LL Parcel, and 13.3 percent in soil samples collected from the DMCA. PCP is retained as a site COC.
- **Chlorinated Solvents:** PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and 1,2-DCA were not detected in any soil samples collected during the RI from the LL Apartments Parcel, LL Parcel, or the DMCA. These compounds are not retained as site COCs.

- **BTEX:** Benzene, toluene, ethylbenzene, and xylene were detected in less than 5 percent of soil samples collected from the LL Apartments Parcel and were not detected in soil samples collected from the LL Parcel. In soil samples collected from the DMCA benzene and xylene were not detected, but toluene and ethylbenzene were detected at a frequency greater than 5 percent. Therefore, toluene and ethylbenzene are retained as site COCs.
- **Dioxins/Furans:** Dioxin/furan TEQs were detected at a frequency of 99.4 percent in soil samples collected from the LL Apartments Parcel, 100 percent in soil samples collected from the LL Parcel, and 100 percent in soil samples collected from the DMCA. These frequencies are not surprising as dioxins/furans are commonly detected in surface soil within urban settings[8]. Dioxins/furans are retained as site COCs.

The following contaminants are retained as soil COCs for the Site; arsenic, lead, gasoline range TPH, diesel range TPH, heavy oil range TPH, cPAHs, PCP, toluene, ethylbenzene, and dioxins/furans.

6.1.2 Soil Contaminant of Concern Cleanup Levels

The applicable soil cleanup levels for the LL Apartments Parcel are the MTCA Method B cleanup levels protective of direct contact (or MTCA Method A where Method B is not available); for the LL Parcel, the MTCA Method B cleanup levels protective of direct contact (or MTCA Method A where Method B is not available), cleanup levels protective of ecological receptors, and Washington State background concentrations; and for the DMCA, the MTCA Method C cleanup levels protective of worker direct contact. Soil cleanup levels protective of groundwater are also applicable to all three parcels. Additional discussion of protection of ecological receptors and soil cleanup levels protective of ground water follows.

6.1.2.1 Application of Washington State Background Concentrations at the Lora Lake Parcel Associated with the Site-specific TEE

A site-specific TEE conducted for the LL Parcel identified dioxins and furans as ecological COCs for the LL Parcel. Footnote “a” from MTCA WAC 173-340-900 Ecological Indicator Soil Concentrations Table 749-3 states:

> “Exceedances of the values in this table do not necessarily trigger requirements for cleanup action under this chapter. Natural background concentrations may be substituted for ecological indicator concentrations provided in this table.”

Although the LL Parcel and Site are located within an urban setting, MTCA allows the substitution of natural background, and not urban background for EICs. The TEE EICs for wildlife exposure for dioxins and furans (2 pg/g and 2 pg/g) are less than the WSDOE-determined Washington State natural background soil concentration of 5.2 pg/g (WSDOE 2010). This natural background concentration was generated by WSDOE from a

[8] Refer to Appendix M for an overview dioxin/furan levels detected in both urban and rural soils as part of multiple regional, national, and international studies.

re-evaluation of its 1999 WSDOE dataset. The reevaluation incorporated two updates to the 2007 MTCA TEQ calculation method: the 2005 World Health Organization (WHO) Toxic Equivalency Factors (Van den Berg et al. 2006) and the requirement to calculate natural background by assigning non-detected congeners a value of one-half of the detection limit (MTCA WAC 173-340-709(5)(a)). WSDOE established 5.2 pg/g dioxins/furans TEQ as the Washington State natural background concentration, calculated as the lower of the nonparametric 90th percentile, or four times the true 50th percentile of a background dataset (WAC 173-340-709; WSDOE 2010).

WSDOE's 2010 Washington State dioxin/furan natural background soil concentration of 5.2 pg/g is proposed as the LL Parcel soil cleanup level for protection of ecological receptors per the allowable substitution of background under WAC 173-340-900 Table 749-3.

6.1.2.2 Empirical Data Demonstration: LL Apartments Parcel Soil to Groundwater Pathway

To determine if the LL Apartments Parcel soil, contaminated by releases from industrial activity no more recently than 30 years ago, is a potential current source of contaminants to groundwater, samples were collected from wells within the Central and Eastern Source Areas (where maximum soil COC concentrations were detected). COC data from these samples were compared to downgradient groundwater COC concentrations and the groundwater cleanup levels protective of human health via drinking water beneficial use. This empirical data evaluation was conducted for all soil COCs, as summarized below.

The duration of time since the potential release and the localized elevated COC groundwater concentrations within the Central and Eastern Source Areas indicates that what COCs were released to property soils and groundwater likely have been transported as far as they will go, and additional migration and/or leaching of COCs from the source area soils to groundwater is not expected, as demonstrated in the following sections and in the dioxin/furan groundwater to surface water demonstration as described above in Section 5.2.2.2.

6.1.2.2.1 Arsenic and Lead

The MTCA Method A groundwater arsenic cleanup level is 5 µg/L. The maximum arsenic concentration detected in groundwater sampled at the LL Apartments Parcel is 14.2 µg/L at MW-1, located within the Central Source Area. In groundwater sampled from all other LL Apartments Parcel groundwater monitoring wells (outside of the source area and those wells located downgradient and adjacent to the LL Parcel or adjacent to the DMCA) arsenic was either not detected or detected at concentrations less than the cleanup level.

Lead was not detected in groundwater samples collected from any site monitoring wells.

6.1.2.2.2 Total Petroleum Hydrocarbons

Diesel range and gasoline range TPH were not detected at concentrations greater than MTCA Method A cleanup levels (500 and 800 µg/L, respectively) in any groundwater samples collected from site monitoring wells. Heavy oil range TPH was detected in one groundwater sample collected from MW-1 at a concentration of 530 µg/L, greater than the MTCA Method A cleanup level of 500 µg/L. The only exceedance in site soils of any fraction of TPH (including the sum of diesel range and heavy oil range TPH) is a heavy oil range TPH exceedance of the 2,000 mg/kg MTCA Method A cleanup level in the 2 to 6 foot bgs soil samples collected from PSB11 (2,700 mg/kg), located within the Central Source Area and approximately 21 feet from MW-1.

Ethylbenzene and toluene were detected at a frequency of less than 5 percent in soil samples collected from the LL Apartments Parcel, were not detected in soil collected from the LL Parcel, and were detected at a frequency greater than 5 percent only at the DMCA. All soil concentrations of ethylbenzene and toluene were less than MTCA Method A cleanup levels. Ethylbenzene and toluene were detected in groundwater at concentrations less than MTCA Method A cleanup levels at the LL Apartments Parcel, and were not detected in groundwater samples collected from the DMCA.

6.1.2.2.3 Semivolatile Organic Compounds

The MTCA Method B groundwater cPAH TEQ cleanup level is 0.12 µg/L. The maximum cPAH TEQ concentration detected in groundwater sampled at the LL Apartments Parcel is 0.02 µg/L at MW-1, located within the Central Source Area. In groundwater sampled from any other LL Apartments groundwater monitoring wells and those wells located downgradient and adjacent to the LL Parcel or adjacent to the DMCA cPAHs were not detected. Therefore, there are no groundwater cleanup level exceedances of cPAHs.

The groundwater MCL PCP cleanup level is 1 µg/L. The maximum PCP concentration detected in groundwater sampled at the LL Apartments Parcel is 1.4 µg/L at MW-5, within the Eastern Source Area. All other groundwater samples collected during the RI were less than the PCP cleanup level.

6.1.2.2.4 Dioxins/Furans

The MTCA Method B groundwater dioxin/furan TEQ cleanup level is 6.7 pg/L. The maximum dioxin/furan TEQ concentration detected in groundwater during the RI monitoring events is 38.3 µg/L at MW-1, located within the Central Source Area. All other groundwater sampling results showed dioxins/furans TEQ concentrations less than the MTCA Method B cleanup level.

The evaluation of the soil to groundwater pathway at the LL Apartments Parcel empirically demonstrates that prior to remediation, groundwater COC concentrations within the LL Apartments Parcel but outside the source area are already less than the applicable groundwater cleanup levels and there is no indication of impacts to downgradient groundwater. The soil-to-groundwater pathway is not a concern because this evaluation demonstrates that contamination is not migrating from the Site in groundwater. The only area of groundwater contamination at levels greater than cleanup levels is within the Central and Eastern Source Areas (where contamination is located at and below the water table). In addition, following implementation of the remedial action, compliance monitoring will be conducted to confirm compliance with groundwater cleanup levels through the standard point of compliance. Therefore, soil cleanup levels protective of groundwater are not required to be calculated.

The applicable soil cleanup levels for the site COCs are presented in Table 6.4.

6.2 GROUNDWATER

6.2.1 Final Contaminants of Concern

Groundwater samples collected at the Site during the RI were analyzed for the following chemical groups:

- Arsenic and lead by USEPA Method 6010
- TPH (diesel range and oil range) by NWTPH-Dx
- TPH (gasoline range) by NWTPH-G
- cPAHs by USEPA Method 8270
- PCP by USEPA Method 8041
- PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and 1,2-DCA by USEPA Method 8260C
- BTEX by USEPA Method 8021
- Dioxins/furans by USEPA Method 1613

The summary statistics and frequencies of detections for these PCOCs analyzed in groundwater samples, collected as part of all environmental investigations conducted at the LL Apartments Parcel and downgradient are presented in Table 4.2. The summary statistics and frequencies of detections for these PCOCs analyzed in groundwater samples collected as part of the DMCA investigation are presented in Table 4.9. Table 6.3 provides the summary statistics and frequencies of detections for these PCOCs analyzed in groundwater samples collected as part of the 2010 to 2011 RI[9] only. A review of the 2010 to 2011 RI groundwater data indicates the following:

- **Arsenic and Lead:** Arsenic was detected in greater than 5 percent of groundwater samples collected from the LL Apartments Parcel, the LL Parcel, and the DMCA and is retained as a site COC. Lead was not detected in the groundwater samples collected from the LL Apartments Parcel, the LL Parcel, or the DMCA; therefore, lead is not retained as a site COC for groundwater.
- **TPH:** Gasoline range and heavy oil range TPH were detected at a frequency of 8 and 5.6 percent in groundwater samples collected from the LL Apartments Parcel; however, gasoline, diesel, and heavy oil range TPH were not detected in groundwater samples collected from the LL Parcel or the DMCA. Diesel range TPH was detected at a frequency of 3.7 percent of groundwater samples

[9] Pre-RI groundwater sampling results are influenced by suspended solids and are not likely representative of groundwater quality (Section 4.2.2). Therefore, only the 2010 to 2011 RI groundwater data are used to evaluate site conditions.

collected from the LL Apartments Parcel, less than 5 percent. Conservatively, all three TPH fractions are retained as groundwater COCs for the Site.

- **cPAHs:** cPAH TEQs were detected at a frequency of 7.41 percent in groundwater samples collected from the LL Apartments Parcel; however, cPAHs were not detected in groundwater samples collected from the LL Parcel or the DMCA. cPAHs are retained as groundwater COCs for the Site.
- **PCP:** PCP was detected at a frequency of 18.5 percent in groundwater samples collected from the LL Apartments Parcel (including those wells located within the LL Parcel); however, PCP was not detected in groundwater samples collected from the DMCA. PCP is retained as a groundwater COC for the Site.
- **Chlorinated Solvents:** PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and 1,2-DCA were not detected in the groundwater samples collected from the LL Apartments Parcel, the LL Parcel, or the DMCA, and are, therefore, not retained as site COCs in groundwater.
- **BTEX:** Benzene, toluene, ethylbenzene, and xylene were detected at a frequency of less than 5 percent in the groundwater samples collected from the LL Apartments Parcel, and were not detected in groundwater collected from the LL Parcel or the DMCA. Therefore, BTEX compounds are not retained as site COCs in groundwater.
- **Dioxins/Furans:** Dioxins/furans TEQ were detected at a frequency of 56.8 percent in groundwater samples collected from the LL Apartments Parcel and the LL Parcel, and 100 percent in groundwater samples collected from the DMCA. Dioxins/furans are retained as site COCs.

The following contaminants are retained as groundwater COCs for the Site: arsenic, cPAHs, PCP, TPH, and dioxins/furans.

6.2.2 Groundwater Contaminant of Concern Cleanup Levels

As discussed above in Section 5.2, the applicable groundwater cleanup levels for the Site include MTCA Method B (or Method A where Method B is not available) groundwater cleanup levels and state and federal MCLs for the protection of human health via drinking water beneficial use.

The MTCA regulations (WAC 173-340-720(3)(b) and WAC-173-340-720(4)) stipulate that a groundwater cleanup level should defer to the MCL for the most toxic congener or compound (e.g., 2,3,7,8-TCDD for dioxins/furans and benzo(a)pyrene for cPAHs) that is protective of human health via consumption of groundwater without exceeding the acceptable cancer risk level of 10^{-5} (WSDOE 2005 and 2007). The MCL for dioxins/furans in groundwater is 30 pg/L, which is higher than the adjusted MTCA Method B dioxin/furan groundwater cleanup level calculated using MTCA Equation 720-2 (WAC 173-340-720(4)(B)) with a risk level of 10^{-5}. Therefore, the adjusted MTCA Method B dioxin/furan groundwater cleanup level of 6.7 pg/L is applied as the site dioxin/furan groundwater cleanup level. Similarly, the MCL for cPAHs (benzo(a)pyrene) in groundwater is 0.2 µg/L, which is higher than the adjusted MTCA Method B dioxin/furan groundwater cleanup level calculated using MTCA Equation 720-2 (WAC 173-340-720(4)(B)) with a risk level of 10^{-5}. Therefore, the adjusted MTCA Method B cPAH groundwater cleanup level of 0.12 µg/L is applied as the site cPAH groundwater cleanup level.

Table 6.2 identifies the groundwater ARARs for the protection of human health via drinking water. MTCA Method B (Method A where Method B is unavailable) is the most stringent groundwater ARAR for groundwater COCs arsenic, and dioxins/furans. For PCP, however, the adjusted MTCA Method B groundwater cleanup level (2.2 µg/L) is greater than the MCL for PCP in groundwater of 1 µg/L. Therefore, per WAC 173-340-720(3)(b) and WAC 173-340-720(4), the MCL for PCP in groundwater is applied as the site cleanup level. Table 6.4 identifies the cleanup levels for the site groundwater COCs.

6.3 SEDIMENT

6.3.1 Final Contaminants of Concern

Surface sediment samples collected during the RI at Lora Lake and Miller Creek were analyzed for the following chemical groups:

- Arsenic and lead by USEPA Method 6010
- cPAHs by USEPA Method 8270
- PCP by USEPA Method 8041
- PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and 1,2-DCA by USEPA Method 8260C
- Dioxins/furans by USEPA Method 1613

TPH and BTEX were not analyzed in sediment samples due to the highly volatile nature of gasoline range TPH and BTEX compounds, as well as their ability to readily undergo biodegradation in surface sediments. Consequently, cPAHs were used as indicator chemicals for the petroleum hydrocarbon compounds. Subsurface sediment samples collected in Lora Lake were not analyzed for VOCs, including BTEX, because the sampling methodology used (freeze-coring, discussed further in Section 3.3.1.3) potentially releases VOCs during freezing and thawing.

Lora Lake and Miller Creek COCs are evaluated for surface sediment because these samples represent the biologically active zone of the lake and creek sediments (i.e., where the potential for contaminant exposure by ecological receptors occurs). The lake subsurface sediment data from Lora Lake are not evaluated relative to COC concentrations and site cleanup levels since there is no benthic or human exposure pathway. The lake subsurface sediment data are included in the development of the CSM and in the FS alternatives evaluation. Additionally, the analytes that are identified below as surface sediment COCs are the analytes detected in the subsurface sediments.

The summary statistics and frequencies of detections for these PCOCs analyzed in the surface sediment samples collected as part of the 2010 to 2011 RI are presented in

Tables 4.3 and 4.4. A review of the Lora Lake and Miller Creek surface sediment data indicates the following:

- **Arsenic and Lead:** Arsenic and lead were detected in greater than 5 percent of surface sediment samples collected from Lora Lake and Miller Creek and are retained as site COCs.
- **cPAHs:** cPAHs were detected at a frequency of 100 percent in surface sediment samples collected from Lora Lake, but were not detected in the surface sediment samples collected from Miller Creek. cPAHs are retained as site COCs.
- **PCP:** PCP was detected at a frequency of 33.3 percent in surface sediment samples collected from Lora Lake. PCP was not detected in the surface sediment samples collected from Miller Creek. PCP is retained as a site COC.
- **Chlorinated Solvents:** PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and 1,2-DCA were not detected in the surface sediment samples collected from Lora Lake or Miller Creek; therefore, they are not retained as site COCs.
- **Dioxins/Furans:** Dioxins/furans were detected in greater than 5 percent of the surface sediment samples collected from Lora Lake and Miller Creek. Dioxins/furans are retained as surface sediment site COCs.

The following contaminants are retained as surface sediment COCs for Lora Lake and Miller Creek: arsenic, lead, cPAHs, PCP, and dioxins/furans.

6.3.2 Surface Sediment Contaminant of Concern Cleanup Levels

The surface sediment cleanup levels for Lora Lake and Miller Creek include the SMS freshwater sediment chemical and biological criteria (Chapter 173-204 WAC). These chemical- and biological-based cleanup levels are protective of benthic aquatic life within the surface sediments of Lora Lake and Miller Creek.

There is currently no human health exposure pathway for surface water or sediment via direct contact in Lora Lake because access to Lora Lake is restricted. A potential human health exposure pathway does exist at Miller Creek, however, via downstream recreational consumption of aquatic organisms (i.e., fish) that spend some period of time in Lora Lake and may bioaccumulate site COCs via surface water and sediment exposure before returning to Miller Creek. Public access to fishing in Miller Creek begins approximately 1.3 miles downstream from Lora Lake, at the point that Miller Creek exits the secured STIA operational area. The revised SMS Rule provides specific requirements for the establishment of sediment cleanup levels to address the human health via fish consumption exposure pathway (WAC 173-204-560). To comply with the revised SMS requirements, surface sediment cleanup levels protective of human health have been derived. The derivations of these sediment cleanup levels were provided in a technical memorandum submitted to WSDOE in December 2014 (Floyd|Snider 2014).

Additionally, surface water ARARs for the protection of human health via fish consumption are available and applicable for the Lora Lake and Miller Creek surface sediments via sediment contaminants leaching to surface water. The assessment of sediment leaching to surface water is included in the LL Parcel FS.

Table 6.4 identifies the SMS freshwater sediment chemical criteria and the human health criteria for the surface sediment COCs within Lora Lake and Miller Creek (WSDOE 2013b). Table 6.5 identifies SMS freshwater sediment biological criteria (Chapter 173-204 WAC).

6.4 POINTS OF COMPLIANCE

Points of compliance (locations where the cleanup levels shall be achieved) are established for each impacted medium at the Site: soil, groundwater, and sediment. The points of compliance for each medium are discussed separately below.

6.4.1 Soil Point of Compliance

The point of compliance for soil is based on the soil direct contact exposure pathway. The MTCA standard point of compliance for soil direct contact is throughout the Site, from the ground surface to a depth of 15 feet bgs (WAC 173-340-740 (6)(d); WSDOE 2007). Compliance with the direct contact cleanup level for site soil is determined by direct sampling of soil following source area remediation and comparing the post-cleanup soil concentrations to the site soil cleanup levels presented in Table 6.4.

The standard point of compliance for soil protection of groundwater is throughout the Site, and protects the pathway of soil contamination leaching to groundwater. At this Site, groundwater contamination is limited to one area where concentrations of hydrophobic contamination in soil are present in the saturated zone. Groundwater concentrations exceeding the groundwater cleanup levels are most likely attributable to contaminated saturated soil impacting groundwater through contribution of suspended solids and/or dissolved solids to the groundwater column, and not through leaching of dissolved phase contaminants. The current dataset supports this conclusion, since groundwater contamination at the Site is limited to the area where soil contamination extends into the saturated zone. Based on this, the soil point of compliance protective of direct contact has been selected for the Site; however, groundwater remedial technologies evaluated in the FS will include remedies that protect groundwater given the pathway of contaminated saturated soil impacting groundwater via solids transport.

6.4.2 Groundwater Point of Compliance

The standard point of compliance for groundwater under MTCA is “throughout the site from the uppermost level of the saturated zone extending vertically to the lowest depth which could potentially be affected by the site” (WAC 173-340-720 (8); WSDOE 2007). Prior to remediation, groundwater concentrations of site COCs within the Lora Lale Parcel and the DMCA are less than the groundwater cleanup levels. At the Lora Lake Apartments Parcel Central and Eastern Source Areas the standard point of compliance for groundwater applies to the Site, and cleanup levels will be met by the remedies proposed in the LL Apartments Parcel FS.

6.4.3 Surface Sediment Point of Compliance

The point of compliance for surface sediment within Lora Lake and Miller Creek is based on protection of aquatic life (benthic organisms), protection of human health via fish consumption, and protection of surface water quality via sediment leaching. Per SMS, the vertical zone of compliance is the biologically active zone or the top 10 cm of sediments. Given the soft, unconsolidated nature of the lake surface sediments, however, surface sediments collected from Lora Lake as part of the 2010 to 2011 RI were collected to a depth of 15 cm. During Lora Lake surface sediment sampling and sediment freeze coring, the depth of the biologically active layer could not be visually identified in the sediment cores. The vertical zone of compliance for Lora Lake is the top 15 cm of sediments, conservatively estimated as the biologically active zone.

Miller Creek samples were collected to a depth of 10 cm, consistent with the SMS standard biologically active zone, because the creek sediments do not have the same unconsolidated nature of the lake surface sediments. In Miller Creek, the vertical zone of compliance is the top 10 cm, consistent with the SMS standard.

7.0 Nature and Extent of Contaminants of Concern

This section describes the physical properties and behavior of each site COC. Understanding the chemical-specific properties and the nature of the COCs in the context of the site geologic and hydrogeologic conditions described in Section 2.0 is necessary to predict the fate of the contaminants within each medium. This section evaluates the areas of contamination throughout the Site and establishes appropriate points of compliance for each contaminated medium.

7.1 CHEMICAL AND PHYSICAL PROPERTIES

The chemical and physical properties of site COCs influence their fate and transport in the environment and the selection of remedial technologies. Table 7.1 presents the chemical-specific properties for the COCs. The following properties were considered especially relevant at this Site:

- **Solubility and Hydrophilic Properties.** Chemicals with high aqueous solubilities and low partitioning coefficients (partition coefficient [Kd] and/or Koc/octanol-water partition coefficient [Kow]) tend to dissolve into groundwater and remain in groundwater for long periods of time, increasing their ability to migrate in groundwater. The site COCs of dioxins/furans and cPAHs, however, have low solubilities and high partitioning coefficients. They are typically sorbed onto suspended soil particles and organic carbon, and therefore, do not readily migrate with groundwater.

  Partitioning properties for metals are dependent on properties of the groundwater in which they are located—pH, redox potential, and the presence of other ions in solution. Metals behavior is more complex, but can still be predicted based on these properties.

- **Degradability.** Chemicals will degrade to daughter chemicals (e.g., less chlorinated chemicals than the parent compound) due to numerous processes, the two most common of which are biological degradation and chemical degradation. Chemicals that do not degrade easily are referred to as persistent chemicals. Dioxins/furans and cPAHs (which are high molecular weight PAHs) are persistent chemicals. Many chemicals will rapidly degrade under one set of conditions but not under another. For example, toluene readily degrades under aerobic conditions while PCP readily degrades in the environment by chemical, microbiological, and photochemical processes. Consequently, discussions of degradation must include a clear understanding of the conditions necessary for the degradation to occur.

- **Volatility.** Chemicals with low boiling points and high vapor pressures are considered volatile and are likely to move from soil and shallow groundwater source areas into the pores in the unsaturated vadose zone. Once they are present in the form of soil gas, they have the potential to migrate in the vadose zone by diffusion and convection. Dioxins/furans, cPAHs, and PCP are not volatile chemicals.

The chemical and physical properties of each of the site COCs, as presented in Table 7.1, are summarized below.

7.1.1 Arsenic

Arsenic is a metalloid and is commonly treated as a metal. Arsenic forms various complexes depending on the prevailing soil and groundwater geochemistry. Arsenic comes from both natural and anthropogenic sources. Under most conditions arsenic tends to adsorb to soil, forming relatively insoluble and immobile complexes with iron, aluminum, and magnesium oxides; however, under reducing conditions commonly associated with petroleum-impacted groundwater contamination, arsenic becomes more soluble and may be mobilized. The factors most strongly influencing arsenic mobility in water include redox potential, pH, metal sulfide and sulfide ion concentrations, iron concentrations, temperature, salinity, distribution and composition of the biota, season, and the nature and concentration of natural organic matter. For example, arsenic is naturally sequestered in subsurface environments with significant peat content.

7.1.2 Lead

Lead is a naturally-occurring metal; however, where lead levels are elevated, the source is generally anthropogenic. Lead compounds were historically used as a pigment in paints, dyes, and ceramic glazes; in caulk; and in leaded gasoline (discontinued in the 1980s). Lead exists in various forms and tends to be relatively immobile. Common forms of lead are strongly sorbed to organic matter in soil; little is transported through runoff to surface water or leaching to groundwater, except under acidic conditions.

7.1.3 Total Petroleum Hydrocarbons

Petroleum hydrocarbons are commonly measured in bulk using TPH analyses. These analyses provide limited information about the actual compounds present, but provide a general indication of the range of petroleum hydrocarbons (e.g., light, volatile, short-chained organic compounds versus heavy, long-chained, branched compounds). Some standard petroleum products are automotive gasoline, Stoddard solvent, jet fuel, diesel fuel, fuel oils, mineral oils, lubricants, and asphalt. In general, petroleum products will migrate through the soil as bulk oil by gravity and capillary action. Bulk oil may be retained by the soil as it flows as “residual saturation,” and individual compounds that comprise the TPH may dissolve into air or water (ATSDR 1999). The majority of petroleum products are less dense than water and, if present in sufficient volume, the free-phase petroleum product will “float” on the groundwater table; denser petroleum products may sink through the groundwater. A thin layer (i.e., less than 0.01 foot) of free-phase petroleum (light non-aqueous phase liquid) has been observed at the groundwater table at MW-1, located within the LL Apartments Parcel Central Source Area.

Diesel range and heavy oil range hydrocarbons have low volatility, relatively low solubility and tend to sorb to soil. Hydrocarbons biodegrade in the environment with the rate of degradation depending on the type of hydrocarbons (e.g., shorter chain hydrocarbons degrade faster) and several environmental factors such as oxygen content, pH, moisture content, temperature, nutrient concentrations, and microbes (ATSDR 1999).

7.1.4 Pentachlorophenol

Pure PCP exists as colorless crystals. PCP was widely used as a pesticide and wood preservative, but since 1984, the purchase and use of PCP has been restricted. The sorption or mobility of PCP in soil is controlled primarily by soil pH and the amount of PCP sorbed at a given pH. Sorption increases with increasing organic content of the soil. The presence of co-solvents, such as alcohols or petroleum hydrocarbons, decreases the adsorption of PCP to soil by increasing its effective solubility. The mobile phase is more likely to leach to groundwater where it could partition into the aqueous phase. PCP readily degrades in the environment by enhanced chemical, microbiological, and photochemical processes (ATSDR 2001). In soil, reductive dehalogenation appears to be the most significant PCP degradation pathway that ultimately leads to ring cleavage, liberation of chloride, and carbon dioxide evolution.

7.1.5 Carcinogenic Polycyclic Aromatic Hydrocarbons

The transport and fate of PAHs in the environment are largely determined by their physical and chemical properties (e.g., Henry's Law Constant and Koc). These properties are approximately correlated to their molecular weights; the low and medium molecular weight compounds constitute the non-carcinogenic PAHs (nPAHs), while the high molecular weight compounds, with the exception of benzo(g,h,i)perylene (nPAH), constitute the cPAHs. PAHs have moderate to strong soil sorption capacity and low water solubility; therefore, they are fairly immobile in soil and do not readily leach to groundwater. The principal process for degradation of PAHs in soil is microbial metabolism. Degradation rates are affected by the degree of contamination, environmental factors, the soil organic content, the soil structure and particle size, characteristics of the microbial population, the presence of contaminants toxic to microorganisms, and the physical and chemical properties of the PAHs (ATSDR 1995).

7.1.6 Ethylbenzene

Ethylbenzene is a clear, colorless liquid that smells like gasoline. Ethylbenzene is found naturally in oil, is used in fuels and solvents, and large quantities are produced to make styrene. Some consumer products containing ethylbenzene are gasoline, paint, ink, pesticides, carpet glues, varnishes, tobacco products, and automotive products. If ethylbenzene is released to the atmosphere, it will exist predominantly in the vapor phase, because of its vapor pressure. Ethylbenzene will evaporate rapidly from water or will biodegrade readily under aerobic conditions. Ethylbenzene is only moderately adsorbed by soil because of its measured Koc, and likely leaches to groundwater. Ethylbenzene can be taken up by biota, but generally is metabolized and does not bioaccumulate (ATSDR 2010).

7.1.7 Toluene

Toluene is a clear, colorless liquid with a distinctive smell. Toluene occurs in the environment in a number of ways: naturally in crude oil and in the tolu tree; as an addition to gasoline; produced during the process of making gasoline and other fuels from crude oil; when making coke from coal; and as a by-product in the manufacture of styrene.

Toluene is used in the manufacture of paint, paint thinner, fingernail polish, lacquer, adhesives, and rubber, and in some printing and leather tanning processes. Toluene does not typically persist in the environment, because it tends to evaporate from surface water and surface soil and chemically degrade rapidly in the atmosphere. Based on the low soil sorption capacity and high water solubility of toluene, it can be fairly mobile in soil and leach to groundwater. Biodegradation readily occurs both in soil and groundwater under aerobic conditions, but degradation is much less apt to occur under anaerobic conditions. Toluene can be taken up by biota, but generally is metabolized and does not bioaccumulate (ATSDR 2000).

7.1.8 Dioxins/Furans

Dioxins and furans are two classes of similar chemicals that both contain two carbon benzene ring structures. All dioxins contain two oxygen atoms, while all furans contain one oxygen atom. They can be anthropogenically and naturally produced as trace impurities or incidental byproducts in chlorophenols, chlorinated herbicides, commercial aroclor (PCB) mixtures, and bleached paper production or combustion (ATSDR 1998 and 1994). Dioxins/furans are characterized by extremely low vapor pressures, high log Kows, high Kocs, and extremely low water solubilities. These factors indicate a strong affinity for soil, particularly soil with high organic content. The strong adsorption to soil, low water solubilities, and high Koc values indicate that the dioxin/furan rate of transport from unsaturated zone soil to the water table via rain infiltration would be extremely low. Once sorbed to particulate matter or bound in the sediment organic phase, dioxins/furans exhibit little potential for leaching or volatilization. The only environmentally significant transformation process for these congeners is believed to be photodegradation of chemicals not bound to particles (e.g., in the gaseous phase or at the soil/air or water/air interface). Bacterial degradation of dioxins and furans is possible, but is a very slow process.

7.2 EXTENT OF CONTAMINATION

The nature and extent of contamination at the LL Apartments Parcel is well defined because of the multiple environmental investigations conducted within the last 5 years.

The primary site COCs consist of dioxins/furans, cPAHs, PCP, arsenic, and lead, with lesser amounts of TPH and associated VOCs (ethylbenzene and toluene). Dioxins/furans have impacted shallow soil throughout the LL Apartments Parcel, shallow soil at the LL Parcel, and deeper soil within the LL Apartments Parcel Central and Eastern Source Areas. Other COCs are primarily located within the Central and Eastern Source Areas, with some cPAH contamination located in the soil “Other Areas”. The historical releases and operations within the Central and Eastern Source Areas have impacted the shallow soil, deeper soil, and the shallow groundwater, but have not impacted the groundwater below the shallow portion of the aquifer beneath the Site. As indicated by the 2010 to 2011 RI data, shallow groundwater contamination is limited to the LL Apartments Parcel, within the Central and Eastern Source Areas. Groundwater downgradient of the LL Apartments Parcel at the LL Parcel and DMCA has not been impacted. There are no COC exceedances of MTCA Method C soil cleanup levels.

Section 4.0 figures present the soil, groundwater, and sediment data for the Site on a series of concentration maps. Figures 7.1, 7.2, 7.3, and Tables 7.2 through 7.5 present data for only those COCs with concentrations that exceed the site cleanup levels in soil, groundwater, and/or surface sediment, as determined in Section 6.0. Similar to the Section 4.0 figures, Figures 7.1 and 7.3 use all site soil data collected between 2007 and 2011. The Section 4.0 figures and Figure 7.2 that show groundwater concentrations use only 2010 to 2011 RI data due to the data quality concerns discussed in Section 4.2.2.

Additionally, off-site data collected as part of a Phase II ESA conducted at an adjacent property, the Former Seattle City Light Sunnydale Substation, are used to assist in the delineation of cPAH and dioxin/furan contamination beyond the LL Apartments Parcel property boundary (Pinnacle GeoSciences 2009; refer to Sections 3.1.4 and 4.2.1.4).

The following subsections summarize from the detailed parcel-specific data reports the extent of contamination in soil, groundwater, and surface sediment (refer to Appendices F, G, and H). For this summary, the vertical extent of soil contamination is evaluated by reference to three vertical soil intervals: surface, shallow subsurface, and subsurface contamination. Surface soil contamination is representative of COC cleanup level exceedances detected in the 0-to-0.5-foot sample depth interval. Shallow subsurface contamination is representative of COC cleanup level exceedances detected in sample depth intervals ranging from 0.5–4 feet bgs. This shallow subsurface interval consists of samples collected from the 0.5–2 feet bgs, 1.5–2 feet bgs, and 2–4 feet bgs intervals. Subsurface contamination is representative of COC cleanup level exceedances detected in sample depth intervals greater than 4 feet bgs.

Histograms presenting COC concentrations detected in soil samples collected during the 2010 to 2011 RI at the LL Apartments Parcel were prepared for the COCs with the largest number of soil cleanup level exceedances: dioxins/furans, cPAHs, PCP, lead, gasoline range TPH, and heavy oil range TPH (Figures 7.4, 7.5, 7.6, and 7.7). The extent of contamination for COCs that exceed site media cleanup levels are described below.

7.2.1 Extent of Metals Contamination

7.2.1.1 Arsenic and Lead in Soil

Figure 7.1 and Tables 7.2 and 7.5 show the arsenic and lead soil exceedances of the site cleanup levels. The LL Apartments Parcel and LL Parcel arsenic soil cleanup level is the MTCA Method A cleanup level of 20 mg/kg. The DMCA arsenic soil cleanup level is the MTCA Method C industrial use cleanup level of 88 mg/kg. The LL Apartments Parcel and LL Parcel lead soil cleanup level is the MTCA Method A cleanup level of 250 mg/kg. The DMCA lead soil cleanup level is the MTCA Method A industrial use cleanup level of 1,000 mg/kg. The locations where detected lead concentrations exceed these cleanup levels include the following:

- **LL Apartments Parcel Central Source Area.** Lead surface and shallow subsurface contamination was detected in Borings LL-01 and PSB-11 at maximum concentrations of 265 mg/kg in the 1.5–2 feet bgs interval and 2,880 mg/kg at 2–4 feet bgs, respectively.

- **LL Apartments Parcel Eastern Source Area.** Lead surface contamination was detected in the soil samples from MW-4 and MW-5 at maximum concentrations of 370 mg/kg and 294 mg/kg, respectively. Sample exceedances in soil were collected from the 0–0.5 foot bgs interval.

LL Apartments Parcel or LL Parcel soil samples contained arsenic at concentrations less than the MTCA Method A cleanup level of 20 mg/kg. DMCA soil samples contained arsenic at concentrations less than the MTCA Method C cleanup level of 88 mg/kg. LL Parcel and DMCA soil samples contained lead at concentrations less than the MTCA Method A and Method C cleanup levels of 250 and 1,000 mg/kg, respectively.

7.2.1.2 Arsenic and Lead in Groundwater

Arsenic has been detected in both groundwater and soil at the Site. Figure 7.2 and Table 7.3 show the locations and concentrations of arsenic groundwater exceedances. The locations where detected concentrations exceed the MTCA Method A cleanup level for arsenic of 5 µg/L include the following:

- **LL Apartments Parcel Central Source Area.** The total arsenic maximum concentration of 14.2 µg/L was detected in the April 2011 RI sample collected from MW-1. The dissolved arsenic maximum concentration at this location, 11.9 µg/L, was detected in the January 2011 RI event.
- **LL Apartments Parcel Eastern Source Area.** In the January 2011 RI sample collected from MW-5 dissolved arsenic was detected at a concentration of 5.4 µg/L.

Arsenic was not detected in any other groundwater samples collected from the monitoring wells located on the LL Apartments Parcel, or in any LL Parcel or DMCA monitoring well samples at concentrations greater than the MTCA Method A cleanup level.

Lead was not detected in any groundwater samples collected as part of the 2010 to 2011 RI sampling events.

7.2.1.3 Arsenic and Lead in Surface Sediment

The detected concentrations of arsenic and lead in Lora Lake and Miller Creek surface sediments were less than the freshwater benthic CSLs of 120 mg/kg and 1,300 mg/kg, respectively (results presented in Table 7.4), but the Lora Lake surface sediment samples exceeded the freshwater benthic SCO levels for arsenic (14 mg/kg) and lead (360 mg/kg). The CSL serves as the level above which cleanup sites are designated, and also serves as the upper end of the range within which cleanup standards for a site may be selected, based on balancing environmental protectiveness, cost, and technical feasibility. The SCO serves as the long-term goal for sediments of the state, and the lower end of the range within which cleanup standards for a site can be selected.

The maximum detected concentration of arsenic in the surface sediment samples collected from Lora Lake is five times the benthic SCO, and approximately one-half of the benthic CSL. The maximum detected concentration of lead in the surface sediment samples collected from Lora Lake is less than 1.4 times the benthic SCO, and approximately one-third of the benthic CSL. Additionally, the biological toxicity testing in both Lora Lake and Miller Creek indicates that the surface sediments are unlikely to cause adverse impacts to ecological receptors.[10] Therefore, the results of the biological toxicity testing indicate that the arsenic and lead concentrations detected in Lora Lake surface sediment do not result in adverse biological effects to benthic receptors.

The detected concentrations of arsenic and lead in Lora Lake do indicate that the Lora Lake surface sediment has the potential to pose adverse human health effects. The SCOs for arsenic and lead are 11 mg/kg and 21 mg/kg, respectively. All samples collected in Lora Lake exceeded the SCO for both analytes with the exception of LL-SED5 for arsenic only (with a concentration of 7 mg/kg). None of the detected arsenic or lead concentrations exceeded the SCO in Miller Creek, indicating the surface sediment in Miller Creek does not have the potential to pose adverse human health effects.

7.2.2 Extent of Petroleum Hydrocarbon Contamination

7.2.2.1 Total Petroleum Hydrocarbons in Soil

Figure 7.1 and Table 7.2 show the gasoline range, diesel range, and heavy oil range TPH soil exceedances. The locations where detected concentrations exceed the MTCA Method A cleanup levels for gasoline range (100 mg/kg), diesel range (2,000 mg/kg), and heavy oil range (2,000 mg/kg) range TPH are the following:

- **LL Apartments Parcel Central Source Area.** TPH subsurface contamination was detected in soil from LLP-04 and MW-1 at maximum gasoline range, diesel range, and heavy oil range concentrations of 1,900 mg/kg, 8,900 mg/kg, and 17,000 mg/kg, respectively. Sample exceedances in the LLP-04 and MW-1 borings were near the groundwater interface, in the soil intervals of 14.5--15.5 feet bgs and 14–15 feet bgs, respectively. Heavy oil range TPH was detected at a concentration of 9,800 mg/kg in the 6.5–7 feet bgs interval collected from LLP-02, also located within the Central Source Area.

  Gasoline range TPH shallow subsurface contamination was detected in soil from PSB-11 at a maximum concentration of 150 mg/kg, from the 1.5–2 feet bgs interval. Heavy oil range TPH shallow subsurface contamination was also detected in soil from PSB-11 at a maximum concentration of 2,700 mg/kg, from the 2–4 feet bgs interval.

No other LL Apartments Parcel, LL Parcel, or DMCA soil samples contained TPH at concentrations greater than the MTCA Method A cleanup levels. The LL Apartments Parcel soil data indicate that the extent of TPH contamination for all three hydrocarbon ranges is limited to a localized area of the Central Source Area.

[10] The LL-SED2 sediment sample from Lora Lake failed the CSL criterion for midge survival; however, this failure is thought to be associated with sulfides. Refer to Section 4.3.1.3 and Appendix G.

7.2.2.2 *Total Petroleum Hydrocarbons in Groundwater*

TPH was detected at a concentration greater than the MTCA Method A cleanup levels at one location at the Site (Table 7.3). Heavy oil range TPH was detected at a concentration of 0.53 mg/L in the groundwater collected from MW-1 during the January 2011 RI sampling event, greater than the MTCA Method A cleanup level of 0.5 mg/L. The extent of TPH groundwater contamination is limited to this one sample collected from MW-1 located within the LL Apartments Parcel Central Source Area.

7.2.3 Extent of Pentachlorophenol Contamination

7.2.3.1 *Pentachlorophenol in Soil*

Figure 7.1 and Table 7.2 show the locations and concentrations of PCP soil exceedances. The locations where detected concentrations exceed the MTCA Method B cleanup level of 2,500 µg/kg include the following:

- **LL Apartments Parcel Eastern Source Area.** PCP surface contamination detected in soil from MW-4 and MW-5 at maximum concentrations of 15,000 µg/kg and 2,700 µg/kg, respectively. Sample exceedances in surface soil were collected from the 0–0.5 foot bgs interval. The concentrations of the underlying (1.5–2.0 feet bgs) samples collected from the MW-4 and MW-5 borings were 57 µg/kg and 53 µg/kg, respectively, indicating that concentrations decrease rapidly with depth.
- **LL Apartments Parcel Central Source Area.** The next highest concentration of PCP detected in site soil was located in shallow subsurface soils in the Central Source Area and did not exceed the MTCA Method B cleanup level of 2,500 µg/kg[11]. PCP was detected in the soil sample collected from the 1.5-2 feet bgs interval of PSB-11 at a concentration of 2,400 µg/kg.

The LL Apartments Parcel soil data indicate that the extent of PCP soil contamination is limited to the Central and Eastern Source Areas and within the surface and shallow subsurface soil. No LL Parcel or DMCA soil samples contained PCP at concentrations greater than the MTCA Method B cleanup level.

7.2.3.2 *Pentachlorophenol in Groundwater*

PCP has been detected in site groundwater. Figure 7.2 and Table 7.3 show the location and concentration of the PCP groundwater exceedance, which is described below:

- **LL Apartments Parcel Eastern Source Area.** The PCP maximum detected concentration of 1.4 µg/L in the January and April 2011 RI samples collected from MW-5 exceeded the CUL for groundwater, which is state and federal MCL of 1 µg/L.

[11] The laboratory reporting limits for soil samples collected from Borings LLP-04 and MW-1 were greater than the MTCA Method B cleanup level due to elevated TPH concentrations in the samples.

The only other detections of PCP during the 2010 to 2011 RI monitoring events were in a sample collected from MW-1 at a concentration of 0.76 µg/L during the January 2011 RI event and a sample collected from MW-9 at a concentration of 0.47 µg/L during the August 2010 RI event. PCP was not detected at concentrations greater than the state and federal MCL in any other groundwater samples collected at the Site.

7.2.3.3 Pentachlorophenol in Surface Sediment

PCP was not detected at concentrations exceeding the SCO or CSL in any Lora Lake or Miller Creek surface sediment samples. At LL-SED2, PCP was not detected; however, the detection limit was elevated at approximately 2.0 times the SCO.

7.2.4 Extent of Carcinogenic Polycyclic Aromatic Hydrocarbon Contamination

7.2.4.1 Carcinogenic Polycyclic Aromatic Hydrocarbons in Soil

Figure 7.1 and Table 7.2 show the locations and concentrations of cPAH TEQ soil exceedances. The locations where detected concentrations exceed the MTCA Method B cleanup level of 137 µg/kg are described below:

- **Lora Lake Apartments Central Source Area.** cPAH shallow subsurface contamination was detected in soil at PSB-11 at maximum TEQ concentrations of 150 µg/kg and 270 µg/kg collected from the 1.5–2 feet bgs and 2--4 feet bgs intervals, respectively. The concentration of the underlying (4–6 feet bgs) sample collected from the PSB-11 boring was 23 µg/kg.

  cPAH subsurface contamination was detected in soil at TEQ maximum concentrations of 880 µg/kg and 760 µg/kg in samples collected from the 14--5 feet bgs interval at MW-1 and 14.5–15.5 feet bgs at LLP-4, respectively.

- **Lora Lake Apartments Eastern Source Area.** cPAH surface contamination was detected at maximum TEQ concentrations of 150 µg/kg and 240 µg/kg, in samples collected from the 0–0.5 foot bgs interval at MW-4 and MW-5, respectively. The cPAH TEQ concentrations of samples collected from the underlying interval (1.5–2.0 feet bgs) collected from the MW-4 and MW-5 borings were 3.8 µg/kg and 7.5 µg/kg, respectively, indicating that, consistent with PCP, the concentrations decrease rapidly with depth. The cPAH TEQ concentration for a soil sample collected from the 11.5–13 feet bgs interval of MW-5, however, had a cPAH concentration of 140 µg/kg, slightly greater than the MTCA Method B cleanup level.[12]

  cPAH surface contamination was detected directly downgradient of MW-5 within the LL Apartments Eastern Source Area (PSB-20) at a maximum TEQ concentration of 350 µg/kg from the 0–0.5 foot bgs interval. The underlying (1.5–2 feet bgs) sample collected from the PSB-20 boring, located west of and adjacent to Des Moines Memorial Drive, was 14 µg/kg.

[12] The depth of cPAH soil cleanup level exceedances as described in MW-4 and MW-5 borings may be attributable to the LL Apartments Parcel regrading activities that were performed during construction of the apartment complex and are described in more detail in Section 2.4.2.

- **LL Apartments Other Area.** cPAH shallow subsurface contamination was detected southwest of the LL Apartments Parcel Central Source Area (LL-08) at a maximum TEQ concentration of 160 µg/kg, collected from the 2–4 feet bgs interval. Off-site soil samples (DP-3) collected on the Former Seattle City Light Sunnydale Substation property, located adjacent to this portion of the LL Apartments Parcel, have maximum cPAH TEQ concentrations of 13 µg/kg collected from 1.5 feet bgs, and 0.2 µg/kg collected from 3 feet bgs.

The LL Apartments Parcel soil data indicate that the extent of cPAH soil contamination is primarily within the Central and Eastern Source Areas, with two additional, localized soil exceedances in shallow subsurface samples collected from downgradient of the Eastern Source Area and southwest of the Central Source Area. No LL Parcel or DMCA soil samples contained cPAHs at concentrations greater than the MTCA Method B or MTCA Method C respective cleanup levels.

7.2.4.2 Carcinogenic Polycyclic Aromatic Hydrocarbons in Groundwater

In groundwater samples collected from MW-1 located within the LL Apartments Parcel Central Source Area cPAHs were detected at concentrations less than the MTCA Method B cleanup level of 0.12 µg/L.

There were no cPAHs detected in any other groundwater samples collected from the monitoring wells located on the LL Apartments Parcel or the LL Parcel, or any DMCA monitoring wells.

7.2.4.3 Carcinogenic Polycyclic Aromatic Hydrocarbons in Surface Sediment

cPAHs were not detected at concentrations exceeding the SCO or CSL in any Lora Lake or Miller Creek surface sediment samples.

7.2.5 Extent of Dioxin/Furan Contamination

7.2.5.1 Dioxins/Furans in Soil

Figure 7.3 and Tables 7.2 and 7.5 present the dioxin/furan TEQ soil exceedances. In addition, Figures 4.10, 4.11 and 4.12 present dioxin/furan TEQ concentrations measured in the 0-to-0.5-foot, 0.5-to-2–foot, and 2-to-4-foot depth intervals. The locations where detected concentrations exceed the site cleanup levels are discussed for each site parcel separately.

Lora Lake Apartments Parcel

Figures 7.8 and 7.9 present LL Apartments Parcel cross sections that show dioxin/furan TEQ results by depth. As shown in Figure 4.9, approximately 20 percent of the northern portion of the site soils and 10 percent of the southern portion of the site soils do not contain concentrations of dioxins/furans greater than the cleanup level.[13] The locations where detected concentrations of dioxins/furans exceed the MTCA Method B cleanup level are described below and are organized by depth:

- **Surface Soil Contamination: 0–0.5 foot bgs.** Contamination in the 0-to-0.5-foot interval is the most widespread, and covers approximately 70 percent of the LL Apartments Parcel. There are fewer exceedances in the deeper, 0.5–2 feet bgs and 2–4 feet bgs sampling intervals. Figure 7.10 presents dioxin/furan soil concentration histograms by sampled depth interval.
  - The maximum surface soil dioxin/furan TEQ concentrations (0–0.5 foot bgs) were detected in the Eastern Source Area, collected from MW-4 (2,570 pg/g) and MW-5 (3,100 pg/g).
  - Dioxin/furan exceedances in the surface interval within the Central Source Area ranged from 57 pg/g to 493 pg/g.
  - Dioxin/furan exceedances within the 0–0.5 foot bgs interval along the northern, western, and southern LL Apartments Parcel property boundaries ranged from 17.7 pg/g (LLA-HA3) to 58.7 pg/g (PSB-03), but there were also areas along the northern and southern boundaries with no exceedances, as shown in Figure 4.10.
  - Dioxin/furan exceedances measured within the 0–0.5 foot bgs interval along the eastern LL Apartments Parcel property boundary adjacent to Des Moines Memorial Drive ranged from 16.6 pg/g (PSB-24) to 209 pg/g (PSB-18), where the highest concentrations were detected in the Eastern Source Area and the lowest concentrations were detected in the northeast corner.
- **Shallow Subsurface Soil Contamination: 1.5–2 feet bgs and 2–4 feet bgs.**
  - Shallow subsurface soil dioxin/furan contamination in the 1.5–2 feet bgs sample depth interval extends across the LL Apartments Parcel to a slightly smaller extent than the surface interval. The extent of the dioxin/furan contamination in the 2-to-4-foot interval is reduced even further, as shown in Figures 4.11 and 4.12 for the 0.5-to-2-foot and 2-to-4-foot intervals, respectively.
  - In the 1.5–2 feet bgs depth interval samples, the maximum dioxin/furan TEQ concentrations were detected in the Central Source Area (LL-01, LL-10, and PSB-11, at concentrations of 1,810 pg/g, 2,600 pg/g, and 21,200 pg/g, respectively). The PSB-11 dioxin/furan TEQ concentration of 21,200 pg/g was the highest dioxin/furan concentration detected at the Site.
  - The dioxin/furan TEQ concentrations detected in the 1.5–2 feet bgs interval of Borings MW-4 and MW-5 in the Eastern Source Area are substantially lower than the 0–0.5 foot bgs interval surface samples and were measured at 31 pg/g and 24 pg/g, respectively.

[13] The LL Apartments Parcel soil cleanup level for dioxins/furans is the MTCA Method B TEQ cleanup level of 13 pg/g, for protection of human health.

- Dioxin/furan TEQ concentrations detected within the 1.5–2 feet bgs interval along the northern, western, and southern LL Apartments Parcel property boundaries ranged from 15.2 pg/g (SSB-02) to 33.8 pg/g (LL-07), with several samples on the northern, western, and southern boundaries of the Site with no exceedances.
- Dioxin/furan exceedances within the 1.5–2 feet bgs interval along the eastern LL Apartments Parcel property boundary, adjacent to Des Moines Memorial Drive, ranged from 13.2 pg/g (PSB-16) to 31.2 pg/g (MW-4), with several samples in the northeastern and southeastern corners of the Site with no exceedances.
- The dioxin/furan exceedances in the 2–4 feet bgs interval are primarily localized to the Central Source and Eastern Source Areas. A sample collected from LL-08 (650 pg/g) is the only dioxin/furan exceedance located outside of the Central and Eastern Source Areas on the LL Apartments Parcel. This LL-08 result is horizontally bound by results from samples located off-site and to the south collected during the Phase II ESA Former Sunnydale Substation Investigation.
- Dioxin/furan TEQ concentrations detected in the 2–4 feet bgs interval within the Central Source Area range from 0.75 pg/g to 11,700 pg/g, with the maximum concentration detected in Boring PSB-11. With the exception of LL-08, there are no dioxin/furan exceedances in the depth interval 2–4 feet bgs along the southern, western, or northern property boundaries.

- **Subsurface Soil Contamination: Deeper than 4 feet bgs.**
  - Subsurface soil dioxin/furan TEQ detections exceed the cleanup level in the Central and Eastern Source Areas at depths greater than 4 feet bgs. There were no dioxin/furan exceedances in subsurface soil (greater than 4 feet bgs) in areas of the Site other than the Central and Eastern Source Areas.
  - The Central Source Area subsurface (greater than 4 feet bgs) dioxin/furan exceedances vary by depth. The maximum dioxin/furan TEQ concentration of 2,490 pg/g was detected in the 4–6 feet bgs sample interval from PSB-11. The contamination was not bound by depth in the PSB-11 soil boring, because the deepest sample collected from PSB-11 between 14–16 feet bgs had a dioxin/furan TEQ concentration of 2,050 pg/g. No additional deeper samples were collected for dioxin/furan analysis from PSB-11; however, samples from adjacent borings, MW-1 and PSB-12, collected from the depth intervals of 14 feet bgs and 14–17 feet bgs contained dioxin/furan TEQ concentrations of 302 pg/g and 74.1 pg/g, respectively.
  - The Eastern Source Area subsurface (greater than 4 feet bgs) dioxin/furan exceedances ranged in depth from the 4–6 feet bgs interval to 15 feet bgs at PSB-15, with a maximum dioxin/furan TEQ concentration of 572 pg/g detected in the 6.5–8 feet bgs sample interval collected from MW-5.

The LL Apartments Parcel soil data indicate that the extent of dioxin/furan soil contamination between ground surface and 2 to 4 feet bgs covers approximately

70 percent of the LL Apartments Parcel footprint, but that subsurface contamination (deeper than 4 feet bgs) is limited to the Central and Eastern Source Areas, as shown in Figures 4.9 through 4.12.

Lora Lake Parcel

The LL Parcel soil cleanup level proposed for dioxins/furans is the 90th percentile natural background concentration of 5.2 pg/g given in WSDOE's technical memorandum (WSDOE 2010), substituted for the TEE dioxin and furan EICs, as described in Section 6.1. Soil samples were collected from 6 locations at the LL Parcel to depths of 4 feet bgs. The locations where detected concentrations exceed the natural background concentration are described below:

- Four locations exceed the dioxin/furan TEQ cleanup level in surface soil within the LL Parcel. Surface samples (0–0.5 foot bgs) collected from LL-SB2, LL-SB4, LL-SB5, and LL-SB6 reported dioxin/furan TEQ concentrations of 13.2 pg/g, 5.59 pg/g, 8.76 pg/g, and 40.4 pg/g, respectively.
- Two locations exceeded the dioxin/furan TEQ cleanup level in shallow subsurface soil within the LL Parcel. The dioxin/furan TEQ concentrations for the samples collected from the 1.5–2 feet bgs and 2–4 feet bgs sample intervals of LL-SB5 were 10.8 and 22.7 pg/g, respectively. The dioxin/furan TEQ concentration for the sample collected from the 1.5–2 feet bgs sample interval of LL-SB6 was 7.57 pg/g.

The LL Parcel soil data indicate that, with the exception of sampling location LL-SB5 and LL-SB6, the extent of dioxin/furan soil contamination is limited to surface soils.

Dredged Material Containment Area

The DMCA soil cleanup level for dioxins/furans is the MTCA Method C industrial land use cleanup level of 1,500 pg/g. There are no soil dioxin/furan exceedances at the DMCA.

7.2.5.2 Dioxins/Furans in Groundwater

Dioxins/furans have been detected in groundwater at the LL Apartments Parcel collected during the 2010 to 2011 RI sampling events. Figure 7.2 and Table 7.3 show the location and maximum concentration of the dioxin/furan groundwater sample in which detected concentrations exceed the MTCA Method B cleanup level for dioxins/furans of 6.7 pg/L:

- The dioxin/furan maximum detected TEQ concentration of 38.3 pg/L in the January 2011 RI sample was collected from MW-1, located within the Central Source Area.

Dioxins/furans were not detected in any other groundwater samples collected from the monitoring wells located on the LL Apartments Parcel, LL Parcel, or DMCA monitoring wells at concentrations greater than the MTCA Method B cleanup level.

7.2.5.3 Dioxins/Furans in Surface Sediment

Elevated concentrations of dioxins/furans were detected in the surface sediments collected from Lora Lake. Figure 4.18 shows the detected concentrations of dioxins/furans in the surface sediments of Lora Lake and Miller Creek. Table 7.4 presents those surface sediment samples with dioxins/furans TEQ concentrations greater than the SCO and CSL in surface sediments collected from Lora Lake.

The detected dioxin/furan TEQ concentrations in Lora Lake surface sediment samples ranged from 7.55 pg/g to 217 pg/g. The lowest TEQ concentration of 7.55 pg/g was detected in Sample LLSED-5, located within the sediment settling basin in the northwestern corner of Lora Lake. The maximum TEQ concentration of 217 pg/g was detected in Sample LLSED-2, located at the deepest point within Lora Lake. The LLSED-5 sample had the lowest organic carbon content and highest total solids content of Lora Lake surface sediment samples, while LLSED-2 had the highest organic carbon content and the lowest total solids content. LLSED-2 also had the highest total sulfides concentration of Lora Lake surface sediment samples. Elevated dioxin/furan concentrations, ranging from 149 pg/g to 193 pg/g were also detected at the other Lora Lake surface sediment samples LLSED-1, LLSED-3, and LLSED-4. Dioxins/furans were detected at TEQ concentrations ranging from 0.33 pg/g to 0.44 pg/g in the surface sediments collected from Miller Creek.

While benthic criteria do not exist for dioxins/furans TEQ, all surface sediment samples in Lora Lake exceeded the human health dioxins/furans TEQ SCO and CSL (presented in Table 7.4 and derived in a memorandum in 2014 [Floyd|Snider 2014]), indicating that the Lora Lake surface sediment has the potential to result in adverse human health effects. Both the SCO and the CSL are equal to the recommended PQL for dioxins/furans TEQ of 5 pg/g per the *Draft Sediment Cleanup Users Manual II* (SCUM II, WSDOE 2013c). None of the dioxins/furans TEQ concentrations in samples collected from Miller Creek exceeded the human health dioxins/furans TEQ SCO or CSL.

7.2.6 Calculation of Contaminant Mass

As presented in Appendix N, the mass concentration data for dioxins/furans, PCP, and cPAHs were used to calculate the volume of contaminated soil and total mass of contaminants present in soil at concentrations greater than cleanup levels at the LL Apartments Parcel and the LL Parcel. This analysis was not conducted for the DMCA because the detected soil COC concentrations do not exceed the MTCA Method C cleanup levels. The analysis was conducted for dioxins/furans, PCP, and cPAHs because these COCs were found to be representative of the extent of all site COCs. The calculations were conducted by first delineating contaminant areas within each depth interval by grouping samples with concentrations on the same order of magnitude and bounding the areas with clean samples. The average mass concentration in each of those depth area intervals was then used to determine a volume of contaminated soil. By assuming the soil density, a contaminant mass was calculated.

The results of the calculations indicate that a total of 0.031 kg of dioxins/furans, 4.9 kg of PCP, and 0.88 kg of cPAHs are present in LL Apartments Parcel and the LL Parcel soils.

The majority of the contaminant mass for all three COCs is on the LL Apartments Parcel, where 100 percent of the PCP and cPAH contaminant mass, and 99.9 percent of the dioxin/furan contaminant mass is located. On the LL Apartments Parcel, 480 cubic yards of soil are contaminated with PCP, 1,800 cubic yards of soil are contaminated with cPAHs, and 39,000 cubic yards of soil are contaminated with dioxins/furans.

Approximately 0.12 percent (0.00004 kg) of the dioxin/furan contaminant mass, or 1,400 cubic yards of dioxin/furan contaminated soil is located on the Lora Lake Parcel.

7.3 AREAS OF CONTAMINATION

As described in the previous RI sections, three areas have been investigated as part of the LL Apartments RI/FS: the LL Apartments Parcel, the LL Parcel, and the DMCA. Soil and groundwater quality have been investigated in all three of these areas. Additionally, the chemical quality and biological toxicity of surface sediments have been investigated at Lora Lake and the reach of Miller Creek within the LL Parcel. Subsurface sediments collected from Lora Lake were also sampled and analyzed.

The areas of contamination and associated media located within each investigational area (parcel) have been defined for the Site and are discussed below.

7.3.1 Lora Lake Apartments Parcel—Central and Eastern Source Areas Soil

The soil in the Central and Eastern Source Areas of the LL Apartments Parcel is contaminated from the ground surface to a depth of 15 to 20 feet bgs from past releases associated with historical barrel-washing operations, auto-wrecking operations, and soil relocation during apartment construction and landscaping. Contaminants in soil within these source areas include: dioxins/furans, cPAHs, PCP, TPH, and lead. Outside these source areas, soil contamination generally does not exceed 2 to 4 feet in depth.

7.3.2 Lora Lake Apartments Parcel—Shallow Soil

In general, beyond the extent of the LL Apartments Parcel Central and Eastern Source Areas, dioxin/furan contamination is present in soil shallower than 2–4 feet bgs across the central portion of the parcel, and along the eastern portion of the LL Apartments Parcel (Figures 7.4 and 7.8).

7.3.3 Lora Lake Parcel—Shallow Soil

On the LL Parcel, dioxin/furan soil contamination is present in 4 surface samples (0--0.5 foot bgs) and 3 shallow subsurface samples (1.5–2 feet bgs and 2–4 feet bgs).

7.3.4 Lora Lake Apartments Parcel—Groundwater

The only area of groundwater contamination at the Site is within the LL Apartments Parcel Central and Eastern Source Areas. COCs have been detected at concentrations greater than cleanup levels only at MW-1 and MW-5. As stated above, the contaminants in groundwater within the source areas are heavy oil range TPH, dioxins/furans, PCP, and arsenic. During RI sampling, COCs have not been detected at concentrations greater than cleanup levels in any of the other site wells, including the DMCA wells.

7.3.5 Lora Lake—Surface Sediment

The Lora Lake surface sediment has elevated levels of dioxins/furans, arsenic, and lead. Detected concentrations of dioxins/furans TEQ were greater than the human health SCO in all samples collected from Lora Lake surface sediment. No detected concentrations of dioxins/furans TEQ were greater than the human health SCO in Miller Creek. Detected concentrations of arsenic and lead were greater than their respective human health SCOs in all Lora Lake surface sediment samples (except arsenic in LL-SED5). Sediment cleanup alternatives protective of downstream human consumption of fish will be evaluated in the LL Parcel FS.

Biological toxicity testing indicated that the surface sediments are unlikely to cause adverse impacts to ecological receptors due to elevated chemical concentrations.

7.3.6 Dredged Material Containment Area—Soil

DMCA soil samples contained no COCs at concentrations greater than MTCA Method C soil cleanup levels.

8.0 Conceptual Site Model

MTCA Chapter 173-340-200 defines the CSM as a:

> "conceptual understanding of a site that identifies potential or suspected sources of hazardous substances, types and concentrations of hazardous substances, potentially contaminated media, and actual and potential exposure pathways and receptors." (WSDOE 2007).

Sections 2.0 through 7.0 have described in detail the suspected sources of hazardous substances, how they were released, the types and concentrations of chemicals detected at the Site, the impacted media at the Site, and the actual and potential exposure pathways and receptors. This section provides a conceptual summary of the detailed information described in the previous sections. Figure 8.1 presents a graphical representation of the CSM for the Site.

8.1 SOURCES OF HAZARDOUS SUBSTANCES

There are two primary sources of contamination to the soil and groundwater at the LL Apartments Parcel: the barrel-washing operations conducted in the 1940s to 1950s, and auto-wrecking activities conducted from the 1950s to the 1980s. Secondary processes that have re-distributed contamination at the Site include stormwater collection and discharge, Lora Lake dredging and dredge material containment, and regrading during apartment construction. These secondary processes have resulted in additional migration of contaminated media at the Site, and are discussed in the following sections.

8.1.1 Barrel-washing Operations

The operational history of the LL Apartments Parcel included barrel-washing during the 1940s to early 1950s. Review of historical records and aerial photographs during this time period indicate that barrels and drums brought to the property were rinsed and the leachate and wash water were discharged to the ground in the vicinity of the Central and Eastern Source Areas, either directly to the ground or to sump/pond structures. This operation is thought to be the main source of dioxins/furans, PCP, cPAHs, and TPH to the Site, and the cause of the high levels of contamination in the Central and Eastern Source Areas. Based on general information about barrel-washing operations during these years, it is likely that barrels and drums used for storage of a variety of chemicals would have been brought to the LL Apartments Parcel for cleaning. Some of the most commonly used chemicals during that period included herbicides and pesticides (historically, PCP was widely used as a pesticide), petroleum products, and wood-treating chemicals that also contained PCP. Dioxins/furans were contaminants that would have been present within each of these chemical mixtures, and wood-treating chemicals commonly contained cPAHs and PCP as well as dioxins/furans.

The dioxin/furan congener profiles from samples collected from the LL Apartments Parcel are not consistently or completely indicative of a specific known source of dioxins/furans; however, the congener profiles do have characteristics that are consistent with those dioxin/furan signatures or profiles of PCP and herbicides and pesticides, as well as general urban traffic exhaust profiles (Appendix D from Ecology and Environment Inc. 2011). The presence and mixture of non-specific dioxin/furan profiles are consistent with what is known about the historical barrel-washing operations, in that multiple different types of chemical mixtures would have been present in the barrels received on-site, and discharged into the same cleanout area. The highest dioxin/furan concentrations were detected within the center of the LL Apartments Parcel in the proximity of the historical barrel/drum cleanout area (the area we have called the Central Source Area in this RI/FS). These facts indicate that the most likely site-specific source of dioxins/furans (as well as other COCs) was the historical barrel-washing operations and specifically the drum cleanout pond area in the Central Source Area.

8.1.2 Auto-wrecking

Auto-wrecking activities were conducted at the LL Apartments Parcel from the 1950s to the 1980s. The auto-wrecking operations were generally end-of-life auto storage, where vehicles were stored until disposed of. It is unknown if incineration activities were conducted at the Site, but these activities were commonly conducted in auto yards during that time frame. Auto-wrecking and storage at the LL Apartments Parcel may have resulted in surface spills and releases of TPH to the ground surface from the vehicles and site equipment, although the majority of TPH contamination at the LL Apartments Parcel is located in the Central Source Area, rather than wide-spread across the auto-wrecking yard footprint. The TPH contamination is, therefore, most likely associated with the historical barrel-washing operations, and less with the auto-wrecking facility.

8.2 CONTAMINANT MIGRATION AND CONTAMINATED MEDIA

The historical operations discussed above have resulted in releases of chemicals to the ground surface at the Site. These chemicals have contaminated site soil, groundwater, and, potentially, lake sediment. Contaminant migration and the resulting contaminated media are discussed in the following sections, as well as these secondary migration pathways: soil contamination leaching to groundwater, earthmoving, and stormwater discharge.

8.2.1 Surface to Subsurface Migration

Research of historical site operations and general practices during the time periods when barrel washing occurred at this Site indicates that sludges, rinsate water, and chemicals were likely released to the ground surface, sumps, and/or a pond structure in the Central Source Area during the active years of barrel-washing operations. The contents of barrels cleaned at the Site are not confirmed, but based on the common chemicals used at the time and the COCs identified in site soil, it is assumed that these multiple chemicals may all have been released to the Site by barrel-washing in the Central Source Area: lead and arsenic, PCP, dioxin/furan-containing herbicides/pesticides, cPAH-containing materials, and petroleum. Some of these chemicals could then have migrated through the vadose zone via gravity flow until reaching the groundwater table.

Barrel-washing operations are assumed to be responsible for the soil contamination in the surface and subsurface of the Central Source Area from releases to the ground surface and subsurface in sumps and ponds, and from downward contaminant migration to underlying subsurface soil.

8.2.2 Soil Leaching to Groundwater

Low-level concentrations of site COCs in groundwater within the Central and Eastern Source Areas indicate that contaminants may have leached to groundwater after migrating through subsurface soil to reach the groundwater table. Since the 1980s, ongoing migration and leaching of soil contamination to groundwater and the LL Apartments Parcel may have been somewhat limited by the site pavement and building coverage, which would prevent rainwater infiltration. The majority of the LL Apartments Parcel was paved during construction of the apartment complex and stormwater drainage control features were installed that would have limited the volume of rainwater infiltrating the subsurface, and, therefore, reduced the potential leaching of soil contaminants to groundwater.

In addition, as discussed in Section 7.0, key site COCs are hydrophobic (including dioxins/furans, cPAHs, and PCP), with high partitioning coefficients, and would not readily migrate to or with groundwater. This is supported by the site data, the current limited extent of groundwater contamination, and further supported by the BIOSCREEN modeling presented in Appendix L. The majority of site COCs are not detected in site groundwater. The locations where COCs have consistently been detected at concentrations greater than site cleanup levels are co-located with those areas where soil contaminant concentrations are highest; in the Central and Eastern Source Areas, and does not extend downgradient. The existing groundwater data for the Central and Eastern Source Areas show low-level concentrations of PCP, arsenic, cPAHs, and dioxins/furans, and one exceedance of heavy oil range TPH, indicating that some degree of soil contaminant impact to groundwater is occurring in these areas of elevated subsurface soil contamination. Given the hydrophobic nature of these COCs, there is also a high potential that these concentrations in groundwater are associated with contaminated soil particles that are present in the groundwater, rather than dissolved-phase contaminants.

Soil leaching to groundwater does not appear to be occurring in other areas of the Site such as the DMCA, LL Parcel, or the western portion of the LL Apartments Parcel, where contamination is limited to shallow soil at the LL Parcel and LL Apartments Parcel and no soil cleanup level exceedances occur at the DMCA. In all of these areas of the Site, groundwater concentrations do not exceed cleanup levels.

8.2.3 Migration via Regrading and Earthwork

Site regrading activities are likely responsible for the widespread presence of dioxins/furans across the shallow surface soil at the LL Apartments Parcel. It is not well documented if regrading activities were conducted during the auto-wrecking years at the property; however, aerial photographs contained in Appendix A do show the footprint of car storage and operational areas increasing over the years of occupation, and grading of the property may have been conducted to expand the operational footprint and clear the property for car storage.

Substantial regrading activities occurred during the construction of the apartment complex in the mid-1980s. These regrading activities are likely responsible for moving dioxins/furans and other COC-contaminated soil from the Central Source Area to other areas of the LL Apartments Parcel, including the Eastern Source Area. Prior to the construction of the apartment complex in the 1980s, a roadway entrance to the property existed along the southern portion of the eastern property line (Appendix A). This roadway no longer exists, and the current elevation of this portion of the property is more than 10 feet above the elevation of Des Moines Memorial Drive, with slopes along the property line at approximately 1.5:1. Filling and/or regrading in this area may be responsible for the steep slopes and greater depth of contaminated fill observed in this portion of the Eastern Source Area.

The characteristics of the shallow surface soil contamination are also indicative of re-working of site soil versus migration of contamination through the soil. Concentrations of dioxins/furans (as well as other COCs) show substantial variation in vertical and horizontal extent, magnitude of concentrations, and location, and do not decrease in concentration with increasing distance away from the source area, as is typical with plumes of contamination migrating away from a source area.

No additional site grading activities have occurred since construction of the apartment complex in the mid-1980s.

8.2.4 Overland Transport

Surface soil contamination at the LL Apartments Parcel is present up to the Des Moines Memorial Drive Right-of-Way, and, in select locations, is also present on the east side of the roadway, on the LL Parcel. Elevated concentrations of dioxins/furans in surface soil on the east side of Des Moines Memorial Drive may be associated with contamination at the LL Apartments Parcel; however, this contamination is not assumed to be associated with earth-moving activities or material placement. Throughout the operating years of the barrel-washing and auto-wrecking facilities, residential homes were located along the east side of Des Moines Memorial Drive between the LL Apartments Parcel, and Lora Lake (1940s and 1950s to the 1990s). Additionally, Des Moines Memorial Drive has been a primary thoroughfare since the 1930s. A review of all available historical records did not discover any reports of material movement, dumping, or similar activity from the barrel-washing or auto-wrecking facilities onto the residential properties to the east, now the LL Parcel.

Given the topographic changes between the LL Apartments Parcel and the LL Parcel, overland transport of surface soil through wind transport, surface runoff during STEs, and other similar mechanisms may be responsible for transport of dioxin/furan-contaminated soil from the LL Apartments Parcel to the shallow soil at the LL Parcel. In addition, urban background sources of dioxins/furans are a likely contributor to surface soil along the roadway.

Surface soil contamination adjacent to roadways is commonly attributed to urban sources such as vehicle exhaust and historical pesticide/herbicide use along roadway shoulders. Although these are the more likely sources of dioxin/furan contamination to the areas immediately adjacent to Des Moines Memorial Drive, the potential for the LL Apartments Parcel to have contributed to the dioxin/furan concentrations at the LL Parcel shallow soil cannot be eliminated.

8.2.5 Stormwater System Infiltration and Discharge

A stormwater main line carrying stormwater from residential Burien extends through the LL Apartments Parcel before discharging to Lora Lake. Runoff from the LL Apartments Parcel joins the main line flow through a network of catch basins and stormwater piping. The SWIA conducted in accordance with the site AO investigated the integrity of the on-site stormwater conveyance system piping, and monitored the quality of stormwater entering and exiting the LL Apartments Parcel. Statistical evaluation of the resulting data indicates that under current conditions, stormwater quality exiting the LL Apartments Parcel is statistically equivalent to stormwater entering the property. Stormwater carried by the system is known to contain concentrations of dioxins/furans on the order of 1 pg/L to 37 pg/L. Dioxins/furans are known to be ubiquitous in urban environments, consistently detected at varying concentrations in soil throughout urban areas (Appendix M). The ubiquitous presence of dioxins/furans in urban surface soil suggests that dioxins/furans are also likely present in urban stormwater runoff.

The SWIA indicated that under current conditions, contamination at the LL Apartments Parcel does not add to contaminant levels in stormwater as it passes through the property. There was no historical testing conducted during historical operations at the property prior to construction of the apartment complex to determine if stormwater quality was degraded at that time by passing through the property.

Migration of contaminated soil from the LL Apartments Parcel to Lora Lake may have occurred historically by contaminated soil entering the storm system through cracks or breaks in the system, or through surface runoff into the system through on-site catch basins. Potentially contaminated soil could have been transported in stormwater flow to Lora Lake and discharged to lake sediments. A stormwater drainage system on the property during the auto-wrecking operations also discharged stormwater to Lora Lake. During the 2010 to 2011 RI, elevated concentrations of dioxins/furans were detected in sediment samples collected from Lora Lake. These dioxins/furans may have originated from historical contributions of LL Apartments Parcel soil entering the stormwater system, as well as historical and ongoing inputs from urban stormwater. Historical migration of soil from the LL Apartments Parcel through the stormwater conveyance system to Lora Lake sediments is a potential historical migration pathway and cannot be eliminated as a source of dioxins/furans to lake sediments.

As discussed in Section 7.0, dioxins/furans have low solubility and high partitioning coefficients, and do not readily partition from solid particles to water. Once sorbed to lake sediment (or the stormwater solids that settle out and become lake sediments), dioxins/furans are expected to remain sorbed to the solids, particularly those with high organic content, and are not expected to leach into surface water and/or migrate downstream in the dissolved phase. Sediment samples collected in Miller Creek do not contain elevated concentrations of dioxins/furans. Detected dioxin/furan TEQ concentrations in Miller Creek sediments are all less than 1 pg/g. Sediment transport from

Lora Lake to Miller Creek is limited because the drainage culvert from Lora Lake to Miller Creek is located at the lake surface, rather than submerged. Sediments that settle out at the low point of the lake are approximately 10 feet lower than the outlet culvert elevation.

The dioxin/furan TEQ concentrations in Lora Lake sediment samples ranged from 7.5 pg/g to 217 pg/g, while dioxin/furan TEQ concentrations measured in stormwater in-line solids travelling through the system ranged from 44 pg/g to 181 pg/g. The similar order of magnitude of these concentrations indicate that the dioxins/furans observed in Lora Lake sediments are likely a result of the discharge of urban stormwater from the approximate 78-acre City of Burien Upgradient Stormwater Drainage Area shown in Figure 3.3, and settling of stormwater solids to create lake sediments. This conclusion is also supported by the fact that the top layers of sediment in the lake—the recently deposited sediments—are contaminated at this level.

8.2.6 Lake Dredging

Lora Lake was dredged in 1982 in response to resident complaints of the lake filling in from siltation. Sediments were hydraulically dredged by King County from the lake and were placed in the DMCA, likely moving dioxins/furans to the DMCA. The concentrations of dioxins/furans detected in samples collected from apparent dredge materials in the DMCA range from 41.1 pg/g to 71.9 pg/g. These concentrations are consistent with the concentrations of dioxins/furans observed in Lora Lake sediments.

Groundwater sampling in wells surrounding the DMCA did not contain concentrations of dioxins/furans greater than the cleanup level, indicating that dioxins/furans in DMCA soil are not leaching to groundwater under current conditions. This finding is consistent with known dioxin/furan behavior in the environment.

8.3 EXPOSURE PATHWAYS AND RECEPTORS

Figure 8.1 presents a conceptual model of the site conditions with current and potential exposure pathways and receptors identified. Current pathways in this document refer to pathways that exist under current site conditions. These pathways may not be of concern, however, if contamination is not present at concentrations greater than cleanup levels, or other conditions control exposure through that pathway as discussed below. Potential exposure pathways in this document refer to pathways that do not exist under current site conditions, but may be present in the future. The populations or receptors of concern at the Site are Port workers throughout the Site, potential future commercial/industrial workers at the LL Apartments Parcel, wildlife at the LL Parcel, recreational fishers downstream in Miller Creek harvesting and consuming aquatic species, and aquatic species in Lora Lake. The following sections describe how these receptors may be exposed to contamination at the Site.

8.3.1 Current Exposure Pathways and Receptors

8.3.1.1 Lora Lake Apartments Parcel

The current exposure pathways at the LL Apartments Parcel are limited to human exposures. There are no ecological exposure pathways at the LL Apartments Parcel, due to the parcel's commercial zoning, and current site conditions with contiguous pavement and limited vegetation as determined by the TEE process presented in Appendix K. Human exposures are primarily limited to Port workers, as the LL Apartments Parcel is located within Port security fencing that prevents public access and potential public exposures. However, a portion of the LL Apartments Parcel is located outside of the security fencing along Des Moines Memorial Drive and is accessible to the public. The current human exposure pathways at the LL Apartments Parcel include the following:

- **Direct Contact (Incidental Ingestion) of Surface Soil by Port Workers.** This pathway is partially interrupted by paving and landscaping that is present over the majority of contaminated soil areas at the LL Apartments Parcel. This pathway would include incidental ingestion occurring during soil disturbing activities such as utility work, landscaping, trenching, or regrading.
- **Direct Contact (Incidental Ingestion) of Subsurface Soil and Groundwater by Port Workers.** This pathway is partially interrupted by paving and landscaping at the LL Apartments Parcel. This pathway is only of concern at the LL Apartments Parcel where subsurface soil and groundwater contamination is accessible. This pathway would include incidental ingestion occurring during activities such as excavation or subsurface drilling that disturb subsurface soil and/or encounter groundwater.
- **Direct Contact (Incidental Ingestion) of Surface and/or Shallow Subsurface Soil by the public.** A portion of the LL Apartments Parcel outside of the security fencing is accessible by the public: the zone along the southeastern property line, east of the Eastern Source Area. This zone is along Des Moines Memorial Drive at the foot of the topographic slope and extends to the paved edge of Des Moines Memorial Drive.

There are no other current exposure pathways at the LL Apartments Parcel, as use of the area is restricted, and there are currently no Port or industrial operations conducted at the property.

8.3.1.2 Lora Lake Parcel

The current exposure pathways at the LL Parcel consist of human, ecological, and aquatic organism exposures. Human exposures are limited to Port workers, as the LL Parcel is located within security fencing for the STIA, preventing public access and associated public exposures. As discussed in Appendix K potential ecological exposures at the LL Parcel would be limited to soils contaminated with dioxins/furans; however, ecological exposures are restricted due to the management of the parcel under the FAA WHMP for control of avian and wildlife species. The control of terrestrial and ecological receptors is described in greater detail in Appendix K.

The current human exposure pathways at the LL Parcel include the following:

- **Direct Contact (Incidental Ingestion) of Surface and/or Shallow Subsurface Soil by Port Workers.** This pathway exists at the LL Parcel where shallow soil contamination is present. Worker exposure may occur during ground disturbing activities such as landscaping, trenching, or utility work.
- **Direct Contact (Incidental Ingestion) of Surface and/or Shallow Subsurface Soil by the Public.** The majority of the LL Parcel is secured with fencing and restricted access; however, a small portion of the parcel is potentially accessible by the public, such as parcel soils adjacent to Des Moines Memorial Drive. This pathway potentially exists at the LL Parcel where shallow soil contamination is assumed to be present outside of the secured portion of the parcel, based on sampling results from within the secured fencing.
- **Human Consumption of Aquatic Species.** There is no human health exposure pathway for surface water or sediment via direct contact in Lora Lake because access to Lora Lake is restricted. A potential human health exposure pathway does exist in Miller Creek, however, via downstream recreational consumption of aquatic organisms (i.e., fish) that spend some period of time in Lora Lake and may bioaccumulate site COCs via surface water and sediment exposure before returning to Miller Creek. Public access to fishing in Miller Creek exists approximately 1.3 miles downstream from Lora Lake, at the point that Miller Creek exits the secured STIA operational area. The drainage culvert that connects Lora Lake to Miller Creek is not a blockage to fish passage between the creek and the lake.

The current ecological and aquatic organism exposure pathways at the LL Parcel include the following:

- **Ingestion and Trophic Transfer of Shallow Soil Contamination by Wildlife.** A potential exposure pathway exists for wildlife to be exposed to dioxin/furan contaminated shallow soils within the Lora Lake Parcel.

- **Direct Contact with Surface Sediments by Aquatic Organisms.** A potential exposure pathway exists for aquatic organisms (benthic infauna) to be exposed to contaminated surface sediment (i.e., the top 10 to 15 cm of sediment) within Lora Lake and Miller Creek. The freshwater sediment biological and chemical criteria under SMS are applicable for the protection of ecological receptors in freshwater environments . Dioxins/furans are not sufficiently toxic to aquatic organisms to estimate toxicity; therefore, there are no available promulgated dioxin/furan sediment standards for the protection of aquatic life. Under the WSDOE Sediment Management Standards, toxicity of sediments to benthic organisms can be determined through use of bioassay testing. Results of bioassay testing are definitive and "trump" comparison of chemical concentrations to chemical criteria. Bioassay testing was performed for Lora Lake sediments, and determined that Lora Lake sediments are not toxic to aquatic organisms due to elevated chemical concentrations.

There are no other current exposure pathways at the LL Parcel, as use of the area is restricted, and there are currently no Port or industrial operations conducted at the property.

8.3.1.3 1982 Dredged Material Containment Area

Similar to the LL Parcel, public access to the DMCA is restricted by Port security fencing and institutional controls. Therefore, the current human exposure pathways are limited to soil disturbing activities conducted by Port workers. The TEE presented in Appendix K determined that the DMCA does not provide significant ecological habitat, and that because of the proposed future land use (after remedial action) and the commercial/industrial zoning of the property, cleanup levels protective of terrestrial and ecological receptors are not applicable at the DMCA. The current human exposure pathway includes the following:

- **Direct Contact (Incidental Ingestion of Surface and/or Shallow Subsurface Soil by Port Workers.** This pathway exists at the DMCA where shallow soil contamination is present. Port worker exposure could occur during soil disturbing activities such as landscaping, trenching, or utility work.

There are no other current exposure pathways at the DMCA, as use of the area is restricted, and there are currently no Port or industrial operations conducted at the property.

8.3.2 Potential Exposure Pathways and Future Site Use

The LL Apartments Parcel future land use is planned to include commercial and light industrial facilities. Because of this potential future commercial use, the Port has selected unrestricted MTCA Method A or B soil cleanup levels to support future parcel use rather than industrial soil cleanup levels.

No land use changes are expected to occur within the LL Parcel because it is within the FAA RPZs, and is a part of the Miller Creek/Lora Lake/Vacca Farm Wetland and Flood Plain Zone mitigation area required by the NRMP for expansion of the STIA and construction of the 3rd Runway (Parametrix 2001). The majority of the LL Parcel is secured with fencing and restricted access; however, a small portion of the parcel is potentially accessible by the public, such as parcel soils adjacent to Des Moines Memorial Drive, which are assumed to be impacted based on results of sampling from within the secured fencing. Future land uses at the DMCA are expected to include airport-compatible uses in compliance with the FAA RPZs, such as temporary construction laydown, or equipment storage. All of the current pathways discussed above are expected to remain in the future. In addition to the pathways discussed above, the following may also be exposure pathways of concern in the future.

8.3.2.1 Groundwater Ingestion

Currently there is no drinking water supply aquifer within the immediate vicinity of the Site; however, per MTCA 173-340-720 (2) and (4)(b), site shallow groundwater could potentially become a source of drinking water in the future and therefore is classified as potable to protect drinking water beneficial uses. Although completion of a drinking water well within the shallow groundwater table beneath the Site is highly unlikely, there are currently no restrictions on the use of groundwater in this area as drinking water. Therefore, potability is a potential future exposure pathway at the Site. The area where potable cleanup levels exceed the criteria is limited to the Central and Eastern Source Areas on the LL Apartments Parcel. In addition to remedial actions, the Port may consider institutional controls in the FS that would restrict drinking water uses while concentrations in groundwater remain greater than the site cleanup levels to control the potential groundwater ingestion pathway.

8.3.2.2 Inhalation—Indoor Air

The LL Apartments Parcel is the only property where future use would include the construction of buildings, and therefore, the indoor air pathway is evaluated only for this parcel. The LL Apartments Parcel COCs to be considered for the inhalation pathway are dioxins/furans, PCP, cPAHs, arsenic, lead, ethylbenzene, and toluene. TPHs are also a COC; however, when evaluating vapor intrusion the individual constituents of TPH are evaluated separately (e.g., benzene, toluene, ethylbenzene and xylenes), and no promulgated air cleanup levels exist for TPH. As described in Section 3.1.3.1, a sub-slab vapor investigation was conducted by AECOM in 2008 that sampled and analyzed soil vapor for VOCs beneath the former apartment buildings (ENSR/AECOM 2008a). Results of the sub-slab soil vapor investigation determined that the concentrations of volatile COCs in soil gas at the LL Apartments Parcel are not at levels expected to affect the indoor air quality at the LL Apartments Parcel. Because the concentrations of all detected VOCs in soil gas samples that met the analytical quality control standards were less than the 2002 USEPA soil gas screening values (USEPA 2002) and the shallow soil gas screening levels in the 2009 WSDOE Draft Guidance for Evaluating Soil Vapor Intrusion in Washington State, the soil vapor intrusion pathway is not a potential pathway of concern for this Site under current or future conditions.

As the LL Parcel is within the FAA RPZ-Controlled Activity Area and FAA RPZ-Extended Object Free Area, as well as part of the Miller Creek/Lora Lake Upland Buffer and Flood Plain Zone Mitigation Area, no buildings will be constructed on this parcel in the future. The DMCA is also located within the FAA RPZ-Extended Object Free Area (Figure 2.5) and construction of buildings within this area is restricted now, and in the future.

8.4 CONCEPTUAL SITE MODEL SUMMARY

Figure 8.1 is a graphical representation of the CSM that shows the areas of contamination, impacted media, current and potential contaminant migration pathways, and receptors at the Site. The nature and extent of contamination at the Site has been sufficiently characterized by the investigations conducted, and the current and potential exposure pathways have been determined for the purposes of assessing and selecting remedial alternatives in the FS.

In summary, the current and potential exposure pathways and receptors of concern at the Site are the following:

- For the LL Apartments Parcel
  - Direct contact with surface and subsurface soil by future commercial parcel users
  - Direct contact with surface and subsurface soil by Port workers
  - Groundwater ingestion
- Lora Lake Parcel
  - Direct contact with surface and subsurface soil by Port workers
  - Direct contact with surface and subsurface soil by public in the unsecured areas
  - Ingestion and trophic transfer of shallow soil contamination by wildlife
  - Direct contact with surface sediments by aquatic organisms
  - Downstream human consumption of aquatic species
- DMCA
  - Direct contact with surface and subsurface soil by Port workers

The remaining sections of this report contain the FS, which will define cleanup action areas and evaluate remedial options for the Site to address and interrupt these exposure pathways to protect human health and the environment.

Part Three—Lora Lake Apartments Parcel Feasibility Study

9.0 Feasibility Study Introduction

Part 3 of this document presents the FS for the LL Apartments Parcel. This FS also describes actions to be conducted on the DMCA parcel. As discussed in the RI, there are no COCs exceeding MTCA Method C cleanup levels at the DMCA. The future land use plans for the DMCA will consist of surface improvements (placement of a compacted gravel or engineered surface) for airport operational support uses, which will eliminate a potential wildlife exposure pathway at the DMCA. Surface improvements at the DMCA are described in this document, and will be completed prior to, or concurrent with cleanup actions at the LL Apartments Parcel. Institutional controls will be placed on the DMCA to maintain the industrial land use zoning at the DMCA in perpetuity.

This FS has been developed in accordance with MTCA WAC 173-340-350(8) (WSDOE 2007). The FS develops and evaluates remedial action alternatives for the LL Apartments Parcel, and then presents a Proposed Preferred Remedial Alternative to WSDOE for consideration. The FS tasks include the following:

- Determine remedial action goals and objectives for the LL Apartments Parcel.
- Evaluate ARARs (i.e., identify applicable local, state and federal laws).
- Define Cleanup Areas based on contamination extents.
- Compile, evaluate, and screen potentially applicable remedial technologies.
- Aggregate and evaluate proposed remedial alternatives that meet the requirements outlined by MTCA.
- Compare remedial alternatives to the MTCA requirements for a cleanup action per WAC 173-340-350(8).
- Complete a Disproportionate Cost Analysis (DCA) procedure consistent with WAC 173-340-360(3)(e) to identify the alternative that is permanent to the maximum extent practicable.
- Propose the Preferred Remedial Alternative for the LL Apartments Parcel to WSDOE for consideration in development of the CAP for the Site.

9.1 DEFINITION OF REMEDIAL ACTION OBJECTIVES

RAOs are determined to specifically identify goals that should be accomplished to ensure compliance with ARARs. The following RAOs are defined for the LL Apartments Parcel:

- Protect human receptors from exposure to LL Apartments Parcel contamination that exceeds applicable cleanup levels.
    - o Remove unacceptable human health risk resulting from direct contact with contaminated soil.

  - Remove unacceptable potential future human health risk that could result from consumption of drinking water within the vicinity of the LL Apartments Parcel.
- Eliminate the potential for contaminated surface or subsurface soil at the LL Apartments Parcel to enter the stormwater conveyance system discharging to Lora Lake.
- Prevent migration of contaminants from the LL Apartments Parcel by erosion, groundwater migration, or stormwater processes.
- Remediate contaminants in a method that does not interfere with or restrict proposed site development and future use plans.
  - Allow for commercial or light industrial redevelopment of the LL Apartments Parcel.
  - Allow for potential property transfer of that portion of the LL Apartments Parcel that is outside of the designated FAA Controlled Activity and RPZ-Extended Object Free Areas.

Each remedial alternative proposed in this FS will be evaluated for its ability to accomplish the RAOs listed above.

9.2 APPLICABLE LOCAL, STATE, AND FEDERAL LAWS

The selected cleanup alternative must comply with MTCA cleanup regulations (WAC 173-340) and with applicable local, state, and federal laws. Together, these regulations and laws are identified as ARARs for the LL Apartments Parcel. Under WAC 173-340-350 and WAC 173-340-710, the term "applicable requirements" refers to regulatory cleanup standards, standards of control, and other environmental requirements, criteria, or limitations established under state or federal law that specifically address a remedial action, location, COC, or other circumstance at the Site. The "relevant and appropriate" requirements are regulatory requirements or guidance that do not apply to the Site under law, but have been determined to be appropriate for use by WSDOE. ARARs are often categorized as location-specific, action-specific, or chemical-specific.

Remedial actions conducted under a consent decree with WSDOE are exempt from procedural requirements required by state and local ARARs, such as permitting and approval requirements; however, remedial actions must demonstrate compliance with the substantive requirements of those ARARs (WAC 173-340-710(9)). This exemption applies to procedural permitting requirements under the Washington State Water Pollution Control Act, the Solid Waste Management Act, the Shoreline Management Act, and local laws requiring permitting such as City of SeaTac and City of Burien regulations. Remedial actions are not exempt from procedural requirements of Federal ARARs.

9.2.1 Location-specific ARARs

Location-specific ARARs are those requirements that restrict the allowable concentration of hazardous substances or the performance of activities, including remedial actions, solely because they occur in specific locations. Of particular importance are the following:

- The FAA requirements applicable to the Site due to its proximity to the STIA; (the FAA RPZ-Controlled Activity Area and RPZ-Extended Object Free Area restrictions).

The requirements and restrictions apply as location-specific ARARs for areas of the LL Apartments Parcel located within the FAA RPZs (Port of Seattle 2005a). Table 9.1 outlines all the location-specific ARARs that were considered and identifies those applicable to the LL Apartments Parcel cleanup.

9.2.2 Action-specific ARARs

Action-specific ARARs are requirements that define acceptable management practices and are often specific to certain kinds of activities that occur or technologies that are used during the implementation of cleanup actions. Activities could include excavation, grading or capping of soil, and upland disposal of excavated soil. Any construction activities or excavations will require compliance with stormwater regulations. Table 9.2 identifies all action-specific ARARs considered for applicability to the LL Apartments Parcel cleanup.

9.2.3 Chemical-specific ARARs

The remediation of contaminated LL Apartments Parcel media must meet the cleanup levels developed under MTCA. These potential cleanup levels are considered chemical-specific ARARs. Chemical-specific ARARs consist of those requirements that regulate the acceptable amount or concentration of a chemical that may be found in or released to the environment. The most stringent applicable requirements for cleanup of chemical concentrations on the LL Apartments Parcel were selected as the applicable cleanup levels. Table 9.3 identifies chemical-specific ARARs considered for applicability to the LL Apartments Parcel.

10.0 Lora Lake Apartments Parcel Cleanup Areas

This section identifies Cleanup Areas for the LL Apartments Parcel.

There are no required Cleanup Areas for the DMCA because there are no exceedances of the MTCA Method C cleanup levels at the DMCA. Institutional controls will be placed on the DMCA because Method C cleanup levels will be applied to the parcel. These institutional controls will ensure that industrial zoning and the continued use of the property as an engineered surface are maintained in perpetuity. This will also maintain the conditions that result in excluding the DMCA from the TEE process.

Since the application of technologies to a given area of the LL Apartments Parcel is based primarily on the nature and extent of the contamination, Cleanup Areas have been determined so that a single remedial component may be conducted in areas with similar nature and extent of contamination conditions, as described below.

10.1 NATURE AND EXTENT OF CONTAMINANTS OF CONCERN

The RI identified the following contaminated media at the LL Apartments Parcel:

- Central, Eastern, and Western Source Areas Soil
  - Surface and subsurface soil is contaminated with dioxins/furans, cPAHs, PCP, TPH, and lead.
- Shallow Soil
  - Surface and shallow subsurface soil is contaminated with dioxins/furans in other areas of the LL Apartments Parcel.
- Groundwater
  - Groundwater in the Central and Eastern Source Areas is contaminated with dioxins/furans, PCP, arsenic, and heavy oil range TPH.

10.2 CLEANUP AREA IDENTIFICATION

The LL Apartments Parcel has been divided into Cleanup Areas for application of remedial technologies (Figure 10.1). In the FS evaluation of alternatives, technologies will be selected for each Cleanup Area, then alternatives will be developed and evaluated for their ability to comply with the MTCA Threshold Requirements and Other MTCA Requirements for a remedial action (WAC 173-340-360(2)), discussed in Section 13.0. The characteristics of each Cleanup Area are described in the following sections.

10.2.1 Cleanup Area A

Cleanup Area A designates two separate locations at the LL Apartments Parcel where dioxin/furan soil contamination is present at concentrations exceeding 1,000 pg/g. The total acreage of Cleanup Area A is approximately 0.7 acres, comprising two different locations as identified on Figure 10.1:

- The Central Source Area, which is the location of the historical barrel-washing drum cleanout pond.
  - Contamination in soil in this area extends from the ground surface to a depth of 15 to 20 feet bgs, and extends into the recessional outwash aquifer. Contaminants in this area are dioxins/furans, cPAHs, PCP, TPH, and lead. Data obtained from the deep groundwater well investigation confirmed that contamination observed in soil and the shallow groundwater has not impacted deeper groundwater.
  - RI sampling in this area did not define the vertical extent of soil contamination in some locations. The potential need for additional data will be considered during the evaluation of technologies and remedial design.
  - The Central Source Area location within Cleanup Area A is approximately 0.4 acres, as shown on Figure 10.1.
- The Eastern Source Area along the eastern property line in the vicinity of Monitoring Wells MW-4 and MW-5.
  - Soil contamination in this location is present at depths up to 15 feet bgs with dioxins/furans, lead, PCP, and cPAHs in surface soil, and cPAHs and dioxins/furans present at depth. The dioxin/furan contamination at concentrations greater than 1,000 pg/g is confined to the top 1 foot of soil in this location.
  - The Eastern Source Area location within Cleanup Area A is approximately 0.3 acres, as shown on Figure 10.1.

10.2.2 Cleanup Area B

Cleanup Area B includes all locations within the LL Apartments Parcel where the maximum detected dioxin/furan TEQ concentration in soil at any depth is between 100 pg/g and 1,000 pg/g. Cleanup Area B surrounds the more distinct source areas within Cleanup Area A. In combination, Cleanup Area B and Cleanup Area A contain all soil on the LL Apartments Parcel where dioxin/furan TEQ concentrations are greater than 100 pg/g.

The total acreage of Cleanup Area B is approximately 2.2 acres and consists of the following locations, identified on Figure 10.1:

- A zone along the southeastern property line, east of the Eastern Source Area. Much of this area is outside the property fence, along Des Moines Memorial Drive at the foot of the topographic slope.
  - Soil samples collected from the right-of-way along Des Moines Memorial Drive contained concentrations of dioxins/furans of up to 205 pg/g at depths 0 to 6 feet bgs.
  - Cleanup Area B extends to the paved edge of Des Moines Memorial Drive, including any unpaved areas along the road shoulder or between the road and sidewalk, if present.

- o Because soil beneath Des Moines Memorial Drive is effectively capped by the road pavement, the Cleanup Area does not extend into the roadway. Institutional controls may be implemented in the roadway for worker protection if analytical data collected in the area during design or remedy implementation indicate that contamination is present beneath the roadway at levels of concern.

- A zone between and north of the Central Source Area and the Eastern Source Area.
  - o Dioxin/furan contamination is present in soil between 0 and 2 feet bgs at concentrations greater than 100 pg/g.
- The west-central portion of the LL Apartments Parcel. This location is included within Cleanup Area B to encompass dioxin/furan contamination observed in surface soils from Boring PSB-04 at a concentration of 194 pg/g.
- The Western Source Area near the LL Apartments Parcel property boundary with the Former Seattle City Light Sunnydale Substation.
  - o In the Western Source Area, cPAH contamination is present in soil from LL-08 at a concentration of 160 µg/kg and dioxin/furan contamination is present in soil from LL-12, PSB-06, and LL-08 at concentrations ranging from 234 to 702 pg/g from 0 to 4 feet bgs.
  - o This is the only area of the LL Apartments Parcel outside of the Central and Eastern Source Areas where non-dioxin/furan contamination is present at concentrations greater than applicable cleanup levels.

10.2.3 Cleanup Area C

Cleanup Area C includes all locations within the LL Apartments Parcel where the maximum detected dioxin/furan TEQ concentration at any depth is between 13 pg/g and 100 pg/g; 13 pg/g is the cleanup level for dioxin/furan applicable to the LL Apartments Parcel. In combination, Cleanup Areas A, B, and C contain all soil on the LL Apartments Parcel at concentrations greater than cleanup levels. The total acreage of Cleanup Area C is approximately 3.3 acres and includes the following locations, identified on Figure 10.1:

- The western portion of the property. In this area, dioxin/furan was detected in soil between 0 and 2 feet bgs, at concentrations ranging from 15.2 pg/g to 33.8 pg/g.
  - o Cleanup Area C has been defined to conservatively extend past the western property line to the paved edge of 8th Avenue South, as shown in Figure 10.1, to encompass any unpaved areas between the roadway pavement and the property fencing, consistent with the approach described above for soil along Des Moines Memorial Drive on the eastern property boundary.
- The northeast corner of the property, extending to the property boundary or the edge of existing paving along Des Moines Memorial Drive.
  - o In this location, exceedances of the cleanup level are present in shallow soil (0 to 2 feet bgs) at concentrations ranging from 16.6 pg/g to 26.2 pg/g.

  - Existing data do not currently define the horizontal extent of contamination at concentrations greater than the dioxin/furan cleanup level of 13 pg/g beyond the northeast corner of the property. In shallow soil at the property boundaries, however, dioxin/furan concentrations are within the typical range of urban background concentrations (refer to Appendix M) and are likely not solely attributable to historic sources at the LL Apartments Parcel. Off-property areas will be remediated to the extent feasible, given site conditions, and will extend to the edge of the pavement along Des Moines Memorial Drive to the east and to the north of the LL Apartments Parcel to an extent determined in design based on chemical concentrations and accessibility considerations. It is not anticipated that remediation will be conducted on the embankment adjacent to SR 518 to the north. Any additional data necessary to determine the extent of contamination in the northeast corner of the property would be collected during design.

- In the southeast corner of the property, the concentration of dioxins/furans in a surface soil sample collected outside the LL Apartments Parcel property boundary was 17.7 pg/g. Cleanup Area C extends past the property line in this area to encompass this elevated concentration and is located within the secured LL Apartments Parcel fencing for the adjacent Port-owned property.

10.3 LOCATION OF CONTAMINANT MASS IN CLEANUP AREAS

Appendix N presents a calculation of contaminant mass in the site soil that exceeds the cleanup level, as required by the AO.[14] The mass of chemical contaminants in site soil was determined by estimating the volume of soil with contaminant concentrations greater than the applicable cleanup levels, then calculating the chemical mass given the average soil concentrations in that area. The calculations indicate that approximately 0.031 kg (1.1 ounces) of dioxin/furan chemical mass has contaminated approximately 39,000 cubic yards of soil at the LL Apartments Parcel. Approximately 88 percent of this dioxin/furan mass in soil is located within the LL Apartments Parcel Cleanup Area A, and approximately 96 percent of this total mass is located within the LL Apartments Parcel Cleanup Areas A and B. Although 39,000 cubic yards of soil at the LL Apartments Parcel has been contaminated by chemical releases at the property, the contaminated soil is located at varying depths across the Site, and a total of approximately 49,000 cubic yards of soil would require excavation to remove all contaminated soil, including areas where contaminated material is located beneath clean soil.

The results of calculations for PCP and cPAH contaminant masses in soil where contaminant concentrations exceed the applicable cleanup levels indicate that approximately 5 kg (11 pounds) of PCP and approximately 0.88 kg (1.9 pounds) of cPAHs have contaminated more than 480 cubic yards and 1,800 cubic yards of site soil, respectively. The cPAH and PCP contaminant masses are located entirely within the LL Apartments Parcel Cleanup Areas A and B.

[14] The contaminant masses in site groundwater were considered negligible for this evaluation because of the volume of contaminated groundwater compared to the volume of contaminated soils at the Site, and the orders of magnitude difference between contaminant concentrations in soils as compared to groundwater.

11.0 Lora Lake Apartments Parcel Identification of Remedial Technologies

This section identifies and briefly describes the most commonly implemented remedial technologies for remediation of the site-specific COCs with concentrations greater than cleanup levels (lead, TPH, PCP, cPAHs, and dioxins/furans) at the LL Apartments Parcel, and the application and limitations of each technology.

Section 12.0 then describes the preliminary technology screening performed to eliminate technologies that do not meet the RAOs applicable to the LL Apartments Parcel, are not technically feasible, and/or do not address the types of contamination present.

11.1 IDENTIFICATION AND DESCRIPTION OF SOIL TECHNOLOGIES

The following technologies are commonly used to address the soil COCs present at the LL Apartments Parcel at concentrations greater than cleanup levels, which are lead, TPH, PCP, cPAHs, and dioxins/furans.

11.1.1 No Action

No action indicates that no active remedial technology would be implemented. No action provides a reference for comparison of the benefits of other remedial technologies.

11.1.2 Institutional Controls

Institutional controls are physical, legal, and administrative measures that are implemented to minimize or prevent human exposure to contamination by restricting access to the Site. Institutional controls often involve deed restrictions or covenants, site advisories, use restrictions, or consent decrees, and would be implemented at the Site to limit or prohibit activities that may interfere with the integrity of any cleanup action or result in exposures to hazardous substances at the Site. Institutional controls are typically implemented in addition to other technologies when those technologies leave COCs on-site at concentrations greater than cleanup levels.

The institutional controls technology is applicable to all LL Apartments Parcel soil COCs with concentrations greater than cleanup levels.

11.1.3 Surface Capping

Surface capping is an example of a containment remedy that places a cap over contaminated soil to control surface water infiltration, erosion, and wind migration of soil. Surface capping provides a physical barrier, preventing human health exposures via direct contact. Surface caps can be constructed as: a hard cap such as asphalt, concrete, or gravel designed to meet permeability requirements and prevent human health exposures; a clean fill cap, of variable thickness to prevent human health exposures; or an engineered cap designed to achieve permeability requirements, prevent human health exposures, and control water runoff. Surface capping requires maintenance to maintain the integrity of the cap in perpetuity and is often implemented with institutional controls.

The surface capping technology is applicable to all LL Apartments Parcel soil COCs with concentrations greater than cleanup levels.

11.1.4 Solidification and Stabilization

Solidification or stabilization of soil that contains COCs at concentrations greater than cleanup levels physically and chemically immobilizes the contaminants within the soil matrix, thereby reducing or eliminating contaminant mobility. With solidification, the contaminants are either enclosed or bound within the soil matrix via a binding agent such as modified sulfur cement, polyethylene extrusion, or emulsified asphalt. Stabilization involves adding and mixing a chemical compound with the contaminated soil to make the COC immobile through a chemical reaction that forms a new compound that is less toxic than the parent COC or through adsorption processes. Both of these technologies would be combined with leachability testing and/or long-term groundwater compliance monitoring to ensure that the contaminants are immobile and do not leach to groundwater.

The solidification and stabilization technologies are applicable to lead, PCP, and dioxin/furan contamination, but are not as effective in treating TPH and cPAH contamination.

11.1.4.1 In-situ Vitrification

In-situ vitrification is a solidification and stabilization technology that applies high temperatures via electrical current to soil and any other underlying material to immobilize inorganic contaminants and destroy organic contaminants. The inorganic contaminants are incorporated into a vitrified glass/vitreous mass and the organic contaminants are destroyed by pyrolosis (i.e., incineration that chemically decomposes organics by heat in the absence of oxygen). The resulting vitreous mass is chemically durable and leach resistant. The technology is effective to a depth of approximately 20 feet bgs, but requires very high electricity loads. Vaporization of volatile contaminants via in-situ vitrification also requires capture and treatment of the VOCs.

In-situ vitrification is applicable to all LL Apartments Parcel soil COCs with concentrations greater than cleanup levels.

11.1.5 Excavation and Landfill Disposal

Excavation of soil contamination using standard construction equipment is a common method to achieve remediation goals. For off-site disposal, excavated contaminated soil is transported either by truck or rail to an appropriate licensed landfill. Following soil removal, excavated areas are subjected to confirmation soil sampling prior to backfill, compaction, and site restoration. Excavation may require relocation of structures, shoring to maintain sidewall stability, and may require dewatering, or drawdown of the groundwater table if excavation is to occur below the groundwater table.

Excavation is applicable to all LL Apartments Parcel soil COCs with concentrations greater than cleanup levels.

11.1.6 Soil Vapor Extraction

Soil vapor extraction (SVE) is a process that extracts soil vapor from unsaturated soil in the vadose zone by applying a vacuum to the subsurface. Vacuum is applied by a blower connected to extraction wells screened within the area of contamination. The controlled flow of air removes accumulated volatile vapors from the unsaturated zone, which causes additional volatilization of chemicals in the soil to the vapor phase. Soil vapor extracted from the subsurface is processed through a treatment system, typically including filters for particulate removal, condensate removal, and treatment by oxidation or carbon filtration. SVE systems may be enhanced with air sparging and/or groundwater extraction if contamination extends below the water table.

SVE is applicable to site TPH soil contamination, but is not effective in treating the other types of LL Apartments Parcel contamination.

11.1.7 Chemical Oxidation

Chemical oxidation involves injecting oxidizing agents, such as ozone, hydrogen peroxide, or permanganate, into the subsurface to rapidly destroy organic chemicals. Injection can be applied in both vadose and saturated zones, but is most effective in treating chemicals in groundwater. Applicability of chemical oxidation is dependent on soil types and the homogeneity of the subsurface, as injected solutions tend to follow preferential pathways through heterogeneous soil. Volumes of injected agent and rate of chemical injection are dependent on the subsurface conditions at the Site. Injection points may be installed as permanent injection wells or may be injected via temporary borings. The effectiveness of injections is quite dependent on site conditions, which typically are heterogeneous, making it difficult to obtain an even and effective distribution of the oxidant. Further, a high soil oxidant demand (i.e., high soil organic content that consumes the added oxidant) or other oxidizer sink may significantly reduce the effectiveness of chemical oxidants.

Chemical oxidation is applicable to lead, TPH, PCP, and cPAH soil contamination at the LL Apartments Parcel, but would not effectively remediate dioxins/furans.

11.1.8 Soil Flushing

Soil flushing involves injecting water, or water containing an additive (to enhance chemical solubility), into the subsurface to “flush” chemicals out of the soil pore space. In many instances, surfactants or solvents are used as the additive. The flushing solution is either directly applied to the soil through injection wells or injected into the groundwater within the zone of contamination. Chemicals leach from the soil into solution, which is then extracted by a downgradient series of wells, treated, and re-injected. The effectiveness of the soil flushing process is dependent on hydrogeologic variables such as soil types, soil moisture, and chemical characteristics. The ability to capture the flushing solution in the downgradient network to avoid downgradient transport of the “flushed” soil contamination is critical to the successful application of this technology.

Soil flushing is applicable to lead soil contamination at the LL Apartments Parcel, but is not effective in treating the other types of LL Apartments Parcel contamination.

11.1.9 Soil Mixing by Auger

Soil mixing is a process that treats the subsurface soil by mixing amended soil in overlapping soil columns. The soil columns are formed by advancing a large-diameter auger into the subsurface, in combination with a series of mixing shafts. As the mixing shafts are advanced into the soil, grout or slurry containing a reactant that destroys the organic chemical (for example, zero-valent iron or a chemical oxidant) is pumped through the hollow stem of the shaft and injected into the soil. The auger flights and mixing blades on the shafts blend the soil with the grout or slurry in pug-mill fashion (i.e., achieving a homogeneous mixture in a short time period using fast continuous mixing). This process generates a large amount of spoils that are difficult to handle, and can also leave wedges of untreated soil in the spaces between the installed soil columns.

Soil mixing is applicable to lead, TPH, and PCP soil contamination at the LL Apartments Parcel, but would not effectively remediate cPAH or dioxin/furan contamination.

11.1.10 Thermal Treatment

Thermal treatment (which is commonly applied via electrical resistance heating or thermal conduction) is a process that quickly and evenly heats the subsurface to volatilize chemicals with low boiling points (e.g., TPH) by passing electrical current or direct heat through zones of contaminated soil and groundwater. With electrical resistance heating, a current is delivered to the subsurface through a series of closely spaced electrodes. Resistance to the flow of electricity between electrodes via the natural resistance of the soil matrix generates heat in the subsurface. Silty zones of soil can be heated as effectively as sandier zones due to the superior electrical resistance properties of silt or clay. If heated close to the boiling point of water, the heating process volatilizes chemical droplets embedded in soil into a vapor phase. The contaminated vapors, along with steam produced by the boiling of groundwater, are recovered by a subsurface network of vapor recovery wells. The steam that is removed from the subsurface through the vapor recovery network is condensed and treated. Chemicals in the vapor stream are typically treated using activated carbon or thermal oxidation.

Thermal treatment is applicable to LL Apartments Parcel TPH soil contamination, but is not effective in treating the other types of LL Apartments Parcel contamination.

11.2 IDENTIFICATION AND DESCRIPTION OF GROUNDWATER TECHNOLOGIES

The following technologies may be applicable for remediation of groundwater contamination at the LL Apartments Parcel that consists of arsenic, PCP, heavy oil range TPH, and dioxins/furans.

11.2.1 No Action

No action indicates that no active remedial measure would be implemented and provides a reference for comparison of the benefits of other remedial technologies.

11.2.2 Institutional Controls

Institutional controls are physical, legal, and administrative measures that are implemented to minimize or prevent human exposure to contamination by restricting access to the Site. Institutional controls often involve deed restrictions or covenants, site advisories, use restrictions, or consent decrees and would be implemented at the Site to limit or prohibit activities that may interfere with the integrity of any cleanup action or result in exposures to hazardous substances at the Site. Institutional controls are typically implemented in addition to other technology(s) when that technology leaves COCs on-site at concentrations greater than cleanup levels.

The institutional controls technology is applicable to all LL Apartments Parcel groundwater COCs with concentrations greater than cleanup levels.

11.2.3 Chemical Oxidation

Chemical oxidation involves injecting oxidizing agents such as ozone, hydrogen peroxide, or permanganate into the subsurface to rapidly destroy organic chemicals. Injection can be applied in both vadose and saturated zones, but is most effective in treating chemicals in groundwater. Applicability of chemical oxidation is dependent on soil types and the homogeneity of the subsurface because injected solutions tend to follow preferential pathways through heterogeneous soil. The volume of injected agent and the rate of chemical injection are dependent on the subsurface conditions at the Site. Injection points may be installed as permanent injection wells or may be injected via temporary borings. The effectiveness of injections is quite dependent on site conditions, which typically are heterogeneous, making it difficult to obtain an even and effective distribution of the oxidant. Further, a high soil oxidant demand (i.e., high soil organic content that consumes the added oxidant) or other oxidizer sink may significantly reduce the effectiveness of chemical oxidants.

The chemical oxidation technology is applicable to arsenic, PCP, and heavy oil range TPH groundwater contamination at the LL Apartments Parcel, but would not effectively remediate dioxin/furan contamination in groundwater.

11.2.4 Monitored Natural Attenuation

Monitored natural attenuation involves regular groundwater sampling and analysis to monitor the results of one or more naturally-occurring physical, chemical, or biological processes that reduce the mass, toxicity, volume, and/or the concentration of chemicals in site soil and/or groundwater. These naturally-occurring processes may include: biodegradation; dispersion; dilution; sorption; volatilization; and chemical or biological stabilization, transformation, or destruction of contaminants. Monitored natural attenuation may be implemented as a stand-alone remedial technology or in combination with other remedial technologies.

Monitored natural attenuation is applicable to all groundwater contamination at the LL Apartments Parcel; however, due to the persistent nature of the majority of site COCs with concentrations greater than cleanup levels. would consist mainly of dispersion, dilution, and sorption processes.

11.2.5 Source Removal

Source removal as a groundwater remedial action would consist of excavation of soil contamination that is currently resulting in groundwater contamination. Source removal is typically conducted as a soil remediation technology (refer to Section 11.1.5, above); however, it can also effectively remediate groundwater by removing the contaminant source to groundwater. Source removal would likely require multiple rounds of groundwater monitoring following implementation to confirm that the soil source to groundwater has been effectively removed, and that groundwater concentrations are less than cleanup standards following implementation. Compliance may not occur immediately and may require a short time frame for subsurface conditions to stabilize.

Source removal is applicable to all LL Apartments Parcel groundwater COCs with concentrations greater than cleanup levels.

11.2.6 Permeable Reactive Barrier Wall

Permeable reactive barrier (PRB) walls intercept and treat contaminated groundwater flowing from an upgradient source. Groundwater flows through a treatment wall of reactive material, which for metals is typically composed of zero-valent iron (ZVI) mixed with sand. Barrier walls are generally constructed in one of two configurations, either as a “funnel and gate” configuration that employs angled wing walls to capture and direct the contaminated groundwater to a central treatment unit, or as a linear trench intersecting the plume. Groundwater flows according to its natural gradient through the PRB, where the reactive media within the wall reacts with the dissolved chemicals in groundwater. The life span and effectiveness of a PRB wall is also dependent on the mass of chemicals passing through the wall. PRB walls do not remediate the source area itself, but decrease the contaminant solubility or otherwise immobilize the chemicals migrating from the source area with the groundwater.

PRB walls would be effective at remediating arsenic, PCP, and heavy oil range TPH groundwater contamination at the LL Apartments Parcel, but would not effectively remediate dioxin/furan contamination in groundwater.

11.2.7 Low-permeability Barrier Wall

Barrier wall containment technologies are implemented to contain chemicals in place and typically do not involve further source area treatment. Vertical containment barriers, such as slurry walls, are placed in the subsurface to cut off groundwater flow and stop chemical migration. Slurry walls are typically constructed vertically from the ground surface to a depth greater than the chemical plume in soil and groundwater, or until the wall encounters a confining layer. The slurry wall is constructed of a low-permeability material, typically a soil and bentonite clay mixture, that does not degrade in the environment. Containment remedies are often implemented in combination with permanent pumping remedies to maintain inward gradients within the contained area and provide hydraulic control. Barrier walls and hydraulic control requires maintenance and monitoring in perpetuity.

A low-permeability barrier wall would be effective at remediating all LL Apartments Parcel groundwater COCs with concentrations greater than cleanup levels.

11.2.8 Pump and Treat

Pump and treat involves pumping contaminated groundwater from the subsurface and treating it before it is discharged. Treatment is generally conducted by air stripping or filtration via activated carbon. Groundwater pump and treat can reduce chemical concentrations in saturated soil, but only slowly by increasing the diffusion of soil contamination into groundwater. Extraction system design and treatment are dependent on the site characteristics and chemical type. Extraction wells may be screened at different levels or intervals to maximize the system effectiveness; however, restoration time frames for pump and treat systems are often very long because pump and treat cannot significantly accelerate the removal of mass from source areas, which are often large enough to leach chemicals into groundwater for long periods of time.

The pump and treat technology may be effective at remediating arsenic, PCP, and heavy oil range TPH groundwater contamination at the LL Apartments Parcel, but would not effectively remediate dioxin/furan contamination in groundwater.

12.0 Lora Lake Apartments Parcel Technology Screening and Alternative Development

This section contains a screening of the technologies presented in Section 11.0 in consideration of LL Apartments Parcel conditions. As outlined in earlier sections, the site conditions at the LL Apartments Parcel factor into the applicability of remediation technologies.

The technology screening is followed by aggregation of alternatives using the technologies that are determined to be applicable at the LL Apartments Parcel resulting in protection of human health and the environment. These alternatives are evaluated in Section 13.0 according to the MTCA DCA procedure (WAC 173-340-360(3)(e)(ii)).

12.1 PRELIMINARY TECHNOLOGY SCREENING

The number of technologies applicable for remediation of the LL Apartments Parcel is particularly limited by the presence of dioxin/furan contamination, which is a challenging COC to address[15]. As part of the technology selection process, the technologies identified in Section 11.0 that are found to be applicable to some if not all of the COCs present at the LL Apartments Parcel are screened against site-specific considerations to identify those that are appropriate for LL Apartments Parcel remediation.

The preliminary technology screening process is presented in Table 12.1. The process rejects or retains technologies based on their applicability at the LL Apartments Parcel given: the COCs and impacted media, effectiveness and proven success at similar sites, applicability of the technology within LL Apartments Parcel physical constraints, and the ability of the technology to achieve RAOs. The retained technologies are summarized below and then aggregated into remedial alternatives for evaluation according to the MTCA DCA process presented in Section 13.0.

No action, solidification and stabilization, in-situ vitrification, SVE, chemical oxidation, soil flushing, soil mixing by auger, and thermal treatment were rejected from further evaluation for remediation of soil.

No action, monitored natural attenuation, chemical oxidation, thermal treatment, PRB wall, low permeability barrier walls, and pump and treat technologies were rejected from further evaluation for remediation of groundwater.

12.2 SUMMARY OF RETAINED TECHNOLOGIES AND CONSIDERATION OF ADDITIONAL LORA LAKE APARTMENTS PARCEL CONDITIONS

Based on the preliminary technology screening, the technologies discussed below were retained for aggregation into alternatives to address soil and groundwater contamination at the LL Apartments Parcel. Each technology is discussed in greater detail in the

[15] Because the structure of dioxins/furans is highly resistant to chemical and biological degradation processes, they are considered persistent environmental contaminants that do not naturally degrade over time.

following sections with consideration of the LL Apartments Parcel conditions that may impact the applicability and success of the technology.

12.2.1 Soil-specific Technologies

12.2.1.1 Institutional Controls

Institutional controls have been retained for further evaluation as a soil remedial technology. As a stand-alone technology, institutional controls would not reduce, destroy, or remove any chemical contamination in addition to what would occur via natural processes, but would instead be implemented in addition to other technologies to meet RAOs, ensure long-term protectiveness of the selected remedy, and prevent exposure to contaminated soil. At the LL Apartments Parcel, institutional controls would be implemented with any technology that leaves contamination in place in excess of cleanup levels. Institutional controls that may be implemented for soil could include maintenance of a containment cap over contaminated soil remaining on-site and current and future safety, soil management, and cap restoration requirements for subsurface excavation activities such as utility work, landscaping, or construction that disturbs the ground in areas of soil contamination. When used in combination with other remedial technologies, institutional controls would successfully achieve the LL Apartments Parcel RAOs, and could be implemented given the LL Apartments Parcel physical conditions.

12.2.1.2 Surface Capping

Surface capping of LL Apartments Parcel soil has been retained for further evaluation. When implemented with institutional controls, capping addresses all of the LL Apartments Parcel soil COCs through management of the exposure pathways. Surface capping design would likely vary by LL Apartments Parcel location and depend on future development plans. The goal of capping would be to manage the direct worker contact and surface soil erosion/migration pathways. Cap technologies may be designed to consist of either impermeable or semi-permeable paving, or placement of permeable clean, compacted soil or gravel. Cap design details would be developed during the remedial design phase of the project. Capping used in combination with other remedial technologies, such as source removal to address soil to groundwater concerns, could successfully achieve the LL Apartments Parcel RAOs and could be implemented given the LL Apartments Parcel physical conditions.

12.2.1.3 Source Removal by Excavation and Landfill Disposal

Excavation and landfill disposal of LL Apartments Parcel soil has been retained for further evaluation because it addresses all of the LL Apartments Parcel soil COCs. The technology may be implemented to remove all soil contamination to a selected soil concentration or action level, or be implemented to a limited extent to remove soil hot-spot areas. Soil excavation may be implemented in combination with other technologies depending on the extent of contamination left in place following a focused hot-spot removal. If excavation were conducted as a hot-spot removal, additional actions would be required to manage exposure for the contaminants remaining on the LL Apartments Parcel, and allow for future LL Apartments Parcel operations and redevelopment. When used in combination with other remedial technologies, excavation would successfully achieve the LL Apartments Parcel RAOs, and could be implemented given the LL Apartments Parcel physical conditions.

12.2.2 Groundwater-specific Technologies

12.2.2.1 Institutional Controls

Institutional controls have been retained for further evaluation as a groundwater remedial technology. As a stand-alone technology, institutional controls would not reduce, destroy, or remove any chemical contamination other than what would occur via natural processes. Institutional controls would instead be implemented in addition to other technologies to meet RAOs, ensure long-term protectiveness of the selected remedy, and prevent exposure to contaminated groundwater. At the LL Apartments Parcel, institutional controls would be implemented with any technology that leaves groundwater contamination in place. Institutional controls that may be implemented for groundwater could include current and future restrictions on groundwater withdrawals and use. Institutional controls used in combination with other remedial technologies could successfully achieve the LL Apartments Parcel RAOs, and could be implemented given the LL Apartments Parcel physical conditions.

12.2.2.2 Source Removal by Excavation and Landfill Disposal

Excavation and landfill disposal of LL Apartments Parcel soil has been retained for further evaluation as a groundwater remedial technology because soil source removal would address all groundwater COCs. As described above, the technology may be implemented to remove all soil contamination to a selected soil concentration or action level, or be implemented to a limited extent to remove soil hot-spot areas. Since the presence of dioxins/furans (and other COCs) in LL Apartments Parcel groundwater has been determined to be resulting from particulate contribution from saturated soil to groundwater, excavation beneath the water table as a source removal groundwater remedial technology would address COC exceedances in groundwater. When used in combination with other remedial technologies, excavation would successfully achieve the LL Apartments Parcel RAOs, and could be implemented given the LL Apartments Parcel physical conditions.

12.3 AGGREGATION OF REMEDIAL ALTERNATIVES

The retained technologies described above have been aggregated into remedial alternatives for the LL Apartments Parcel. The alternatives are discussed below and are presented in order from least invasive to the most aggressive, a sequence that reflects an increasing level of effort, protectiveness, and cost. Alternative 1 is a capping alternative and Alternative 5 is a “Full Removal” alternative that is consistent with the MTCA WAC 173-340-200 definition of a permanent cleanup action.

All of the alternatives described below include storm drain system improvements or abandonment and replacement to eliminate the potential for contaminated soil and/or groundwater at the LL Apartments Parcel to infiltrate the stormwater drainage system and discharge to Lora Lake. Currently, stormwater runoff from the City of Burien enters the site stormwater conveyance system on the western side of the LL Apartments Parcel and carries stormwater with detectable concentrations of dioxins/furans and other contaminants across the Site before discharging to Lora Lake. System improvements proposed as part of this remedial action would not address contaminants carried by the upgradient stormwater, but will eliminate the potential for future contribution of any contamination from the LL Apartments Parcel. As a result, recontamination of the Lora Lake sediments may occur over time, but would not be associated with historical operations at the Site.

All of the alternatives listed below include technologies to address all contaminated media (soil and groundwater) on the LL Apartments Parcel. Table 12.2 presents the LL Apartments Parcel alternatives and identifies the technologies applied to soil and groundwater.

The LL Apartments Parcel alternatives will be evaluated according to the MTCA DCA, to compare the costs and benefits of the cleanup alternatives, and identify the alternative that is permanent to the maximum extent practicable. The five alternatives developed for evaluation are described below, and the evaluation according to the MTCA DCA is conducted in Section 13.0.

12.3.1 Alternative 1

Alternative 1 is the lowest capital cost remedial alternative proposed. Alternative 1 includes no contaminant mass removal. Instead, capping and institutional controls are applied to the entire parcel to manage exposure. Although there is no mass removal with this alternative, it complies with the requirements for the protection of human health and the environment through management of the exposure pathways and associated risk.

The detailed design of a soil capping technology would be developed during remedial design and in coordination with redevelopment planning. Soil capping could consist of either an impermeable asphalt or concrete pavement, or a permeable imported soil compacted cap that would allow for groundwater infiltration, but prevent direct contact to underlying contaminated soil. Both capping types would successfully eliminate the direct contact pathway. Areas of the LL Apartments Parcel that are already capped with asphalt or concrete may be left in place if determined during the design process to provide adequate management of the direct contact pathway.

Since contamination at concentrations greater than cleanup levels would remain in place, institutional controls to manage disturbance of contaminated soil would be required. The cap would extend to areas of soil with measured dioxin/furan TEQ concentrations greater than 13 pg/g, as identified by the existing dataset. Additional data collection may be required during the design process to further define the horizontal extent of dioxin/furan contamination in the northeast and southeast corners of Cleanup Area C.

This FS assumes that remedial implementation would be conducted in coordination with site redevelopment activities. Under future developed conditions, institutional controls would manage cap disturbance and cap replacement activities to ensure that the final surface of the LL Apartments Parcel complies with the requirements outlined in this FS and the site CAP. Institutional controls associated with the cap would include soil handling and worker Health and Safety requirements for site workers making future penetrations of the cap. Cap maintenance and monitoring would be required so long as contamination remains at concentrations exceeding cleanup levels. The CAP will require remediation within a definite restoration time frame, whether or not site redevelopment occurs.

Because no soil source material is removed with implementation of Alternative 1, this alternative does not remove contaminated soil located within the saturated zone that has been determined to be the source of dioxins/furans in groundwater (e.g., contaminated suspended solids). Over time, concentrations of groundwater COCs may degrade; however, these reductions would not be expected to reach cleanup levels within a reasonable time frame. Groundwater RAOs would be met through implementation of institutional controls in perpetuity to prevent withdrawal of contaminated groundwater. Institutional controls would be required to manage exposure risk through restrictions of groundwater withdrawals from the shallow contaminated groundwater at the LL Apartments Parcel. Groundwater monitoring would also be required.

12.3.2 Alternative 2

Alternative 2 provides more aggressive remedial action than Alternative 1 through focused contaminant mass removal in Cleanup Area A, and capping of the remaining contaminated soil as shown in Figure 12.1. Active groundwater remediation is also conducted through soil source removal in Cleanup Area A.

The excavation of contaminant mass would be focused in Cleanup Area A. Excavation would target source areas where the dioxin/furan TEQ concentrations are greater than approximately 1,000 pg/g based on all LL Apartments Parcel investigations conducted to date. This remedial action level concentration was selected by evaluating the relationship between incremental soil volume excavation and reduction in site-wide dioxin/furan TEQ mass concentration. A dioxin/furan TEQ concentration of 1,000 pg/g was identified as a break point in the data[16], where a substantial increase in excavation volume is required to achieve a lower dioxin/furan TEQ concentration for soil left on-site. This evaluation is presented graphically in Figure 12.2. The proposed excavation would remove approximately 8,600 cubic yards of soil from Cleanup Area A. It is estimated that excavation with off-site landfill disposal of the area shown in Figure 12.1 will remove approximately 88 percent of the total dioxin/furan contaminant mass present at the LL Apartments Parcel. Approximately 12 percent of the dioxins/furans mass at concentrations greater than the cleanup level at the LL Apartments Parcel would remain in place. A summary of source area excavation calculations is presented in Table 12.3. Contaminant mass calculations are included in Appendix N. For the purposes of this FS, it is assumed that all excavation locations would be backfilled with clean soil.

[16] The evaluation of the relationship between incremental soil excavation volumes and dioxin/furan TEQ concentrations was conducted by calculating average dioxin/furan TEQ concentrations for areas of the LL Apartments Parcel. The data points shown in Figure 12.2 represent these average concentrations. Breakpoints in the data were selected at round numbers, rather than specific points, due to the averaging of data required for evaluation of the soil volume/concentration relationship.

The horizontal extent of excavation within Cleanup Area A would be based on the extent of dioxin/furan contamination, which is the driver COC for soil remediation. The removal of dioxins/furans at concentrations greater than 1,000 pg/g would result in the removal of the full extent of gasoline range, diesel range, and heavy oil range TPH, lead, and PCP contamination at the LL Apartments Parcel greater than cleanup levels. Approximately 11 percent of the total cPAH mass would remain on the LL Apartments Parcel following implementation of the remedial action (Table 12.3).

A Compliance Monitoring Plan will be developed that meets the requirements of WAC 173-340-410. It will have the following components:

- **Protection Monitoring:** To confirm that human health and the environment are adequately protected during construction and any required operation and maintenance period.
- **Performance Monitoring:** To confirm that the IA or cleanup action has attained cleanup standards, remediation levels, and other performance standards such as construction quality control measurements, or permitting requirements.
- **Confirmation Monitoring:** Which confirms that the long-term effectiveness of the remedial action once remediation levels, performance standards, and cleanup levels have been attained. The vertical extent of excavation with this alternative will be designed to address groundwater remediation through source removal. The excavation will extend to approximately 20 feet bgs in the Central Source Area portion of Cleanup Area A, located approximately 5 feet into the saturated zone, to remove contaminated soil currently impacting groundwater quality. Dewatering would be required to manage groundwater encountered in the excavation during soil removal. Groundwater contaminant concentrations are expected to be in compliance with cleanup levels within 2 to 5 years of removing the source of contaminants to groundwater. Compliance monitoring would be conducted following completion to verify that groundwater stabilizes at concentrations less than cleanup levels following soil source removal. Until groundwater concentrations are less than cleanup levels, institutional controls would be required to prevent groundwater withdrawal.

Capping of Cleanup Areas A, B, and C is included in Alternative 2, and is identical to the capping described in Alternative 1 (Section 12.3.1). Capping of a portion of Cleanup Area A is still required following excavation, because although all dioxin/furan contamination with a TEQ concentration greater than 1,000 pg/g would be excavated, deeper contamination with a dioxin/furan TEQ concentration of greater than 13 pg/g would be left on the LL Apartments Parcel in Cleanup Area A.

Institutional controls would be implemented throughout the parcel in areas where contaminants have been capped in place at concentrations greater than cleanup levels to manage direct contact. Institutional controls anticipated with this alternative are identical to those discussed above for Alternative 1.

12.3.3 Alternative 3

Alternative 3 is similar to Alternative 2, but expands the excavation area to include both Cleanup Areas A and B, as shown in Figure 12.3. This excavation removes soil from areas on the LL Apartments Parcel with dioxin/furan TEQ concentrations greater than 100 pg/g (as determined by existing data), for a total excavation volume of 19,000 cubic yards. All excavated soil would be disposed of off-site at an appropriately licensed landfill. For the purposes of this FS, it is assumed that all excavation locations would be backfilled with clean soil.

The remedial action dioxin/furan TEQ concentration of 100 pg/g was selected by evaluating the relationship between incremental soil volume excavation and reduction in site-wide dioxin/furan TEQ mass concentration. From Figure 12.2, the dioxin/furan TEQ concentration of 100 pg/g was identified as a break point on the curve, where there was a disproportionate increase in excavation volume required to achieve a lower dioxin/furan TEQ concentration left on-site. It is estimated that with this excavation volume, approximately 96 percent of the dioxin/furan contaminant mass with concentrations greater than cleanup levels will be removed from the LL Apartments Parcel. Approximately 4 percent of the dioxin/furan contaminant mass at concentrations greater than the cleanup level will remain on the LL Apartments Parcel following excavation. A summary of excavation calculations is presented in Table 12.3. With a few exceptions, excavation of dioxin/furan TEQ contamination to 100 pg/g will remove sample locations where dioxin/furan TEQ concentrations are greater than the range of urban background concentrations (refer to Figure 4.9 and Appendix M).

In addition, this larger excavation removes from the LL Apartments Parcel the full extent of lead, PCP, gasoline range TPH, diesel range TPH, and heavy oil range TPH soil contamination at concentrations greater than cleanup levels. Only 6 percent of the cPAH contaminant mass at the LL Apartments Parcel would be left in place with this alternative, at a depth of 10 to 16 feet bgs and a concentration just exceeding the cleanup level of 137 µg/kg (sample collected from MW-5 was 140 µg/kg from 11.5–13 feet bgs). This cPAH contamination, and the remaining LL Apartments Parcel soil dioxin/furan contamination at concentrations greater than cleanup levels in Cleanup Areas B and C, would be capped consistent with what was described for Alternative 2. Although this alternative includes substantial excavation of contaminated soil, all of Cleanup Area C and portions of Cleanup Area B would still require capping to address dioxin/furan TEQ concentrations between 13 and 100 pg/g in soil remaining in these areas.

A Compliance Monitoring Plan will be developed that meets the requirements of WAC 173-340-410. It will have the following components:

- **Protection Monitoring:** To confirm that human health and the environment are adequately protected during construction and any required operation and maintenance period.
- **Performance Monitoring:** To confirm that the IA or cleanup action has attained cleanup standards, remediation levels, and other performance standards such as construction quality control measurements or permitting requirements.

- **Confirmation Monitoring:** Which confirms that the long-term effectiveness of the remedial action once remediation levels, performance standards, and cleanup levels have been attained.

This alternative includes groundwater remediation through source excavation. Consistent with Alternative 2, the vertical extent of excavation will be designed to address groundwater remediation through source removal. The excavation will likely extend to approximately 20 feet bgs in the Central Source Area portion of Cleanup Area A, located approximately 5 feet into the saturated zone, to remove contaminated soil currently impacting groundwater quality. Dewatering would likely be required to manage groundwater in the excavation during soil removal. Groundwater contaminant concentrations are expected to be in compliance with cleanup levels within 2 to 5 years of source removal. Confirmation monitoring would be conducted following completion to verify that groundwater concentrations stabilize to less than cleanup levels. Until groundwater concentrations are less than cleanup levels, institutional controls would be required to prevent groundwater withdrawal. If groundwater concentrations do not return to cleanup levels within 5 years, additional actions may be necessary, depending upon how close the remaining concentrations are to achieving cleanup levels. These contingency actions will be described in the CAP for the Site.

Institutional controls would be implemented throughout the parcel in areas where contaminants have been capped in place to manage risk associated with direct contact. The institutional controls anticipated with this alternative are identical to those discussed for Alternative 1.

12.3.4 Alternative 4

Similar to Alternative 3, Alternative 4 would excavate all contaminated soil with dioxin/furan TEQ concentrations greater than 100 pg/g for off-site disposal. The remaining contaminated soil containing dioxin/furan TEQ concentrations between 13 pg/g and 100 pg/g would be excavated and consolidated within the site boundary (rather than capping in place) to minimize the extent of capping and institutional controls following excavations (Figure 12.4).

This alternative would include excavation and off-site landfill disposal of 19,000 cubic yards of soil with dioxin/furan TEQ concentrations greater than 100 pg/g. The contaminated soil left on-site with dioxin/furan TEQ concentrations between 13 pg/g and 100 pg/g would be consolidated and contained to minimize the extent of institutional controls. Up to approximately 30,000 cubic yards of soil would be excavated and consolidated within the Site. For the purposes of this FS, it is assumed that all excavation locations would be backfilled to 2 feet of the existing surface with clean soil. If soils were consolidated on the LL Apartments Parcel, consolidation areas would be covered with 2 feet of clean soil.

The goal of consolidation would be to minimize or eliminate the need for capping and institutional controls on that portion of the LL Apartments Parcel that is outside of the designated FAA RPZ-Controlled Activity and RPZ-Extended Object Free Areas. That portion of the property may be transferred for commercial or light industrial redevelopment. Full cleanup and removal of institutional controls from that property would facilitate property transfer and redevelopment and remove the administrative burden of maintaining institutional controls and cap maintenance requirements on a property under the control of third parties. Contaminated soil with dioxin/furan TEQ concentrations less than 100 pg/g removed from this portion of the property could be consolidated on either the northeastern portion of the LL Apartments Parcel within the FAA Controlled Activity Area or at the DMCA, which is within the RPZ-Extended Object Free Area. Both of these locations are expected to remain in Port ownership in perpetuity, and already are subject to deed restrictions, access, and institutional controls for FAA and airport operational purposes.

Soil containing dioxin/furan TEQ concentrations between 13 pg/g and 100 pg/g could be consolidated on the northeastern portion of the LL Apartments Parcel. The consolidation area would require capping to eliminate the direct contact pathway. Institutional controls would be used to maintain the cap in perpetuity, as described for Alternative 1. Soil containing dioxin/furan TEQ concentrations between 13 pg/g and 100 pg/g could also be consolidated on the DMCA, because that range of soil with dioxin/furan TEQ concentrations is less than the applicable DMCA soil cleanup level. Capping of this material would not be required for protection of Port workers. Planned construction of an engineered surface to improve the area for Port uses would provide a barrier to terrestrial growth and ecological exposure, as well as to worker direct contact. Because the DMCA is located in a Port-secured area, there is no public access. No additional institutional controls beyond those required to keep the area in industrial use would be required for the cleanup action if the material was consolidated at the DMCA.

The consolidation of the dioxin/furan contaminated soil that would remain on-site at concentrations greater than 13 pg/g is consistent with the WAC 173-340-370(5) directive that cleanup action alternatives should “minimize the potential for direct contact and migration of hazardous substances” through consolidation when “hazardous substances remain on-site at concentrations which exceed cleanup levels.” On-site consolidation of the contamination that would remain on-site would minimize the area requiring capping and/or restrictive covenants (WSDOE 2007).

If Alternative 4 is selected, the specific location and extent of the soil consolidation area would be selected during the design phase in close coordination with Port development plans. The cost estimate for Alternative 4 assumes that consolidation would occur on the DMCA (Appendix O).

Similar to Alternative 3, groundwater remediation would occur through source removal. Because soil remedial actions would include excavation and consolidation of deep soil contamination, soil located below the water table would be removed, eliminating soil to groundwater pathways. Dewatering would be required to manage groundwater in the excavation during soil removal and consolidation. Achievement of groundwater cleanup levels is expected in 2 to 5 years after source removal activities. Groundwater confirmation monitoring would be required to confirm reduction in groundwater contaminant concentrations. Until groundwater concentrations are less than cleanup levels, institutional controls would be required to prevent groundwater withdrawal.

A Compliance Monitoring Plan will be developed that meets the requirements of WAC 173-340-410. It will have the following components:

- **Protection Monitoring:** To confirm that human health and the environment are adequately protected during construction and any required operation and maintenance period.
- **Performance Monitoring:** To confirm that the IA or cleanup action has attained cleanup standards, remediation levels, and other performance standards such as construction quality control measurements or permitting requirements.
- **Confirmation Monitoring:** Which confirms that the long-term effectiveness of the remedial action once remediation levels, performance standards, and cleanup levels have been attained.

12.3.5 Alternative 5

Alternative 5 is the full removal alternative that excavates all accessible[17] soil at the LL Apartments Parcel with exceedances of applicable cleanup levels. The full excavation of soil with dioxin/furan TEQ concentrations greater than 13 pg/g would remove all other soil COCs that are greater than cleanup levels; no cPAH or PCP contaminant mass at concentrations greater than cleanup levels would remain on the LL Apartments Parcel (Table 12.3). This alternative includes excavation to a maximum depth of 20 feet in the Central Source Area location within Cleanup Area A, and to a depth of approximately 10 to 20 feet in the Eastern Source Area location within Cleanup Area A. Excavation within the Western Source Area location within Cleanup Area B would extend to a depth of approximately 4 feet. Excavation throughout the remainder of Cleanup Areas B and C would be between approximately 1 and 2 feet bgs to remove dioxin/furan TEQ contamination at concentrations greater than 13 pg/g (refer to Figure 12.5). Approximately 49,000 cubic yards of soil would be removed from the LL Apartments Parcel for off-site disposal. Depending on future use plans, backfilling may or may not occur to reconstruct the ground surface. For the purposes of this FS, it is assumed that the excavations within Cleanup Areas A, B, and C would be backfilled to within 2 feet of the existing ground surface.

Source removal for groundwater remediation is included in this alternative, identical to Alternatives 2 through 4 above. Groundwater confirmation monitoring would be required to confirm that reduction in groundwater contaminant concentrations occurred after source removal activities. Achievement of groundwater cleanup levels is anticipated in 2 to 5 years. Until groundwater concentrations are less than cleanup levels, institutional controls would be required to prevent groundwater withdrawal.

In addition to temporary institutional controls for groundwater, the only institutional controls required with implementation of Alternative 5 may be limited controls for any remaining LL Apartments Parcel contamination determined to be present during design

[17] Soil located beneath existing roadways and/or embankments will not be excavated as part of the LL Apartments Parcel remedial actions and are considered inaccessible for this FS evaluation. If required, institutional controls would be used to manage direct worker contact with contaminated soil located beneath existing roadways.

at levels greater than cleanup levels beneath existing roadways bordering the property. These institutional controls would be implemented to protect future worker direct contact. This alternative assumes any contamination located beneath roadways will remain in place, and that removal of public right-of-ways will not be conducted for limited source removal in those areas.

A Compliance Monitoring Plan will be developed that meets the requirements of WAC 173-340-410. It will have the following components:

- **Protection Monitoring:** To confirm that human health and the environment are adequately protected during construction and any required operation and maintenance period.
- **Performance Monitoring:** To confirm that the IA or cleanup action has attained cleanup standards, remediation levels, and other performance standards such as construction quality control measurements or permitting requirements.
- **Confirmation Monitoring:** Which confirms that the long-term effectiveness of the remedial action once remediation levels, performance standards, and cleanup levels have been attained.

13.0 Lora Lake Apartments Parcel Alternatives Evaluation and Disproportionate Cost Analysis

In this section, the alternatives developed for the LL Apartments Parcel in Section 12.0 are evaluated against the MTCA requirements for a cleanup remedy per WAC 173-340-360. The MTCA requirements are introduced in the first section below, followed by the alternatives evaluation that compares each alternative based on its ability to comply with the MTCA requirements.

13.1 MODEL TOXICS CONTROL ACT REQUIREMENTS AND DISPROPORTIONATE COST ANALYSIS EVALUATION CRITERIA

This section provides a summary of the requirements and criteria that each remedial alternative is evaluated against in accordance with MTCA. Each of the proposed remedial alternatives is screened relative to mandatory “MTCA Threshold Requirements” and “Other MTCA Requirements” for evaluation. A DCA is conducted to identify the alternative that is “permanent to the maximum extent practicable,” using DCA evaluation criteria. Based on these evaluations, the Port will recommend a Preferred Remedial Alternative to WSDOE.

13.1.1 Model Toxics Control Act Threshold Requirements

MTCA WAC 173-340-360(2) states that all cleanup actions will meet the minimum requirements for a cleanup action, including the MTCA Threshold Requirements, and when multiple cleanup action components are implemented for a single site, the overall cleanup action shall also meet the minimum requirements discussed below:

- **Protect Human Health and the Environment.** Protection of human health and the environment shall be achieved through implementation of the selected remedial action.
- **Comply with Cleanup Standards.** Cleanup standards, as defined by MTCA, consist of cleanup levels for hazardous substances present at a site, the location, or point of compliance where the cleanup levels must be met, and any regulatory requirements that may apply to the site due to the type of action being implemented and/or the location of the site. All selected cleanup alternatives must meet cleanup standards defined for the site.
- **Comply with Applicable State and Federal Laws.** MTCA WAC 173-340-710 states that cleanup standards shall comply with legally applicable ARARs. ARARs applicable to this Site are detailed in Tables 9.1 through 9.3 and consist of chemical-specific ARARs applicable to the contamination types present at the Site, location-specific ARARs that apply to the physical location of the Site, and action-specific ARARs that apply to the construction components of the remedy.
- **Provide for Compliance Monitoring.** MTCA requires that all selected cleanup alternatives provide for compliance monitoring as described in WAC 173-340-410. Compliance monitoring consists of protection monitoring,

performance monitoring, and confirmation monitoring. Protection monitoring is performed during remedial implementation to monitor short-term risks and confirm protection of human health and the environment during construction activities. Performance monitoring will assess short-term remedy effectiveness and confirm compliance with the site cleanup levels immediately following remedial implementation. Confirmation monitoring will evaluate long-term effectiveness of the remedial action following attainment of the cleanup standards.

13.1.2 Other Model Toxics Control Act Requirements

Cleanup alternatives that meet the Threshold Requirements must also fulfill Other MTCA Requirements described in WAC 173-340-360(2)(b):

- **Use Permanent Solutions to the Maximum Extent Practicable.** The use of permanent solutions to the maximum extent practicable for a cleanup action is analyzed according to the DCA procedure described in WAC 173-340-360(3). Preference is given to alternatives that implement permanent solutions, defined in MTCA as actions that can meet cleanup standards "without further action being required at the site being cleaned up or any other site involved with the cleanup action, other than the approved disposal of any residue from the treatment of hazardous substances (WAC 173-340-200)."

  The DCA process is conducted to identify the alternative that uses permanent solutions to the maximum extent practicable.

- **Provide for a Reasonable Restoration Time Frame.** Restoration time frame is defined in MTCA as "the period of time needed to achieve the required cleanup levels at the points of compliance established for the site." Preference is given to alternatives that provide for a reasonable restoration time frame. For alternatives that rely on natural attenuation and degradation over time to meet cleanup standards, a restoration time frame of 10 years or less is typically accepted as "reasonable."

- **Consideration of Public Concerns.** Public involvement must be initiated according to the requirements set forth in WAC 173-340-600. Public concerns are taken into account at each step in the formal process under MTCA. Public comment was received on the RI/FS Work Plans, and responses were taken into account in the RI/FS development (refer to Appendix I). Formal public comment was conducted on the Draft RI/FS document, and responses were taken into account when WSDOE formalized the decision on the Preferred Remedial Alternative presented in the CAP.

13.1.3 Model Toxics Control Act Disproportionate Cost Analysis

The MTCA DCA is used to evaluate whether a cleanup action uses permanent solutions to the maximum extent practicable as determined by the level of attainment of specific criteria defined in WAC 173-340-360(3)(f). The environmental benefits of each alternative are scored using seven evaluation criteria. Additionally, the cost of each alternative is estimated. For each alternative, a "Cost per Unit Benefit Ratio" is calculated by dividing the total cost for the alternative (in millions) by the total benefit score for that alternative. A lower “cost per unit benefit ratio” value indicates the most benefit for the associated cost. The alternative with the lowest “cost per unit benefit ratio” provides the highest level of environmental benefit and permanence per dollar spent.

As stated in MTCA, the cost of an individual alternative is determined disproportionate “if the incremental costs of the alternative over that of a lower cost alternative exceed the incremental degree of benefits achieved by the alternative over that of the other lower cost alternative” (WAC 173-340-360(3)(e)(i)).

Evaluation of disproportionate cost allows comparison of each alternative to the most permanent alternative presented, as determined by attainment of MTCA criteria. This analysis can be qualitative or quantitative. If multiple alternatives possess equivalent benefits, the lower-cost alternative will be selected. The seven DCA criteria defined in MTCA (WAC 173-340-360(f)) are as follows:

- **Protectiveness.** Overall protectiveness of human health and the environment, including the degree to which existing risks are reduced, the time required to reduce these risks and the overall improvement in environmental quality.
- **Permanence.** The degree to which the alternative permanently reduces the toxicity, mobility, or volume of hazardous substances.
- **Cost.** The cost to implement the alternative consists of construction, net present value of any long-term costs, and agency oversight costs that are recoverable.
- **Effectiveness over the Long-term.** Long-term effectiveness consists of the degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on-site at levels greater than cleanup levels, and the effectiveness of controls in place to control risk while contaminants remain on-site.
- **Management of Short-term Risks.** Short-term risks comprise the risk to human health and the environment associated with the alternative during construction and implementation and the effectiveness of measures taken to control those risks.
- **Technical and Administrative Implementability.** The ability of the alternative to be implemented is based on whether the alternative is technically possible, meets administrative and regulatory requirements, and if all necessary services, supplies, and facilities are readily available.
- **Consideration of Public Concerns.** Whether the community has concerns regarding the alternative and if so, to what extent the alternative addresses those concerns.

13.2 ALTERNATIVES EVALUATION

In the following sections, the proposed remedial alternatives for the LL Apartments Parcel are evaluated for compliance with the MTCA Threshold Requirements, the ability to meet a reasonable restoration time frame, and compliance with the LL Apartments Parcel RAOs defined in Section 9.1. Alternative assessment under the Other MTCA Requirement “Uses Permanent Solutions to the Maximum Extent Practicable” is reported as a part of the discussion of the DCA analysis, which is conducted in Table 13.1 and summarized in Table 13.2 and in the following sections. The DCA analysis conducted in Table 13.1 scores each alternative relative to achievement of the MTCA criteria stated in WAC 173-340-360(3). The alternatives are evaluated relative to their ability to comply with the criteria listed, and are not compared to each other but rather to the criteria. Because some alternatives provide a similar degree of compliance with a given criterion, the associated evaluation statements may be the same or similar.

The Other MTCA Requirement “Consideration of Public Concern” is not included in the detailed alternatives analysis that follows, as the analysis was performed prior to obtaining public input during a public comment period held from October 25, 2013, to January 15, 2014. Public comments received on the Public Review Draft RI/FS dated January 12, 2013 have been considered by WSDOE. WSDOE formally responded to all received public comments in a responsiveness summary (WSDOE 2015).

13.2.1 Alternative 1

Alternative 1 involves capping the LL Apartments Parcel to address direct worker contact pathways. Compliance monitoring and institutional controls would be used to manage future contact with soil and groundwater contamination. This alternative includes stormwater source control through storm drain system improvements and/or abandonment and replacement.

13.2.1.1 MTCA Threshold Requirements

- **Protection of Human Health and the Environment:** Alternative 1 provides protection of human health and the environment through control of the direct contact exposure pathway via capping. Institutional controls for cap maintenance would be maintained in perpetuity to prevent any future direct contact issues. Stormwater system improvements and/or abandonment and replacement would eliminate the potential for contaminant migration from the LL Apartments Parcel to Lora Lake through the stormwater system. Institutional controls would be administered to restrict groundwater use within the contaminated groundwater plume.
- **Compliance with Cleanup Standards:** Alternative 1 complies with MTCA Cleanup Standards by containing the LL Apartments Parcel contamination in place. With contamination covered by a clean cap, soil cleanup levels are met at the point of compliance. Groundwater cleanup standards are met through institutional controls preventing exposure. Institutional and administrative controls would require maintenance of the cap in perpetuity to ensure the contamination remains contained.
- **Compliance with Applicable State and Federal Laws:** Alternative 1 complies with all applicable state and federal laws and MTCA cleanup regulations through containment and institutional controls.

- **Provides for Compliance Monitoring:** Alternative 1 provides for compliance monitoring by conducting protection monitoring during implementation, performance monitoring following completion, and ongoing groundwater confirmation monitoring while contaminants remain on the LL Apartments Parcel at concentrations greater than cleanup levels, likely in perpetuity.

13.2.1.2 Remedial Action Objectives

Through capping and institutional controls, Alternative 1 complies with the RAOs defined for the LL Apartments Parcel. Alternative 1 protects human health from exposure to LL Apartments Parcel contamination through capping and institutional controls to manage direct soil contact and future drinking water exposure. Because the existing LL Apartments Parcel stormwater system will be upgraded or abandoned and replaced, contaminated soil and groundwater from the LL Apartments Parcel would not enter the stormwater conveyance system. Migration of contaminants via groundwater is not occurring at the LL Apartments Parcel. This alternative relies on institutional controls preventing groundwater withdrawal to eliminate potential for exposure to the localized area of groundwater that exceeds cleanup standards. With implementation of institutional controls to manage exposure to COCs remaining on the LL Apartments Parcel at concentrations greater than cleanup levels, the remedial alternative could be implemented in a method that does not restrict proposed site development and future site use plans, although capping and institutional controls would be present on the portion of the property that the Port may transfer for commercial or light industrial redevelopment. Implementation of this alternative would require careful tracking and administrative management of those controls.

13.2.1.3 Restoration Time Frame

Alternative 1 addresses exposure pathways and complies with RAOs within a reasonable time frame through implementation of containment and institutional controls. Exposure pathways are managed through use of these containment and institutional controls immediately following implementation. Groundwater contamination and contaminants in contained LL Apartments Parcel soil are expected to remain on the LL Apartments Parcel at concentrations greater than cleanup levels in perpetuity; however, the controls implemented as part of Alternative 1 protect relevant exposure pathways, as long as these controls are managed and maintained.

13.2.1.4 Disproportionate Cost Analysis

Alternative 1 has the second highest cost per unit benefit ratio because Alternative 1 is not as protective, permanent, or effective over the long-term as the other alternatives. Alternative 1 received a lower score than the other alternatives for implementability because of the need for long-term maintenance and monitoring, and because more institutional controls would be required compared to the other alternatives. Refer to Table 13.2 for additional details.

13.2.2 Alternative 2

Alternative 2 consists of focused mass removal through excavation and off-site disposal in Cleanup Area A to remove soil contaminated with dioxin/furan concentrations greater than 1,000 pg/g TEQ. This alternative would also include capping of the remaining contaminated soil in Cleanup Areas A, B, and C. Alternative 2 would leave approximately 12 percent of the existing mass of dioxins/furans and 11 percent of the existing mass of cPAHs in soil at the LL Apartments Parcel. All other LL Apartments Parcel soil COCs would be excavated as a result of the Alternative 2 dioxin/furan excavation. Groundwater remediation will be achieved through saturated zone soil source removal via excavation. Groundwater compliance with cleanup levels would be expected within 2 to 5 years of remedy implementation. This alternative includes stormwater source control through storm drain system improvements and/or abandonment and replacement.

13.2.2.1 MTCA Threshold Requirements

- **Protection of Human Health and the Environment:** Alternative 2 provides protection of human health and the environment through contaminant mass removal and capping. Implementation of Alternative 2 would provide an immediate reduction of risk through source removal and pathway control. Contamination would remain on the LL Apartments Parcel at concentrations greater than cleanup levels, but would be contained with caps and institutional controls implemented to manage routes of exposure.
- **Compliance with Cleanup Standards:** Alternative 2 complies with all MTCA Cleanup Standards through contaminant removal and containment of COCs that remain on the LL Apartments Parcel at concentrations greater than cleanup levels to address exposure pathways. With remaining contamination covered by a cap, soil cleanup levels are met at the point of compliance. Following an initial stabilization period, groundwater cleanup standards would be met at the standard point of compliance.
- **Compliance with Applicable State and Federal Laws:** Alternative 2 complies with all applicable state and federal laws outlined in Section 9.2 and in Tables 9.1 through 9.3 through contaminant mass removal and capping, with institutional controls in capped areas.
- **Provides for Compliance Monitoring:** Alternative 2 meets the requirements for compliance monitoring by conducting protection monitoring during implementation, performance monitoring following completion of excavation and capping, and confirmation monitoring to confirm groundwater compliance following remedy implementation. Confirmation monitoring for groundwater compliance with the cleanup levels would be anticipated to occur for approximately 2 to 5 years, until groundwater reaches cleanup levels.

13.2.2.2 Remedial Action Objectives

All LL Apartments Parcel RAOs would be met with Alternative 2. Alternative 2 protects human receptors from exposure to LL Apartments Parcel contamination that exceeds applicable cleanup levels by eliminating the risk of direct contact with contaminated soil and eliminating the potential future human health risk resulting from consumption of drinking water within the vicinity of the LL Apartments Parcel. To eliminate the potential for contaminated surface or subsurface soil to enter the stormwater conveyance system and discharge to Lora Lake, Alternative 2 excavates contaminated soil and installs caps while improving or abandoning the stormwater conveyance system. These activities will also prevent the migration of contaminants from the LL Apartments Parcel via erosion, groundwater migration, or stormwater processes. With implementation of institutional controls to manage exposure to COCs remaining on the LL Apartments Parcel at concentrations greater than cleanup levels, the remedial alternative does not restrict proposed site development and future use plans, although capping and institutional controls would be present on the portion of the property that the Port may transfer for commercial or light industrial redevelopment. Implementation of this alternative would require careful tracking and administrative management of those controls.

13.2.2.3 Restoration Time Frame

Alternative 2 addresses exposure pathways and complies with all RAOs within a reasonable time frame through implementation of mass removal, containment technologies, and institutional controls. Exposure pathways are managed through the use of these containment remedies and controls immediately following implementation. Groundwater compliance is anticipated to be achieved within 2 to 5 years of remedy completion, because source area excavation activities would remove the source of contaminants to groundwater.

13.2.2.4 MTCA Evaluation Criteria and Disproportionate Cost Analysis

Alternative 2 received the third lowest cost per unit benefit ratio. Alternative 2 was shown by the DCA to be not as protective, permanent, or effective over the long-term when compared to Alternatives 3, 4, and 5 (Tables 13.1 and 13.2). Source removal activities substantially reduce the level of long-term risk at the LL Apartments Parcel by eliminating 88 percent of LL Apartments Parcel contamination. Contaminants would remain on the LL Apartments Parcel in perpetuity due to the persistent nature of dioxins/furans, but the risk of exposure would be managed by containment remedies and institutional controls. The degree of residual risk would also be greatly reduced compared to Alternative 1 because the dioxin/furan soil concentrations remaining on the LL Apartments Parcel are orders of magnitude less than the concentrations currently present.

13.2.3 Alternative 3

Alternative 3 expands the extent of soil excavation from Alternative 2 to include excavation of Cleanup Area B. All dioxin/furan-contaminated soil with concentrations greater than 100 pg/g would be removed for off-site landfill disposal. Similar to Alternative 2, Alternative 3 includes capping in place contaminated soil with dioxin/furan TEQ concentrations between 13 and 100 pg/g. Alternative 3 would leave only approximately 4 percent of the mass of dioxins/furans and 6 percent of the mass of cPAHs at the LL Apartments Parcel. All other LL Apartments Parcel COCs would be excavated as a result of the Alternative 3 dioxin/furan excavation. Groundwater remediation would be conducted through source removal. This alternative includes stormwater source control through storm drain system improvements and/or abandonment and replacement.

13.2.3.1 MTCA Threshold Requirements

- **Protection of Human Health and the Environment:** Alternative 3 provides protection of human health and the environment through contaminant mass removal and capping. Implementation of Alternative 3 would provide an immediate reduction of risk through source removal and off-site disposal of all soil with dioxin/furan TEQ concentrations greater than 100 pg/g and exposure protection through capping and institutional controls. Some contamination would remain on the LL Apartments Parcel at concentrations greater than cleanup levels, but would be contained with a surface cap and institutional controls to manage routes of exposure.
- **Compliance with Cleanup Standards:** Alternative 3 complies with all MTCA Cleanup Standards through contaminant removal and containment of LL Apartments Parcel COCs that are greater than cleanup levels to address exposure pathways. With remaining contamination covered by a clean cap, soil cleanup levels are met at the point of compliance. Following an initial stabilization period, groundwater cleanup standards would be met at the standard point of compliance.
- **Compliance with Applicable State and Federal Laws:** Alternative 3 complies with all applicable state and federal laws that are outlined in Section 9.2 and in Tables 9.1 to 9.3 through contaminant mass removal and capping.
- **Provides for Compliance Monitoring:** Alternative 3 meets the requirements for compliance monitoring by conducting protection monitoring during implementation, performance monitoring following completion of excavation and capping, and confirmation monitoring to confirm groundwater compliance following remedy implementation. Confirmation monitoring for groundwater compliance with the cleanup levels would be anticipated to occur for approximately 2 to 5 years, until groundwater reaches cleanup levels.

13.2.3.2 Remedial Action Objectives

All LL Apartments Parcel RAOs would be met with Alternative 3, which proposes excavation of contaminated soil, soil capping, and institutional controls. Alternative 3 protects human receptors from exposure to LL Apartments Parcel contamination that exceeds applicable cleanup levels by eliminating the risk of direct contact with contaminated soil and eliminating the potential future human health risk resulting from consumption of drinking water within the vicinity of the LL Apartments Parcel. Alternative 3 uses soil excavation and capping and stormwater conveyance system improvements or abandonment and replacement to eliminate the potential for contaminated surface or subsurface soil at the LL Apartments Parcel to enter the stormwater conveyance system discharging to Lora Lake and prevent migration of contaminants from the LL Apartments Parcel by erosion, groundwater migration, or stormwater processes. With implementation of institutional controls to manage exposure to soil remaining on the LL Apartments

Parcel, the remedial alternative does not restrict proposed site development and future use plans. Capping and institutional controls would be present on the portion of the property that the Port may transfer for commercial or light industrial redevelopment. Implementation of this alternative would require careful tracking and administrative management of those controls.

13.2.3.3 Restoration Time Frame

Alternative 3 addresses exposure pathways and complies with all RAOs within a reasonable time frame through implementation of mass removal, containment technologies, and institutional controls. Exposure pathways are managed through the use of these containment remedies and controls immediately following implementation. Groundwater compliance is anticipated to be achieved within 2 to 5 years of remedy completion, because source area excavation activities would remove the source of contaminants to groundwater.

The time required to comply with RAOs and the Other MTCA Requirements is identical for Alternatives 2 and Alternative 3, since the only difference between the alternatives is excavation and off-site disposal of additional contaminated soil. The time required for groundwater compliance is expected to be consistent between Alternatives 2 and 3 because the removal of saturated soil in the area of impacted groundwater will occur with both of these alternatives.

13.2.3.4 MTCA Evaluation Criteria and Disproportionate Cost Analysis

Alternative 3 received the lowest cost per unit benefit ratio. Alternative 3 scored higher than Alternative 2, because the additional cost associated with this alternative was small compared to the increased benefit received with implementation of this remedy over Alternative 2. Although this alternative was shown in the DCA to be slightly less protective, permanent, and effective over the long-term when compared to Alternatives 4 and 5, the cost of Alternatives 4 and 5 were disproportionately higher and thus, Alternative 3 had the lowest cost per unit benefit ratio of the alternatives. This means that Alternative 3 provides the highest level of environmental benefit and permanence per dollar spent. This alternative is similar to the other alternatives for short-term risk management and implementability.

Source removal activities conducted as part of Alternative 3 substantially reduce the level of long-term risk at the LL Apartments Parcel by removing the majority of LL Apartments Parcel contamination. Contaminants would remain on LL Apartments Parcel in perpetuity due to the persistent nature of dioxins/furans, but the risk of exposure would be managed by implemented containment remedies and institutional controls. The degree of residual risk is also greatly reduced from Alternatives 1 and 2 because the concentrations of remaining dioxins/furans in LL Apartments Parcel soil would be orders of magnitude less than the current the LL Apartments Parcel concentrations.

13.2.4 Alternative 4

With Alternative 4, excavation and off-site disposal are identical to Alternative 3. Soil remaining on-site with dioxin/furan concentrations between 13 and 100 pg/g would be consolidated within the FAA Controlled Activity and/or RPZ-Extended Object Free Areas. These areas are already subject to deed restrictions, access restrictions, and institutional controls for FAA and airport operational purposes. Consolidation would minimize or eliminate the need for capping and institutional controls on that portion of the LL Apartments Parcel that the Port may transfer for commercial or light industrial redevelopment.

Alternative 4 would leave approximately 4 percent of the mass of dioxins/furans and 6 percent of the mass of cPAHs currently in soils at the LL Apartments Parcel on-site at the DMCA consolidation area. All other LL Apartments Parcel COCs would be excavated as a result of the source area excavation. Contaminated soil with dioxin/furan TEQ concentrations less than 100 pg/g could be consolidated on either the northeastern portion of the LL Apartments Parcel within the FAA Controlled Activity Area or at the DMCA, which is within the RPZ-Extended Object Free Area. Groundwater remediation would be conducted through source removal. Contaminated soil that currently exists below the water table would be excavated and disposed of off-site or consolidated above the water table. This alternative includes stormwater source control through storm drain system improvements and/or abandonment and replacement.

13.2.4.1 MTCA Threshold Requirements

- **Protection of Human Health and the Environment:** Alternative 4 provides protection of human health and the environment through contaminant mass removal, consolidation, and institutional controls. Implementation of Alternative 4 would provide an immediate reduction of risk through source removal and pathway control. Some contamination greater than the applicable LL Apartments Parcel cleanup levels would be consolidated on Port-owned property. Institutional controls, and/or a surface cap would manage routes of exposure to protect direct contact with the consolidated soil.
- **Compliance with Cleanup Standards:** Alternative 4 complies with all MTCA Cleanup Standards through removal, consolidation and containment of LL Apartments Parcel COCs that are greater than cleanup levels to address exposure pathways. If soil above cleanup levels is consolidated on the LL Apartments Parcel, that remaining contamination would be capped, such that soil cleanup levels are met at the point of compliance. Following an initial stabilization period, groundwater cleanup standards would be met at the standard point of compliance.
- **Compliance with Applicable State and Federal Laws:** Alternative 4 complies with all applicable state and federal laws that are outlined in Section 9.2 and in Tables 9.1 to 9.3 through contaminant mass removal, consolidation, and containment.

- **Provides for Compliance Monitoring:** Alternative 4 meets the requirements for compliance monitoring by conducting protection monitoring during implementation, performance monitoring following completion of excavation and consolidation, and confirmation monitoring to confirm groundwater compliance following remedy implementation. Confirmation monitoring for groundwater would be anticipated to occur for approximately 2 to 5 years, until groundwater reaches cleanup levels.

13.2.4.2 Remedial Action Objectives

All RAOs applicable to the LL Apartments Parcel would be met with Alternative 4, which proposes excavation and off-site disposal of contaminated soil and consolidation of LL Apartments Parcel soils with lower levels of contamination in a location that allows for minimization of the areas requiring institutional controls. Through source excavation, Alternative 4 protects human receptors from exposure to LL Apartments Parcel contamination that exceeds applicable cleanup levels by eliminating the risk of direct contact with contaminated soil and eliminating the potential future human health risk resulting from consumption of drinking water within the vicinity of the LL Apartments Parcel. Alternative 4 uses soil excavation and storm drain system improvements to eliminate the potential for contaminated surface or subsurface soil at the LL Apartments Parcel to enter the stormwater conveyance system that discharges to Lora Lake. The soil excavation, capping, and storm drain improvements also prevent migration of contaminants from the LL Apartments Parcel by erosion, groundwater migration, or stormwater processes.

Consolidation of soils with lower levels of contamination would minimize or eliminate the need for capping and institutional controls on that portion of the LL Apartments Parcel that the Port may transfer for commercial or light industrial redevelopment. Full cleanup and removal of institutional controls from that property would facilitate property transfer and redevelopment and remove the administrative burden of maintaining institutional controls and cap maintenance requirements on property no longer owned by the Port.

13.2.4.3 Restoration Time Frame

Alternative 4 addresses exposure pathways and complies with the LL Apartments Parcel RAOs within a reasonable time frame through implementation of mass removal and on-site consolidation of remaining contaminated soil in a location selected to minimize institutional controls. Exposure pathways are managed through source removal, consolidation and institutional controls. Immediately following excavation, contaminated soil that remains on-site would be consolidated in a future Port-owned location. Groundwater compliance is anticipated to be achieved within 2 to 5 years of remedy completion, because source area excavation activities would remove the source of contaminants to groundwater. Source removal activities substantially reduce the level of long-term risk at the LL Apartments Parcel by eliminating the majority of LL Apartments Parcel contamination. Contaminated soil consolidated on Port-owned property would remain in perpetuity due to the persistent nature of dioxins/furans, but the risk of exposure would be managed through institutional controls, and capping where required.

The time required for compliance with RAOs and the Other MTCA Requirements is identical between Alternatives 3 and 4, since both alternatives include on-site containment of contaminated soil. The time required for groundwater compliance is consistent between Alternatives 3 and 4 because the removal of saturated soil impacting groundwater is the same for these remedies.

13.2.4.4 MTCA Evaluation Criteria and Disproportionate Cost Analysis

Alternative 4 received the second lowest cost per unit benefit ratio of the five alternatives (Table 13.2). Although Alternative 4 scored slightly lower than Alternative 5 for the benefit score when ranking the DCA evaluation criteria, the cost of Alternative 5 was disproportionately higher. Alternative 4 scored slightly higher than Alternative 3 for the benefit score when ranking the DCA evaluation criteria, but the cost of Alternative 4 was determined to be disproportionately higher.

Alternative 4 was found to be slightly more protective, permanent, and effective over the long-term than Alternative 3 because the footprint of the contamination left on the LL Apartments Parcel is smaller. Alternative 4 is not as protective, permanent, or effective over the long-term as Alternative 5 because Alternative 5 excavates all accessible soil contamination with dioxin/furan TEQ concentrations exceeding 13 pg/g. Alternative 4 ranked similarly to the other alternatives for implementability, but ranked slightly lower for short-term risk management compared to Alternatives 1, 2, and 3 due to increased soil handling. The degree of residual risk present in Alternatives 3 and 4 is greatly reduced from Alternatives 1 and 2 because the concentrations of remaining dioxins/furans in the LL Apartments Parcel soil would be orders of magnitude less than the current LL Apartments Parcel concentrations.

13.2.5 Alternative 5

Alternative 5 proposes excavation and off-site disposal of contaminated soil at the LL Apartments Parcel. Since Alternative 5 removes all contamination from the LL Apartments Parcel property, it is the most protective of all the alternatives proposed. Alternative 5 includes stormwater source control through storm drain system improvements and/or abandonment and replacement.

13.2.5.1 MTCA Threshold Requirements

- **Protection of Human Health and the Environment:** Alternative 5 provides a high degree of protection to human health and the environment through mass removal and off-site disposal of soil with COCs at concentrations exceeding cleanup levels.
- **Compliance with Cleanup Standards:** Alternative 5 complies with all MTCA Cleanup Standards by removing all accessible contaminated soil. With removal of the source of contaminants to groundwater, groundwater compliance would be anticipated within 2 to 5 years of remedy completion. Following this initial stabilization period, groundwater cleanup standards would be met at the standard point of compliance.

- **Compliance with Applicable State and Federal Laws:** Alternative 5 complies with all applicable state and federal laws that are outlined in Section 9.2 and in Tables 9.1 to 9.3 through contaminant mass removal.
- **Provides for Compliance Monitoring:** Alternative 5 meets the requirements for compliance monitoring by conducting protection monitoring during the remedy implementation and performance monitoring following completion of excavation. No long-term confirmation monitoring is anticipated for soil with this alternative, because compliance with cleanup standards would be confirmed by performance monitoring during implementation. The alternative would provide for short-term groundwater confirmation monitoring to ensure that cleanup levels were achieved. Groundwater monitoring would occur for approximately 2 to 5 years, until groundwater reaches cleanup levels.

13.2.5.2 Remedial Action Objectives

All LL Apartments Parcel RAOs would be achieved with Alternative 5, which proposes excavation of contaminated soil. Alternative 5 protects human receptors from exposure to LL Apartments Parcel COCs that exceed applicable cleanup levels by eliminating the risk of direct contact with contaminated soil, and eliminating the potential future human health risk resulting from consumption of drinking water within the vicinity of the LL Apartments Parcel. The alternative eliminates the potential for contaminated surface or subsurface soil at the LL Apartments Parcel to enter the stormwater conveyance system discharging to Lora Lake through soil mass removal and abandonment/replacement or improvements of the current stormwater conveyance system. The alternative prevents migration of contaminants from the LL Apartments Parcel by erosion, groundwater migration, or stormwater processes by removal of the contaminated soil, including all contaminated soil located below the water table. Implementation of the remedial alternative remediates the LL Apartments Parcel COCs in a method that does not restrict proposed site development and future use plans.

13.2.5.3 Restoration Time Frame

Alternative 5 addresses exposure pathways and complies with all RAOs within a reasonable time frame through implementation of mass removal. Groundwater compliance is anticipated to be achieved within 2 to 5 years of remedy completion, following removal of the source of contaminants to groundwater.

13.2.5.4 MTCA Evaluation Criteria and Disproportionate Cost Analysis

Alternative 5 is the most protective, permanent, and effective alternative over the long-term but received the highest cost per unit benefit ratio of all of the alternatives in the DCA (Table 13.2), due to the substantial added cost of the alternative, relative to the degree of added benefit. Alternative 5 scored high in the categories of overall protectiveness, permanence, and long-term effectiveness, but scored slightly lower than the other alternatives in the short-term risk management category due to the increased soil handling required.

13.3 REMEDIAL ALTERNATIVES EVALUATION SUMMARY

Based on the evaluation presented in Tables 13.1 and 13.2 and in the text above, Alternative 3 is selected as the Preferred Remedial Alternative for recommendation to WSDOE. Section 14.0 describes the Preferred Remedial Alternative in greater detail.

14.0 Recommendation of the Preferred Remedial Alternative for the Lora Lake Apartments Parcel

In this section, the Preferred Remedial Alternative proposed by the Port to WSDOE for selection and implementation at the LL Apartments Parcel is described in greater detail. This section explains how the Preferred Remedial Alternative complies with MTCA, LL Apartments Parcel RAOs, and associated ARARs for the lowest cost per degree of benefit,[18] providing the highest level of environmental benefit and permanence per dollar spent, and making it the most permanent to the maximum extent practicable remedy proposed.

14.1 DESCRIPTION OF THE PREFERRED REMEDIAL ALTERNATIVE

The Preferred Remedial Alternative recommended for selection is Alternative 3. Alternative 3 provides the greatest degree of benefit for the associated cost of all the alternatives discussed in Sections 12.0 and 13.0. The Preferred Remedial Alternative components are presented in Figure 14.1. The Preferred Remedial Alternative is a comprehensive final remedy for the LL Apartments Parcel that is compliant with all the applicable remedy selection requirements under MTCA.

The Preferred Remedial Alternative comprises the following individual technologies: stormwater system improvements, contaminant mass removal, contaminant mass containment, and institutional controls where required to control contamination remaining on the LL Apartments Parcel at concentrations greater than cleanup levels. Together, the individual technologies manage the exposure pathways to all contamination on the LL Apartments Parcel. The Preferred Remedial Alternative contains the following components:

- **Cleanup Areas A and B Excavation and Off-site Disposal:** Excavation and off-site landfill disposal of contaminated soil in Cleanup Areas A and B to a depth ranging from 1 to 20 feet bgs to remove LL Apartments Parcel soil with dioxin/furan TEQ concentrations greater than 100 pg/g. In addition, this excavation removes from the LL Apartments Parcel the full extent of lead, PCP, gasoline range TPH, diesel range TPH, and heavy oil range TPH soil contamination at concentrations greater than cleanup levels. The excavation surface area (approximately 125,000 square feet) and volume (approximately 19,000 cubic yards) has been calculated using investigation sample data. The footprint of excavation will be finalized during design. Approximately 4 percent of the mass of dioxins/furans in soil and 6 percent of cPAH contamination in soil at the LL Apartments Parcel would remain on-site following the excavation in Cleanup Areas A and B.
- **Capping:** Contaminated soil containing dioxin/furan contamination with concentrations between 13 pg/g and 100 pg/g would be capped in place on the LL Apartments Parcel. Capping would be used for Cleanup Area C and the

[18] Of the proposed remedial alternatives that comply with the minimum requirements for a cleanup action, as discussed in Section 13.0.

portions of Cleanup Areas A and B where deeper contamination between 13 pg/g and 100 pg/g would remain on-site following excavation. Additional sampling during design will be conducted as needed to delineate the extent of the cap in the northeast and southeast corners of the LL Apartments Parcel. In combination with institutional controls, the surface cap would manage soil direct contact pathways.

- **LL Apartments Parcel Groundwater:** It is expected that groundwater will achieve compliance within 2 to 5 years after the removal of the source area contaminated soil because the source to groundwater is particulate contribution from contaminated saturated soil. Confirmation monitoring will be conducted to document groundwater compliance with cleanup levels following remedy completion.
- **Institutional Controls:** In areas where contamination would remain contained in place following completion of the remedial action, institutional controls would be developed to manage future exposure pathways. Institutional controls will be implemented to prohibit groundwater withdrawal for a temporary period of time until monitoring shows that groundwater is in compliance with cleanup levels. Institutional controls will be implemented in the areas of the LL Apartments Parcel where capped soil with contaminants at concentrations greater than cleanup levels will remain. In addition, institutional controls may be used to manage direct contact in the public right-of-way adjacent to the LL Apartments Parcel for utility workers performing work along 8th Avenue South or Des Moines Memorial Drive, as determined necessary during design.

  The Port may transfer for commercial or light industrial redevelopment the portion of the LL Apartments Parcel that is outside of the designated FAA Controlled Activity and RPZ-Extended Object Free Areas. This will require maintaining institutional controls and cap maintenance requirements on property no longer owned by the Port.

It is assumed that the Preferred Remedial Alternative will be implemented in conjunction with redevelopment activities at the LL Apartments Parcel. The Preferred Remedial Alternative may also be implemented independent of site redevelopment, if necessary, to achieve a preferred remedy construction schedule. If the Preferred Remedial Alternative is implemented independent of site redevelopment, institutional controls would be implemented to ensure that future development occurs in a manner that maintains the integrity of the remedy and protects worker health and safety during construction, as needed.

14.1.1 Excavation and Off-site Disposal

Based on existing data, the excavation of contaminated soil with dioxin/furan TEQ concentrations greater than 100 pg/g in Cleanup Areas A and B is estimated to cover approximately 125,000 square feet of the LL Apartments Parcel to depths ranging from 1 to 20 feet bgs. Figure 14.1 presents the approximate depths of excavation for the different areas of the parcel that will be excavated. These excavation depths were determined based on all existing soil data. Appendix N provides additional detail on the evaluation of contaminant mass at the LL Apartments Parcel. Based on existing RI data, the highest concentration of dioxins/furans remaining at the LL Apartments Parcel after excavation will be 75 pg/g. Excavated contaminated soil with dioxin/furan TEQ concentrations greater than 100 pg/g will be transported off-site for disposal at a licensed landfill.

14.1.2 Lora Lake Apartments Parcel Capping

Soil at the LL Apartments Parcel with dioxin/furan TEQ concentrations less than approximately 100 pg/g and greater than 13 pg/g would be contained beneath a managed cap. The capping technology applied to the LL Apartments Parcel soil will be selected during the design phase in coordination with site redevelopment planning, and would likely include construction of either an asphalt or concrete cap, or a compacted clean soil or gravel cap to manage soil erosion and direct human contact. Areas of the Site that would not be modified by redevelopment activities where an asphalt or cement cap currently exists may not require recapping as part of remedial actions, and will be determined in design. Remedy implementation would likely be completed with site development plans and would be designed in coordination with institutional controls to prevent disturbance of the underlying soil both during site redevelopment and in the future.

If the Preferred Remedial Alternative is not implemented with site redevelopment, soil capping and institutional controls would be designed in a manner to allow for future site redevelopment while maintaining the function of the cap and controls.

Institutional controls associated with the cap are discussed in detail below, and may include soil handling requirements and use of worker Health and Safety Plans, requirements for utility trench backfilling with clean materials to limit future exposures, and cap maintenance requirements.

In areas of the Site where the extent of contamination is not defined by existing data, additional data may be collected during design. Cap extents would be limited by existing roadway infrastructure along 8th Avenue South and Des Moines Memorial Drive. The remedial cap may be integrated into the existing pavement, but would not remove or replace existing public roadways.

14.1.3 Groundwater

The excavation of Cleanup Areas A and B is expected to remove the contaminant mass contributing to the elevated dioxin/furan concentrations in groundwater. Following removal of this saturated soil source, confirmation groundwater sampling would be conducted until groundwater concentrations are in compliance with cleanup levels. It is anticipated that groundwater will be in compliance with cleanup levels within 2 to 5 years. Until groundwater concentrations are less than cleanup levels, institutional controls would be required to prevent groundwater withdrawal. Groundwater encountered during excavation and removed from the subsurface for excavation dewatering would be collected for off-site disposal. The need and method for excavation dewatering will be determined during the design process.

14.1.4 Stormwater Conveyance System Improvements

The Preferred Remedial Alternative includes improvement or abandonment and replacement of the existing stormwater conveyance system in coordination with redevelopment at the LL Apartments Parcel. Storm drain system improvements or replacement as part of development activities would ensure that contaminated groundwater or soil cannot enter the stormwater conveyance system through cracks and joints. Institutional controls will outline requirements for tight-lining and sealing joints for all upgraded or newly-installed drainage system lines at the LL Apartments Parcel.

Currently, stormwater runoff from the City of Burien enters the site stormwater conveyance system on the western side of the LL Apartments Parcel and carries stormwater with detectable concentrations of dioxins/furans and other contaminants across the Site before discharging to Lora Lake. System improvements proposed as part of this remedial action would not address contaminants carried by the upgradient stormwater, but will eliminate any future contribution of contamination from the LL Apartments Parcel. As a result, recontamination of the Lora Lake sediments may occur over time, but would not be associated with historical operations at the Site.

14.2 1982 DREDGED MATERIAL CONTAINMENT AREA LAND USE IMPROVEMENTS

Future land use of the DMCA will be an airport-compatible use such as construction laydown. The Port will retain ownership of the DMCA in perpetuity, as it lies within restricted airport security areas (the RPZ-Extended Object Free Area). Access to the DMCA will continue to be restricted to prohibit public access. Preparation of the approximately 3-acre DMCA area for construction laydown includes clearing and grubbing of existing vegetation to prepare the area for surface improvements. Vegetation clearing in this area would be required, and is not regulated by the NRMP. A wetland mitigation area is located to the east of the DMCA, and a 50-foot buffer around the wetland is required to be maintained and undisturbed by City of SeaTac permitting requirements. Planned construction of the engineered surface to improve the area for Port uses will provide a barrier to terrestrial growth and ecological exposure, as well as to worker direct contact.

DMCA area improvements will be completed prior to, or in coordination with cleanup of the LL Apartments Parcel. Costs for improvements to the DMCA are not included in the cost estimates for this alternative, as these actions are being conducted by the Port for land use improvements and are not associated with a remedial action in that area.

14.3 COMPLIANCE MONITORING REQUIREMENTS

Compliance monitoring requirements associated with remedy implementation consist of protection monitoring during construction activities, performance monitoring to ensure remedy construction in accordance with the project plans and design, and confirmation monitoring following remedy completion to confirm the long-term effectiveness of the remedy.

14.3.1 Protection Monitoring

Protection monitoring during remedy construction will be conducted to confirm protection of human health and the environment during the construction and operation and maintenance activities required at the Site. Protection monitoring requirements will be described in worker Health and Safety Plans covering the worker activities both during construction, and during any future operations and maintenance of the constructed remedy, such as cap monitoring and maintenance activities. Any activities conducted at the LL Apartments Parcel following remedy implementation that disturb capped areas of the LL Apartments Parcel will require development of a Health and Safety Plan that would also describe worker protection monitoring requirements.

14.3.2 Performance Monitoring

Performance monitoring activities will be conducted during remedy construction, and will include the following:

- Analytical testing to confirm excavation extent or cap extent as determined necessary during the design process.
- Quality control monitoring for construction activities, such as survey confirmation of excavation extent, or quality control testing of storm drain system tight-lining.
- Any additional sampling or testing as may be required for substantive compliance with ARARs.

14.3.3 Confirmation Monitoring

Following remedy completion, groundwater monitoring would be required to verify that groundwater concentrations are in compliance with cleanup standards. Groundwater monitoring will be conducted until groundwater is in compliance with cleanup standards. It is anticipated that compliance will be reached within 2 to 5 years following completion of the remedial action.

Long-term monitoring of groundwater and the soil cap may be required to verify that the constructed remedy remains effective. This is likely to be conducted through periodic reviews of the LL Apartments Parcel overseen by WSDOE.

14.4 COMPLIANCE WITH THE MODEL TOXICS CONTROL ACT

The Preferred Remedial Alternative meets the following minimum requirements for selection of a cleanup action under MTCA WAC 173-340-360(2)(a) because it is protective of human health and the environment, complies with cleanup standards, complies with applicable state and federal laws, and provides for compliance monitoring.

The Preferred Remedial Alternative is more protective of human health and the environment than Alternatives 1 and 2 because there is a significant reduction in contaminant mass through removal of contaminated soil for off-site disposal, as all soil with dioxin/furan TEQ concentrations in excess of 100 pg/g is removed for landfill disposal. The Preferred Remedial Alternative would remove approximately 96 percent of the dioxin/furan contaminant mass for off-site disposal, would achieve complete removal of lead, PCP, and TPH contamination, and remove approximately 94 percent of the LL Apartments Parcel cPAH contaminant mass.

Capping of contaminants remaining on-site provides reduction in contaminant mobility and manages contact in conjunction with institutional controls. The Preferred Remedial Alternative is slightly less protective, permanent, and effective over the long-term compared to Alternatives 4 and 5, because contaminant mass would remain on-site in areas that may not be owned by the Port in the future. These areas will require maintenance of a cap and institutional controls in perpetuity. The Preferred Remedial Alternative and Alternative 4 remove the same quantity of contaminant mass for off-site disposal, but the Preferred Remedial Alternative relies on containment and institutional controls for management of exposure pathways to a greater extent than Alternative 4. The Preferred Remedial Alternative would protect human health and the environment in both the short-term and long-term by immediately removing the source of suspended and dissolved solids contamination to groundwater through source removal and containment and management of remaining soil to prevent human contact. Risks to site workers during construction would be mitigated through best management practices (BMPs) and the use of appropriate personal protective equipment. The Preferred Remedial Alternative is more protective than Alternatives 1 and 2 because there is more mass removal and significantly reduced contaminant concentrations in areas subject to institutional controls for management of exposure pathways.

The Preferred Remedial Alternative also meets the Other MTCA Requirements for selection under MTCA WAC 173-340-360(2)(b), such as using permanent solutions to the maximum extent practicable, providing for a reasonable restoration time frame, and consideration of public concerns. The Preferred Remedial Alternative utilizes permanent solutions to the maximum extent practicable, based on a balance between permanence and cost as determined by the DCA. Complete permanence could be obtained only through excavation of all contaminated LL Apartments Parcel soil. On the LL Apartments Parcel, the majority of contaminant mass would be excavated (96 percent) and the remaining mass that would be capped has substantially lower concentrations than the soil removed from the excavation. This soil will be managed with institutional controls and is subject to deed restrictions.

The Draft RI/FS document was provided to the public through a public comment process in coordination with WSDOE. WSDOE prepared a responsiveness summary (WSDOE 2015) that documents how each of the public comments received during the public comment period was considered during final selection of the preferred alternative described in the CAP.

14.5 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The Preferred Remedial Alternative complies with all applicable ARARs outlined in Tables 9.1, 9.2, and 9.3. Chemical-specific ARARs are met through compliance with applicable cleanup level criteria. Location-specific ARARs are met through compliance with all applicable state, federal, local, and STIA regulations in place for the physical location of the Site. Applicable action-specific ARARs would be met through implementation of construction activities in compliance with all applicable construction related requirements such as health and safety restrictions, site use and other local permits, and disposal requirements for excavated soil.

14.6 COMPLIANCE WITH REMEDIAL ACTION OBJECTIVES

The Preferred Remedial Alternative achieves the LL Apartments Parcel RAOs through the following actions:

- The Preferred Remedial Alternative removes all unacceptable human health risk resulting from direct contact with contaminated soil and groundwater. Approximately 96 percent of the contaminant mass is excavated and transported off-site for landfill disposal. Some contamination would remain on the LL Apartments Parcel at concentrations greater than cleanup levels, but would be contained with a surface cap and institutional controls to manage routes of exposure.. Groundwater is remediated to meet potable cleanup standards.
- The Preferred Remedial Alternative eliminates the possibility for LL Apartments Parcel soil to enter the stormwater system and migrate to Lora Lake by removing approximately 96 percent of the contaminant mass from the LL Apartments Parcel, and additionally improving or abandoning and replacing the existing stormwater conveyance system.
- The Preferred Remedial Alternative prevents contaminant migration at the LL Apartments Parcel through excavation and off-site disposal, removing the source to groundwater, implementing stormwater system improvements and capping areas of low-level contamination.
- The Preferred Remedial Alternative remediates contaminants in a method that minimizes restrictions on future site redevelopment activities at the LL Apartments Parcel.

14.7 SITE OWNERSHIP AND ACCESS

The LL Apartments Parcel is currently owned by the Port. The cities of Burien and SeaTac each own portions of the Des Moines Memorial Drive Right-of-Way to the east of the LL Apartments Parcel. WSDOT owns the SR 518 right-of-way immediately north of the LL Apartments Parcel. Proposed remedial actions would take place, for the most part, on Port-owned property; however, depending on the excavation extent determined in design, areas of the City of Burien, City of SeaTac, and potentially the WSDOT right-of-ways may require excavation, or maintenance/replacement of existing pavement to effectively cap soil. Implementation of institutional controls to manage contaminated soil remaining in-place beneath existing roadways will also likely be required. The necessity for construction access to these areas not owned by the Port will be determined during the design process.

The DMCA and northeast corner of the LL Apartments Parcel are expected to remain Port property for the foreseeable future because of their location within the STIA security zones association with the 3rd Runway. The LL Apartments Parcel is currently owned by the Port, but the Port may transfer the portion of the parcel located outside of the designated FAA Controlled Activity and RPZ-Extended Object Free Areas to facilitate commercial or light industrial redevelopment.

14.8 INSTITUTIONAL CONTROLS

The Preferred Remedial Alternative includes select institutional controls to manage future exposure pathways and ensure the longevity of the proposed remedial action.

Institutional controls for the LL Apartments Parcel may include the following:

- **Temporary Restrictions on Groundwater Potability.** Until groundwater concentrations reach potable cleanup levels, institutional controls would be required to prevent withdrawal. It is anticipated that groundwater will reach cleanup levels within 2 to 5 years. No groundwater withdrawals are currently conducted. The site area is served by the Highline Water District public drinking water supply system.
- **Requirements for Cap Disturbance and Worker Safety.** Controls limiting and/or managing disturbance of the constructed soil cap would be implemented to manage cap disturbance, ensure proper reconstruction of disturbed cap areas, and manage worker safety during cap-disturbing activities. This control may also be extended to the public right-of-ways adjacent to the LL Apartments Parcel as determined necessary in design. Controls would apply to activities such as disturbance of the subsurface at the LL Apartments Parcel for utilities construction and maintenance. Portions of the soil cap will be located on areas of the LL Parcel transferred by the Port for light industrial uses. Ongoing coordination with site tenants for access to the parcel to conduct cap monitoring and maintenance, restrictions on site development, and any other potential cap disturbing activities will be required in perpetuity.
- **Storm Drain System and Other Utility Requirements.** Because the Preferred Remedial Alternative includes containment of contaminated soil at concentrations greater than cleanup levels, institutional controls managing the abandonment, maintenance and future modification of drainage features at the Site would be required to ensure that stormwater systems are maintained to restrict inflow of contaminants. Requirements could include periodic inspection and storm drain construction minimum requirements applicable to future repair or reconstruction.

14.9 SUMMARY OF THE ESTIMATED REMEDY COSTS

Estimated remedial costs for the recommended Preferred Remedial Alternative are presented in Appendix O. The costs associated with remedy implementation consist of capital construction costs, groundwater confirmation monitoring following remedy completion, and agency oversight that would include periodic reviews of the constructed remedy. The estimated costs for remedy construction are as follows:

- Agency oversight, planning, and permitting costs associated with remedy implementation are estimated to be $613,000.
- Construction capital costs that include excavation, capping, and storm drain improvements for the LL Apartments Parcel are estimated to be approximately $4.9 million.
- Long-term soil cap monitoring and groundwater monitoring costs for the LL Apartments Parcel are estimated to be $314,000.

The total project cost for the Preferred Remedial Alternative, which includes a $1.3 million contingency cost, is estimated to be $7,100,000.

Part Four—Lora Lake Parcel Feasibility Study

15.0 Feasibility Study Introduction

Part Four of this document presents the FS for the LL Parcel, a parcel of land east of Des Moines Memorial Drive that encompasses Lora Lake and the embankment area between the lake and the roadway. The LL Parcel includes regulated wetland and habitat areas with attendant wildlife hazard management requirements; therefore, remedial actions at the LL Parcel require coordination, input, and permitting from multiple resource agencies[19] and the FAA. The LL Parcel and adjacent areas are also part of the Miller Creek/Lora Lake/Vacca Farm Wetland and Flood Plain Zone mitigation area. Mitigation associated with this area is a requirement of the WSDOE Order #1996-4-0235 (Amendment 2) and the USACE Section 404 permit #1996-4-0235 for the STIA Master Plan Update (MPU) improvements that included construction of the STIA's 3rd Runway (16R/34R). The mitigation plan, including site-specific objectives, functions, and implementation requirements are described in the NRMP (Parametrix 2001). The NRMP supports certain specific ecological functions and is managed within the context of the Port's WHMP (Port of Seattle 2005a), which is the controlling authority for this special use industrial landscape area.

This FS has been developed in accordance with MTCA WAC 173-340-350(8) (WSDOE 2007). The FS develops and evaluates remedial action alternatives for the LL Parcel, and then presents a Proposed Preferred Remedial Alternative to WSDOE for consideration. The FS tasks include the following:

- Determine remedial action goals and objectives for the LL Parcel.
- Evaluate ARARs (i.e., applicable local, state, and federal laws).
- Define Cleanup Areas based on contamination extents.
- Compile, evaluate, and screen potentially applicable remedial technologies.
- Aggregate and evaluate proposed remedial alternatives that meet the requirements outlined by MTCA.
- Compare remedial alternatives to the MTCA requirements for a cleanup action per WAC 173-340-350(8).
- Complete a DCA procedure consistent with WAC 173-340-360(3)(e) to identify the alternative that is permanent to the maximum extent practicable.
- Propose the Preferred Remedial Alternative for the LL Parcel to WSDOE for consideration in development of the CAP for the Site.

[19] The term "resource agencies," as used throughout this document, refers to the permitting and other responsible regulatory agencies. These agencies are WSDOE, USACE, and the Washington State Department of Fish and Wildlife .

15.1 DEFINITION OF REMEDIAL ACTION OBJECTIVES

RAOs are determined to specifically identify goals that should be accomplished to ensure compliance with ARARs. The following RAOs are defined for the LL Parcel:

- Protect human receptors from exposure to LL Parcel contamination that exceeds applicable cleanup levels.
    - Remove unacceptable human health risk resulting from direct contact with contaminated soil.
    - Remove that portion of human health risk from consumption of fish in Miller Creek that may be associated with fish exposure to contaminants in Lora Lake surface sediments.
    - Remove that portion of human health risk from consumption of water in Miller Creek that may be associated with Lora Lake sediment COC concentrations leaching to surface water.
- Prevent migration of contaminants from the site surface soils by erosion.
- Protect wildlife ecological exposure to soil contamination that exceeds applicable cleanup levels.
- Remediate contaminants in a manner that is consistent with the required wetland mitigation functions in compliance with the WHMP and the NRMP.
    - Implement a remedial alternative that is consistent with the FAA RPZ-Extended Object Free Area and FAA RPZ-Controlled Activity Area requirements and use restrictions.
    - Implement a remedial alternative that maximizes ecological benefits to natural systems associated with the Miller Creek basin and minimizes the destruction, loss, or degradation of existing wetlands.
    - Implement a remedial alternative that is consistent with the STIA MPU critical requirements for Lora Lake, as identified in the WHMP and NRMP, such as an alternative that avoids creating new avian wildlife hazards and reduces existing avian wildlife hazards (Port of Seattle 2005a, Parametrix 2001).

Each remedial alternative proposed in this FS will be evaluated for its ability to accomplish the RAOs listed above.

15.2 APPLICABLE LOCAL, STATE, AND FEDERAL LAWS

The selected cleanup alternative must comply with MTCA cleanup regulations (WAC 173-340) and with applicable local, state, and federal laws. Together, these regulations and laws are identified as ARARs for the LL Parcel. Under WAC 173-340-350 and WAC 173-340-710, the term “applicable requirements” refers to regulatory cleanup standards, standards of control, and other environmental requirements, criteria, or limitations established under state or federal law that specifically address a remedial action, location, COC, or other circumstance at the Site. The “relevant and appropriate” requirements are regulatory requirements or guidance that do not apply to the Site under law, but have been determined to be appropriate for use by WSDOE. ARARs are often categorized as location-specific, action-specific, or chemical-specific.

Remedial actions conducted under a consent decree with WSDOE are exempt from procedural requirements required by some state ARARs and by local ARARs, such as permitting and approval requirements; however, remedial actions must demonstrate compliance with the substantive requirements of those ARARs (WAC 173-340-710(9)). This exemption applies to procedural permitting requirements under the Washington State Water Pollution Control Act, the Solid Waste Management Act, the Shoreline Management Act, and local laws requiring permitting such as City of SeaTac regulations. Remedial actions are not exempt from procedural requirements of Federal ARARs.

15.2.1 Location-specific ARARs

Location-specific ARARs are those requirements that restrict the allowable concentration of hazardous substances or the performance of activities, including remedial actions, solely because they occur in specific locations. Of particular importance are the following:

- The FAA requirements applicable to the Site due to its proximity to the STIA; (the FAA RPZ-Controlled Activity Area and RPZ-Extended Object Free Area restrictions). The requirements and restrictions apply as location-specific ARARs for areas of the LL Parcel located within the FAA RPZs (Port of Seattle 2005a).
- Land use restrictions and mitigation project critical requirements required by the WSDOE Order and USACE 404 Permit and described in the Port's WHMP and NRMP.

Table 15.1 outlines all the location-specific ARARs that were considered and identifies those applicable to the LL Parcel cleanup.

15.2.2 Action-specific ARARs

Action-specific ARARs are requirements that define acceptable management practices and are often specific to certain kinds of activities that occur or technologies that are used during the implementation of cleanup actions. Action-specific ARARs may include local grading permits, applicable waste disposal regulations and requirements, and Health and Safety requirements. Table 15.2 identifies all action-specific ARARs considered for applicability to the LL Parcel cleanup.

15.2.3 Chemical-specific ARARs

The remediation of contaminated LL Parcel media must meet the cleanup levels developed under MTCA and SMS. These potential cleanup levels are considered chemical-specific ARARs. The most stringent applicable requirements for cleanup of chemical concentrations on the LL Parcel were selected as the applicable cleanup levels. Table 15.3 identifies chemical-specific ARARs considered for applicability to the LL Parcel.

16.0 Lora Lake Parcel Cleanup Areas

This section identifies Cleanup Areas for the LL Parcel. The application of technologies to the LL Parcel is based primarily on the nature and extent of the contamination and on the physical location and institutional considerations. The LL Parcel includes both soil and sediment contaminated zones that would require different remedies, and Cleanup Areas have been identified for these zones. The following sections describe the main factors that influence remedy application, and then discuss how the LL Parcel is divided into Cleanup Areas for cleanup based on these factors.

16.1 NATURE AND EXTENT OF CONTAMINANTS OF CONCERN

The following areas of contamination at the Site were identified in the RI based on the types of contamination present, the media that have been impacted, and the extent of impact:

- Shallow Soil
  - Surface and shallow subsurface soil is contaminated with dioxins/furans in areas of the LL Parcel.
- Lora Lake—Surface Sediment
  - Biological toxicity testing of lake sediments indicates that surface sediments are unlikely to cause adverse impacts to ecological receptors due to elevated chemical concentrations.
  - Surface sediments in Lora Lake are contaminated with arsenic, lead, and dioxins/furans.
  - Arsenic, lead, and dioxins/furans bioaccumulate in the food chain and can pose a human health risk through consumption of fish.

16.2 LAND USE CONSIDERATIONS

Current and future land use plans can impact the feasibility of remedial technologies and must be considered when determining Cleanup Areas. The LL Parcel is currently located within the FAA STIA RPZ and is part of the mitigation area required by the expansion of the STIA.

The following bulleted statements summarize the land uses that were considered as part of this FS:

- The FAA has established Runway Protection and Approach Transition Zones for the STIA. The LL Parcel is located within the FAA RPZ-Controlled Activity Area and the FAA RPZ-Extended Object Free Area, which require that the area be kept clear of objects including structures, equipment, and terrain, except for those objects necessary for air navigation or aircraft ground-maneuvering purposes. FAA restrictions prohibit any future development that is inconsistent with the area requirements as long as the STIA is an operating airport.

- The LL Parcel is commercially zoned by the City of SeaTac as a mix of "Aviation Operations" and "Aviation Commercial."
- Due to its close proximity to the airport, ecological activities at the LL Parcel have the potential to create wildlife hazards to air operations and are therefore managed under the Port's WHMP. This plan maintains careful control over birds, mammals and plants within the area, to minimize aircraft navigation dangers associated with bird strikes and wildlife in the runway area (Port of Seattle 2005a).
- The LL Parcel and adjacent areas are also part of the Miller Creek/Lora Lake/Vacca Farm Wetland and Flood Plain Zone Mitigation Area required by the NRMP for expansion of the STIA and construction of the 3rd Runway (Parametrix 2001). The NRMP supports certain specific ecological functions and is managed within the context of the WHMP.
    - A critical requirement of the mitigation area is to restore wetland and stream buffer functions in a manner that avoids creating new avian wildlife hazards and reduces existing avian wildlife hazards.
- The WSDOE Order and USACE 404 Permit for the MPU improvements required that restrictive covenants be recorded as deeds associated with the LL Parcel and associated mitigation areas. These restrictive covenants require that the land be used only as a natural wetland area in perpetuity and prohibit any future development. Activities permitted by the restrictive covenants include those related to wetland monitoring, wildlife management, and utility management, and exclude public access to the Vacca Farm Restoration and Miller Creek Buffer Enhancement mitigation areas, which include the Lora Lake and Miller Creek freshwater environments.
- Mitigation sites at STIA are designed and must be maintained to replace and enhance the ecological functions provided by streams and wetlands impacted by the MPU projects at STIA. Creating the Vacca Farm Restoration and Miller Creek Buffer Enhancement mitigation areas (which include the LL Parcel), replaced riparian functions, replaced floodplain functions, improved water quality functions, reduced the habitat value of the area to waterfowl and flocking birds, and enhanced the wetlands and upland buffers.
- Lora Lake is described in the Port's USACE 404 Permit as a palustrine, open water system with some aquatic bed components (Appendix C—Functional Assessment, USACE 2002). Current water quality, hydrologic, and habitat suitability functions for aquatic resources (including Lora Lake, Lake Reba, and associated wetlands) associated with the 3rd Runway and MPU Improvements are described in the permit. In response to discussions with the permitting and other responsible regulatory agencies regarding the set of remedial actions that could be implemented at Lora Lake, the Port qualitatively evaluated the potential effects that the remedial actions could have on the various mitigation-required functions. The Port received feedback on remedial actions that would

reestablish or rehabilitate[20] wetland function versus remedial actions that would, themselves, trigger additional mitigation requirements. The potential effect or influence that cleanup alternatives may have on the functions, ecology, and biology of Lora Lake and Miller Creek Relocation Reach in this special use landscape is a land use consideration.

- As part of the Port's mitigation for MPU improvement impacts, a portion of Miller Creek was relocated. The relocated section of Miller Creek was designed to provide a salmonid spawning habitat; however, the relocation resulted in areas of standing water, and limited flow velocity. The Port implemented corrective actions to limit areas of standing water and improve stream flow. In addition to standing water and limited flow, assessments of the original relocation reach identified stream temperatures greater than and dissolved oxygen levels less than the water quality standards. These deficiencies during the summer months were partially attributed to upstream influences, including discharges from Lora Lake. To further improve water quality in Miller Creek, the resource agencies have recommended that surface flows from Lora Lake entering Miller Creek be prevented during late spring, summer, and early fall. Agency considerations regarding ecological benefit and addressing the temperature and dissolved oxygen issues in the Miller Creek Relocation Reach is a land use consideration for the selection of a remedial alternative.

As described above, discharges from Lora Lake were found to be contributing to the elevated temperatures and low dissolved oxygen in Miller Creek, and therefore the resource agencies have indicated that implementation of a remedial action to Lora Lake may also need to address the effects of lake discharges on Miller Creek water quality.

16.3 CLEANUP AREA IDENTIFICATION

The LL Parcel has been divided into two Cleanup Areas for application of remedial technologies (Figure 16.1). In the LL Parcel FS evaluation of alternatives, technologies will be selected for each Cleanup Area, then alternatives will be developed and evaluated for their ability to comply with the MTCA Threshold Requirements and Other MTCA Requirements for a remedial action (WAC 173-340-360(2)), discussed in Section 19.0. The characteristics of each Cleanup Area are described in the following sections.

16.3.1 LL Parcel Shallow Soil Cleanup Area

Surface and shallow subsurface soil at the LL Parcel are contaminated with dioxins/furans at concentrations greater than the natural background based cleanup level of 5.2 pg/g. The soil exposure pathway of concern at the LL Parcel is primarily limited to current and future direct contact by Port workers and wildlife ecological exposure. A small portion of the LL Parcel is also potentially accessible by the public. Soil contamination exists in two defined areas of the LL Parcel at depths ranging from 0 to 4 feet bgs. Together, these two

[20] Rehabilitation is the manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural or historic functions (and processes) of a degraded wetland. Rehabilitation results in a gain in wetland function but does not result in a gain in wetland acres. This is distinguished from re-establishment, which results in rebuilding a former wetland and results in a gain in wetland acres and functions (WSDOE et al. 2006).

areas of shallow soil contamination are designated as a single cleanup area with unique land use considerations resulting from the current and future uses of the LL Parcel as a wetland aquatic habitat mitigation area (Figure 16.1). FAA requirements and associated hazard control and mitigation plans are in place at the LL Parcel that control site uses and outline requirements for active management of terrestrial and ecological species. Some of the requirements in place for the Cleanup Area include management of plant coverage and diversity to support the targeted ecological functions of this special purpose wetland landscape, and active management of both mammalian and avian species for airplane landing and takeoff (bird strike) safety (Parametrix 2001).

The area of potential soil contamination at the LL Parcel encompasses the area from the eastern paved edge of Des Moines Memorial Drive to the drainage channel (Figure 2.16). This distance is approximately 85 feet wide, including the paved sidewalk that runs between Des Moines Memorial Drive and the LL Parcel security fencing. The eastern limits of these areas have not been defined by analytical data; however, information for the construction of the wetland aquatic habitat mitigation area assists in determination of the eastern Cleanup Area extent. The topography of the LL Parcel grades steeply downslope, towards Lora Lake, beginning at the drainage channel identified on Figure 2.16. The break in the slope where topography changes steeply toward the lake generally marks the edge of the constructed wetland mitigation area. Additional data collection will be conducted prior to design to define the northern and eastern extents of the LL Parcel Shallow Soil Cleanup Area. For the purposes of the FS, the western Cleanup Area boundary conservatively extends across the sidewalk to the edge of pavement of Des Moines Memorial Drive, and extends approximately 160 feet north of Sample Location LL-SB06 along the pavement of Des Moines Memorial Drive. The soil located outside the security fence and underneath the sidewalk in this area would be addressed by the proposed remedial alternative. The eastern edge of the Cleanup Area extends conservatively to the edge of the area excavated during mitigation area construction, which is identifiable as the drainage channel in Figure 2.16.

Although the cleanup level for the LL Parcel Shallow Soil Cleanup Area is 5.2 pg/g, if excavation or capping is implemented at the Site, the extent of the excavation or capping within the LL Parcel fencing may be based on accessibility and a remediation level based on a net environmental benefit determination (WAC 173-340-370(8)). Remediation levels “define the concentration (or other method of identification) of a hazardous substance in a particular medium above or below which a particular cleanup action component will be used” (WAC 173-340-355(2)). Furthermore, “other methods of identification [of the hazardous substance] include physical appearance or location” (WAC 173-340-355(4); WSDOE 2007). The use of remediation levels would be determined during design and is discussed below for each alternative, when proposed.

The LL Parcel Shallow Soil Cleanup Area is shown in Figure 16.1 and is approximately 0.7 acres.

16.3.2 LL Parcel Sediment Cleanup Area

Lora Lake surface sediment bioassay tests demonstrate that the sediments in their current condition are not toxic to benthic organisms due to elevated chemical concentrations. The Lora Lake surface sediments contain elevated levels of dioxins/furans; however, dioxins/furans have not been shown to be sufficiently toxic to aquatic organisms to require a quantitative estimate of toxicity. As a result, dioxin/furan sediment standards for the protection of aquatic life have not been promulgated. The detected concentrations of arsenic and lead in Lora Lake surface sediments are greater than benthic SCO chemical criteria, but less than CSL criteria. Per the SMS, the results of biological toxicity testing are definitive for establishing site-specific sediment cleanup requirements for protection of benthic organisms, regardless of measured chemical concentrations. Biological toxicity testing demonstrates that the Lora Lake surface sediments are unlikely to cause adverse impacts to ecological receptors due to elevated chemical concentrations.

Lora Lake surface sediments contain elevated levels of arsenic, lead, and dioxins/furans relative to the human health risk-based SCO and CSL criteria. While human access to the lake is restricted, a potential human health exposure pathway does exist at Miller Creek, via downstream recreational consumption of aquatic organisms (i.e., fish) that spend some period of time in Lora Lake. Such organisms could bioaccumulate site COCs via surface water and sediment exposure before returning to Miller Creek. Public access to fishing in Miller Creek exists approximately 1.3 miles downstream from Lora Lake, at the point that Miller Creek exits the secured fence line of STIA.

Based on the potential for human health exposures through downstream fish consumption due to elevated concentrations of arsenic, lead, and dioxins/furans in Lora Lake surface sediment, the Port has determined that remedial action is appropriate in Lora Lake to address sediment contamination within the lake.

The LL Parcel Sediment Cleanup Area encompasses surface sediments within the lake and extending to the lake shoreline. Dioxins/furans are present at TEQ concentrations ranging from 7.55 pg/g to 217 pg/g in surface sediments. Because all Lora Lake surface sediment samples exceed human health SCO and CSL criteria for arsenic, lead, and/or dioxins/furans, all Lora Lake surface sediments are encompassed by the LL Parcel Sediment Cleanup Area. An evaluation of sediment contaminant migration is presented in Appendix P.

The LL Parcel Sediment Cleanup Area consists vertically of the top 15 cm of surface sediment, because this is the vertical point of compliance and estimated biologically active zone where potential fish exposure occurs. The lake surface is approximately 3 acres.

16.4 LOCATION OF CONTAMINANT MASS IN CLEANUP AREAS

As presented in the RI, Appendix N presents a calculation of contaminant mass in the Site (LL Apartments and LL Parcels) soil that exceeds the cleanup level, as required by the AO. A calculation of mass present in sediment was not conducted. The mass of chemical contaminants in site soil was determined by estimating the volume of soil with contaminant concentrations greater than the applicable cleanup levels, then calculating the chemical mass given the average soil concentrations in that area. The calculations indicate that approximately 0.00004 kg (0.0014 ounces) of dioxin/furan chemical mass[21] has contaminated approximately 1,400 cubic yards of soil at the LL Parcel. All of this soil mass is located within the LL Parcel Shallow Soil Cleanup Area.

Because the 1,400 cubic yards of contaminated soil is located at varying depths across the cleanup area, removal of all contaminated soil, including areas where contaminated material is located beneath clean soil, would require excavation of approximately 3,700 cubic yards of soil.

The results of analytical testing for PCP and cPAHs indicate that there is no PCP or cPAH mass in the LL Parcel Shallow Soil Cleanup Area that exceeds the applicable cleanup levels.

[21] Mass was calculated by using dioxin/furan TEQs, which represent a sum normalized to the toxicity of 2,3,7,8-TCDD and, therefore, represent the mass TEQs of 2,3,7,8-TCDD. Thus, while the contaminant mass of each individual dioxin/furan congener was not evaluated, the mass presented in this calculation represents the effective toxic mass of dioxins/furans. A similar approach was taken for the cPAH mass calculations.

17.0 Lora Lake Parcel Identification of Remedial Technologies

This section identifies and briefly describes the most commonly implemented remedial technologies for remediation of the COCs present in soil and sediment at the LL Parcel, and the application and limitations of each technology. The COCs at the LL Parcel were selected to be the same as the LL Apartments Parcel COCs (arsenic, lead, TPH, PCP, cPAH, ethylbenzene, toluene, and dioxins/furans) because the LL Apartments Parcel is one of the potential sources of contamination to the LL Parcel. Not all of the site COCs, however, were detected on the LL Parcel, and dioxins/furans were the only COC in soil on the LL Parcel that exceeded a cleanup level. In Lora Lake surface sediments, only arsenic, lead, and dioxins/furans concentrations exceeded cleanup levels. Only remedial technologies that address both the dioxins/furans contamination and other COCs were selected for consideration.

Section 18.0 describes the preliminary technology screening performed to eliminate technologies that do not meet the RAOs applicable to the LL Parcel, are not technically feasible, and/or do not address the types of contamination present.

17.1 IDENTIFICATION AND DESCRIPTION OF SOIL TECHNOLOGIES

The following technologies are commonly used to address dioxins/furans in soil. .

17.1.1 No Action

No action indicates that no active remedial technology would be implemented. No action provides a reference for comparison of the benefits of other remedial technologies.

17.1.2 Institutional Controls

Institutional controls are physical, legal, and administrative measures that are implemented to minimize or prevent human exposure to contamination by restricting access to the Site. Institutional controls often involve deed restrictions or covenants, site advisories, use restrictions, or consent decrees, and would be implemented at the Site to limit or prohibit activities that may interfere with the integrity of any cleanup action or result in exposures to hazardous substances at the Site. Institutional controls are typically implemented in addition to other technologies when those technologies leave COCs on-site at concentrations greater than cleanup levels.

The institutional controls technology is applicable to the LL Parcel soil COC.

17.1.3 Surface Soil Capping

Surface soil capping is an example of a containment remedy that places a cap over contaminated soil to control surface water infiltration, erosion, and wind migration of soil. Surface soil capping provides a physical barrier, preventing human health exposures via direct contact. Surface caps can be constructed as:

- a hard cap such as asphalt, concrete, or gravel designed to meet permeability requirements and prevent human health and ecological exposures,
- a clean fill cap of variable thickness to prevent human health exposures, or
- an engineered cap designed to achieve permeability requirements, prevent human health exposures, and control water runoff.

Surface soil capping requires maintenance to maintain the integrity of the cap in perpetuity and is often implemented with institutional controls.

The surface soil capping technology is applicable to the LL Parcel soil COC.

17.1.4 Solidification and Stabilization

Solidification or stabilization of soil that contains COCs at concentrations greater than cleanup levels physically and chemically immobilizes the contaminants within the soil matrix, thereby reducing or eliminating contaminant mobility. With solidification, the contaminants are either enclosed or bound within the soil matrix via a binding agent such as modified sulfur cement, polyethylene extrusion, or emulsified asphalt. Stabilization involves adding and mixing a chemical compound with the contaminated soil to make the COC immobile through a chemical reaction that forms a new compound that is less toxic than the parent COC or through adsorption processes. Both of these technologies would be combined with leachability testing and/or long-term groundwater compliance monitoring to ensure that the contaminants are immobile and do not leach to groundwater.

The solidification and stabilization technologies are applicable to dioxins/furans contamination.

17.1.4.1 In-situ Vitrification

In-situ vitrification is a solidification and stabilization technology that applies high temperatures via electrical current to soil and any other underlying material to immobilize inorganic contaminants and destroy organic contaminants. The inorganic contaminants are incorporated into a vitrified glass/vitreous mass and the organic contaminants are destroyed by pyrolosis (i.e., incineration that chemically decomposes organics by heat in the absence of oxygen). The resulting vitreous mass is chemically durable and leach resistant. The technology is effective to a depth of approximately 20 feet bgs, but requires very high electricity loads. Vaporization of volatile contaminants via in-situ vitrification also requires capture and treatment of the VOCs.

In-situ vitrification is applicable to the LL Parcel soil COC.

17.1.5 Excavation and Landfill Disposal

Excavation of soil contamination using standard construction equipment is a common method to achieve remediation goals. For off-site disposal, excavated contaminated soil is transported either by truck or rail to an appropriate licensed landfill. Following soil removal, excavated areas are backfilled, compacted, and restored. Excavation may require relocation of structures, shoring to maintain sidewall stability, and may require dewatering, or drawdown of the groundwater table if excavation is to occur below the groundwater table.

Excavation is applicable to the LL Parcel soil COC.

17.2 IDENTIFICATION AND DESCRIPTION OF SEDIMENT TECHNOLOGIES

The following technologies are commonly used to address the LL Parcel COCs present in sediment greater than cleanup levels, which consist of arsenic, lead, and dioxins/furans.

17.2.1 No Action

No action indicates that no active remedial measure would be implemented, and no long-term monitoring would be performed. No action provides a reference for comparison of the benefits of other remedial technologies.

17.2.2 Institutional Controls

Institutional controls are physical, legal, and administrative measures that are typically implemented to minimize or prevent human exposure to contamination by restricting access to the Site. Institutional controls often involve deed restrictions or covenants, site advisories, use restrictions, or consent decrees and would be implemented at the Site to limit or prohibit activities that may interfere with the integrity of any cleanup action, physical control, and/or monitoring system that exists on the Site as part of the cleanup. Institutional controls are also established to prohibit actions of individuals that could potentially result in exposure to hazardous substances at the Site. Institutional controls are typically implemented in addition to another technology when that technology leaves COCs on-site at concentrations greater than cleanup levels.

The institutional controls technology is applicable to all site sediment COCs with concentrations greater than cleanup levels.

17.2.3 Natural Recovery

Natural recovery remedial technologies rely on natural chemical, physical, and biological processes to reduce contaminant concentrations in sediments over time. These technologies typically involve surface sediment chemical monitoring over a period of time to confirm that contamination concentrations are declining and that the desired cleanup level has been or would be ultimately achieved with an appropriate restoration time frame. The two types of natural recovery processes considered for the Site are monitored natural recovery (MNR), and enhanced natural recovery (ENR), discussed below.

17.2.3.1 Monitored Natural Recovery

MNR relies on natural processes to reduce the toxicity of sediments through natural chemical, physical, and biological processes. In general, sediments “naturally recover” by the transformation of or loss of chemical constituents. MNR also reduces exposure to human and ecological receptors through natural containment and attenuation of contaminant concentrations by natural sedimentation.

MNR is applicable in depositional environments with low erosive forces, where the natural sedimentation process gradually buries contaminants, and in areas where the historical sedimentation rate and surface contaminant concentration data indicate that surface sediment concentrations would meet cleanup standards within an acceptable time frame. WSDOE and the USEPA typically consider 10 years to be an acceptable time frame for achievement of cleanup standards for the natural recovery process. MNR is a common management practice in areas with high sedimentation rates and where contaminant characteristics indicate a high likelihood of transformation and attenuation over time.

The MNR technology is applicable to all site sediment COCs with concentrations greater than cleanup levels.

17.2.3.2 Enhanced Natural Recovery

ENR is typically identified with the process of encouraging the natural recovery rate of contaminated sediments by placement of a clean, typically thin, sediment (e.g., sand) layer over the contaminated sediment surface. This clean thin sediment layer does not function as a chemical containment layer (i.e., sediment cap), but is placed to accelerate the natural recovery process by mixing clean sediment with the existing contaminated surface sediments, immediately reducing the surface sediment contaminant concentrations. This reduction in contaminant concentrations reduces the time frame necessary to achieve cleanup levels. In most cases, clean sediment physically similar to the existing substrate is placed in thin uniform layers, or in lifts, to allow for natural sediment transport to distribute the materials throughout the contaminated area.

Similar to MNR, ENR is applicable in depositional environments with low erosive forces that already exhibit low to moderate levels of contamination in surface sediments. The typical recovery time frame associated with ENR is dependent on the type and concentration of contaminants present, and is also reliant on the natural sedimentation rate at a site. The addition of clean material encourages the natural attenuation process in surface sediments, and immediately reduces surface sediment concentrations through mixing; however, the technology continues to rely on burial by cleaner material and natural attenuation of subsurface contaminants to achieve the cleanup levels throughout a site. In some cases, if the existing chemical concentrations are low enough, the addition of clean material may achieve immediate compliance with the site-specific cleanup standards, but that is dependent on the chemical concentrations present and the site cleanup standards.

The ENR technology is applicable to all of the site sediment COCs with concentrations greater than cleanup levels.

17.2.4 Sediment Capping

Sediment capping is the controlled placement of material over areas of known sediment contamination to physically and chemically separate the contaminants from the overlying water column, thereby protecting human health and the environment through control of human and aquatic exposures to the underlying sediments. Granular capping materials vary in size from sand to larger diameter gravel and cobbles. Granular caps can be constructed to incorporate geotextiles for structural stability, and can be amended with organo-clays or carbon to increase the sorption capacity for organic contaminants. Biological and chemical agents are also used in cap material to encourage contaminant attenuation and increase the rate and extent of recovery. Cap amendments commonly increase chemical attenuation, while geotextiles can provide geotechnical stability, and increase the ability of the cap to withstand erosive forces present in the environment. Caps can also be constructed from geomembranes and composite textile materials that provide a low permeability barrier above the contaminated sediments.

Sand caps are constructed with variable thicknesses of clean sand capable of containing the sediment contamination beneath the cap while allowing for attenuation and diffusion of groundwater and contamination breakdown products (including gases) through the cap material. Sand caps are typically constructed in layers that comprise a protective surface layer capable of providing scour and erosion protection, underlain by a chemical attenuation layer with sufficient thickness to provide chemical containment of underlying contaminated sediments. Typically, some degree of mixing occurs when the attenuation layer is placed on the contaminated sediment surface, which must be accounted for when determining the effective thickness of the attenuation and protection layers. An additional surface layer suitable for habitation of benthic biota can also be added as allowed by hydrodynamic conditions.

Sand caps are conventionally placed in a single lift over contaminated sediments with a bottom dump barge or clamshell dredge bucket. Conventional caps are practical in areas with dense underlying sediments. Alternatively, thin-lift capping methods are practical in areas with soft, unconsolidated underlying sediments or in areas where resuspension of underlying materials is a concern. Controlled placement of small lifts with specialized construction equipment and with time between lift placements allows for a more uniform cap placement than conventional capping. Additional benefits of thin lift capping include identification and filling of areas requiring a thicker cap, gradual sediment strengthening, limited mixing zone thicknesses, and limited contaminant resuspension. Construction techniques for the placement of thin-lift caps include hydraulic spraying and a telebelt conveyor method.

The sediment capping technology is applicable to all site sediment COCs with concentrations greater than cleanup levels.

17.2.5 Open Water Filling to Rehabilitate the Wetland

Open water filling of Lora Lake to rehabilitate the wetland would place a thick cap or sand fill material throughout the water footprint of the lake to the existing ground surface surrounding the lake to rehabilitate the lake to its natural wetland condition prior to historical peat mining that created the lake. This technology would completely cover all contamination by physically and chemically separating the contaminants from the overlying sediment column. This technology would protect human health and the environment through eliminating human and ecological exposures to the contaminated sediments.

Temporary silt control and BMPs are typically used during construction to ensure that fill operations do not adversely impact downgradient water quality. For locations with soft, unconsolidated sediments, lake filling would likely be completed in two phases. The first layers of sand would be placed in a manner to minimize disruption and gradually strengthen the underlying sediments. The remainder of the fill would then be placed with a more efficient and more cost-effective methodology. Following the placement of fill material, topsoil would be placed, and fine grading conducted on the converted surface for wetland creation and vegetation plantings.

The open water filling to rehabilitate the wetland technology is applicable to all site sediment COCs with concentrations greater than cleanup levels.

17.2.6 Dredging and Landfill Disposal

Dredging is a remedial technology that involves permanent removal of contaminated material from the aquatic environment for treatment and/or disposal at a licensed facility. Dredging is most commonly implemented to provide a resultant clean surface, to remove source material, and/or to provide specific water column depths for navigation purposes. Dredging can be combined with capping technologies when dredging alone does not achieve the site cleanup requirements due to remaining subsurface contamination or the resuspension of contaminated sediments during dredging. Two common types of dredging include mechanical dredging using a clamshell bucket and hydraulic pipeline dredging.

Mechanical dredging includes the use of a barge mounted dredge or crane that is fit with a mechanical bucket. The bucket is lowered to the sediment surface in an open position and after sinking into the sediment, the bucket closes and the dredged sediment is brought to the water surface. The sediment is placed into a receiving barge or area for dewatering and transport and disposal. Hydraulic dredging consists of a flexible suction pipe connected to a centrifugal pump, with a mechanical agitator or cutter head located at the open end of the pipe. The agitator disrupts the sediment in front of the pipe and the water and loose sediment is sucked up through the pipe to a slurry dewatering and handling area.

Both hydraulic and mechanical dredging have substantial concerns regarding the resuspension and re-deposition of contaminated sediments on the dredge surface, but BMPs are typically implemented during dredging to minimize resuspension. Sediment dredging, particularly hydraulic dredging, creates large volumes of slurry water that requires storage, possible treatment, and dewatering prior to disposal. The type and application of dredging technologies vary with the type of equipment used.

The dredging and landfill disposal technology is applicable to all site sediment COCs with concentrations greater than cleanup levels.

17.2.7 Engineering Controls

Engineering controls are physical measures constructed to block pathways and reduce or eliminate contaminant exposure to ecological and human receptors. Engineering controls focus on preventing access to the contamination. Engineering controls are often used as temporary measures to prevent access to the contaminated site until a permanent cleanup is completed.

Engineering controls vary in nature and scope but could include blocking fish from entering a water body, or the use of engineered equipment or a fence to prevent human contact with contaminated soil. The most common methods to block fish passage to a water body are through the use of different types of screens (traveling, stationary, drum, wedge wire), grates, dams, and weirs. When the only method of entry to the water body is through a pipe, another option is to use a small pipe size that allows adequate flow, but prevents passage of larger objects. Engineering controls require maintenance in perpetuity to assure proper function and prevent exposures.

The engineering controls technology is applicable to all site sediment COCs with concentrations greater than cleanup levels.

18.0 Lora Lake Parcel Technology Screening and Alternative Development

This section contains a screening of the technologies presented in Section 17.0 in consideration of LL Parcel conditions. As outlined in earlier sections, the site conditions at the LL Parcel factor into the applicability of remediation technologies.

The technology screening is followed by an aggregation of alternatives using the technologies that are determined to be applicable at the LL Parcel resulting in protection of human health and the environment. These alternatives are evaluated in Section 19.0 according to the MTCA DCA procedure (WAC 173-340-360(3)(e)(ii); WSDOE 2007).

18.1 PRELIMINARY TECHNOLOGY SCREENING

The number of technologies applicable for remediation of the LL Parcel is particularly limited by the presence of dioxin/furan contamination, which only a focused subset of technologies can address.[22] As part of the technology selection process, the technologies identified in Section 17.0 that are found to be applicable to the COCs present at the LL Parcel at concentrations greater than applicable cleanup levels are screened against site-specific considerations to identify those that are appropriate for LL Parcel remediation.

The preliminary technology screening process is presented in Table 18.1. The end result of the process is rejection or retention of technologies based on their applicability at the LL Parcel given: the COCs and impacted media, technology effectiveness and proven success at similar sites, applicability of the technology within LL Parcel physical constraints, and the ability of the technology to achieve RAOs. The retained technologies are summarized below and then aggregated into remedial alternatives for evaluation according to the MTCA DCA process presented in Section 19.0.

No action, solidification and stabilization, and in-situ vitrification were rejected from further evaluation for remediation of soil.

No action, monitored natural recovery, and enhanced natural recovery were rejected from further evaluation for remediation of sediment.

18.2 SUMMARY OF RETAINED TECHNOLOGIES AND CONSIDERATION OF ADDITIONAL LORA LAKE PARCEL CONDITIONS

Based on the preliminary technology screening, the technologies discussed below were retained for aggregation into alternatives to address soil and sediment contamination at the LL Parcel. Each technology is discussed in greater detail in the following sections with consideration of the LL Parcel conditions that may impact the applicability and success of the technology.

[22] Because the structure of dioxins/furans is highly resistant to chemical and biological degradation processes, they are considered persistent environmental contaminants that do not naturally degrade over time.

18.2.1 Soil-specific Technologies

18.2.1.1 Institutional Controls

Institutional controls have been retained for further evaluation as a soil remedial technology. As a stand-alone technology, institutional controls would not reduce, destroy, or remove any chemical contamination in addition to what would occur via natural processes, but would instead be implemented in addition to other technologies to meet RAOs, ensure long-term protectiveness of the selected remedy, and prevent exposure to contaminated soil. At the LL Parcel, institutional controls would be implemented with any technology that leaves contamination in place in excess of cleanup levels. Institutional controls that may be implemented for soil could include maintenance of a containment cap over contaminated soil remaining on-site. Additionally, institutional controls could include current and future safety, soil management, and cap restoration requirements for subsurface excavation activities such as utility work, landscaping, or construction that disturbs the ground in areas of soil contamination. When used in combination with other remedial technologies, institutional controls would successfully achieve the LL Parcel RAOs, and could be implemented given the LL Parcel physical conditions.

18.2.1.2 Surface Soil Capping

Surface soil capping of LL Parcel shallow soil has been retained for further evaluation. When implemented with institutional controls, capping addresses the LL Parcel soil COC that exceeds cleanup levels through management of the exposure pathways. The goal of capping would be to manage the direct worker contact, terrestrial ecological contact, and surface soil erosion/migration pathways. Cap technologies may be designed to consist of either impermeable or semi-permeable geotextiles, or placement of permeable clean, surface soil to encapsulate contamination promote vegetation growth. Cap design details would be developed during the remedial design phase of the project. Capping used in combination with other remedial technologies, such as institutional controls requiring long-term cap maintenance and worker protection, could successfully achieve the LL Parcel RAOs and could be implemented given the LL Parcel physical conditions.

18.2.1.3 Source Removal by Excavation and Landfill Disposal

Excavation and landfill disposal of LL Parcel shallow soil has been retained for further evaluation because it addresses the LL Parcel soil COC that exceeds cleanup levels. The technology may be implemented to remove all soil contamination to a selected soil concentration or action level, or be implemented to a limited extent to remove soil hot-spot areas. Soil excavation may be implemented in combination with other technologies depending on the extent of contamination left in place following a focused hot-spot removal. If excavation were conducted as a hot-spot removal, additional actions would be required to manage exposure for the contaminants remaining on the LL Parcel, and allow for future LL Parcel land use. When used in combination with other remedial technologies, excavation would successfully achieve the LL Parcel RAOs, and could be implemented given the LL Parcel physical conditions.

18.2.2 Sediment-specific Technologies

18.2.2.1 Sediment Capping

The sediment capping technology has been retained for further evaluation for the treatment of Lora Lake sediments. The sediment capping technology would address the COCs that exceed cleanup levels in sediment by capping the contaminants with a sand cap, providing a chemical and physical barrier. The detailed design of the cap would be finalized during design, but the thickness and material would be based on the numerical cap modeling results described in Appendix P. The cap lift size and placement methodologies would be based on the physical considerations of the lake. Thin (e.g., 6-inch) lifts of sand would be placed on the surface of the lake sediments via the use of a telescopic belt conveyor, or telebelt, and flexifloats, with mounted conveyors for sand placement beyond the reach of the telebelt. The telebelt and construction equipment staging area would be limited to a focused area along the north side of the lake to minimize, to the extent possible, the temporary impact to the existing site vegetation. Sediment capping would manage the exposure pathway by providing a clean sediment surface within the biologically active zone, while covering contaminated material, reducing the potential for resuspension and transport, as well as controlling aquatic exposure to the contaminated sediments. Recontamination of the sediment cap surface is likely, given that Lora Lake receives urban stormwater runoff; however, cap placement in coordination with LL Apartments Parcel remediation, and in particular, stormwater drainage system improvements/abandonment, would eliminate the potential that the Lora Lake Apartments Site could contribute contamination to sediments in Lora Lake. When used in combination with other remedial technologies, sediment capping would successfully achieve the site RAOs, and could be implemented given the site physical conditions.

18.2.2.2 Open Water Filling to Rehabilitate the Wetland

The technology of open water filling to rehabilitate the wetland has been retained for further evaluation for the treatment of Lora Lake sediments. This technology would address the COCs that exceed cleanup levels in the sediment by isolating the contamination and preventing exposure. The technology would place sand to an elevation that would effectively fill in the lake such that there would no longer be any open water and support the establishment of emergent and woody wetland vegetation. The sand fill material would be designed to optimize the continued hydraulic connectivity of groundwater to Miller Creek and minimize and avoid any adverse effect on the base flow conditions in Miller Creek. Following the placement of fill material, topsoil would be placed on the converted surface for wetland creation and vegetation plantings. Consistent with the sediment capping technology, the initial sand placement in the lake would be conducted with thin (e.g., 6-inch) lifts of sand that would be placed on the surface of the lake sediments via the use of a telescopic belt conveyor, or telebelt, and flexifloats, with mounted conveyors for sand placement beyond the reach of the telebelt. The telebelt and construction equipment staging area would be limited to a focused area along the north side of the lake to minimize to the extent possible the temporary impact to the existing site vegetation. Reconfiguration of the stormwater outfall and associated engineering would be developed during design. Open water filling to rehabilitate the wetland would manage the exposure pathway by providing a clean fill surface, eliminating the sediment to surface water pathway, and creating aquatic habitat that is consistent with the goals of the NRMP. Temporary silt control and BMPs during construction would be required to ensure that Miller Creek is not adversely impacted by the placement of the sand fill. When used in combination with other remedial technologies, open water filling to rehabilitate the wetland would successfully achieve the site RAOs, and could be implemented given the site physical conditions.

18.2.2.3 Dredging and Landfill Disposal

The dredging and landfill disposal technology for treatment of Lora Lake sediments has been retained for further evaluation because it addresses the COCs that exceed cleanup levels in the sediment through removal. The lake has been dredged in the past, so the technical applicability of this technology to the Site has been confirmed; however, the effectiveness of a dredging technology is not known. Sediment sampling activities conducted in the lake identified soft flocculent surface sediments with the potential to resuspend and settle during the dredging process. The amount of resuspension and sedimentation that would occur during dredging is unknown. Resuspension during dredging would likely result in post-dredge surface concentrations that do not meet cleanup standards, potentially requiring capping to achieve compliance following completion of the dredging technology. Additionally, resuspension during dredging could spread contamination into Miller Creek.

The previous dredging was conducted hydraulically. This would be the most effective dredging method, given the soft flocculent nature of the sediments. Because of the COC concentrations present in sediment, landfill disposal of dredged sediments would be required. Dewatering of dredged material would also be required prior to disposal, because hydraulic dredging typically generates dredge slurry with high water content. Dewatering could be accomplished with geobags, in an area near the lake such as the DMCA. When used in combination with other remedial technologies, dredging could potentially achieve the site RAOs, and could be implemented given the site physical conditions.

18.2.2.4 Engineering Controls

Engineering controls have been retained for further evaluation for the treatment of Lora Lake sediments. Although the COC concentrations in the sediments that exceed cleanup levels would not be reduced or destroyed, engineering controls would address the sediment exposure pathway by interrupting the route of exposure. Engineering controls, such as installing a grate to block fish passage into and out of the lake and constructing an engineered berm to prevent sediments from reaching the creek, would minimize the risk of human consumption of fish caught in Miller Creek that had migrated from residence in Lora Lake. When used in combination with other remedial technologies, engineering controls could successfully achieve the majority of site RAOs, and could be implemented given the site physical conditions, but may not successfully control sediment transport from Lora Lake to Miller Creek.

18.3 AGGREGATION OF REMEDIAL ALTERNATIVES

The retained technologies described above have been aggregated into remedial alternatives for the LL Parcel. The alternatives are discussed below and are presented in order from least invasive to the most aggressive, a sequence that reflects an increasing level of effort, protectiveness, and cost. Alternative 1 is an institutional and engineering controls alternative and Alternative 4 is a “Full Removal” alternative that is consistent with the MTCA WAC 173-340-200 definition of a permanent cleanup action.

All of the alternatives listed below include technologies to address all contaminated media (soil and sediment) on the LL Parcel. Table 18.2 presents the LL Parcel alternatives and identifies the technologies applied to soil and sediments. Appendix Q presents the estimated alternative costs.

The LL Parcel alternatives will be evaluated according to the MTCA DCA procedures, to compare the costs and benefits of the cleanup alternatives and identify the alternative that is permanent to the maximum extent practicable. The four alternatives developed for evaluation are described below, and the evaluation according to the MTCA DCA is conducted in Section 19.0.

18.3.1 Alternative 1

Alternative 1 is the lowest capital cost remedial alternative proposed, and includes no mass removal. Instead, engineering controls and institutional controls are applied to the LL Parcel Cleanup Areas to manage contaminant exposure through administrative and limited engineering controls. Although there is no mass removal, the pathways of human exposure are addressed through management of the exposure routes. Alternative 1 consists of institutional controls for the LL Parcel Shallow Soil Cleanup Area and engineering controls for the LL Parcel Sediment Cleanup Area.

Alternative 1 would establish institutional controls for management of exposure pathways in the LL Parcel Shallow Soil Cleanup Area. The majority of the cleanup area is located within the STIA security fencing, where public access is already restricted; a small portion is outside the security fence along Des Moines Memorial Drive. The current exposure pathways to the soil in these areas within the fence are direct worker contact and wildlife ecological exposure. The institutional controls that would be applied to the LL Parcel Shallow Soil Cleanup Area would require maintaining the current vegetation to prevent erosion of surface soil. Additional institutional controls for the LL Parcel Shallow Soil Cleanup Area would require development and implementation of a worker health and safety program for activities conducted in these areas and deed restrictions, which are also already in place due to the site location within secured areas of the STIA. These institutional controls are considered appropriate to manage risk to site workers, but not wildlife ecological risk, at the LL Parcel Shallow Soil Cleanup Area.

Engineering controls would be constructed at the outlet of Lora Lake to Miller Creek to prevent sediment movement and fish passage from the lake to the creek. Engineering controls would include reconstruction of the berm between the lake and creek to create a single location for surface water exchange between the lake and the creek. Installation of grates, weirs, or other such methods at the outfall location would control sediment migration and fish passage. Engineering controls would require maintenance to maintain functionality and manage blockages in outfall structures from debris and organic matter. This maintenance would be conducted by Port maintenance personnel.

18.3.2 Alternative 2

Alternative 2 provides a more aggressive remedial action than Alternative 1 through capping of the contaminated soil at the LL Parcel Shallow Soil Cleanup Area and thin-lift capping of sediments at the LL Parcel Sediment Cleanup Area.

Surface soil capping of the LL Parcel Shallow Soil Cleanup Area would require selection of a capping technique appropriate for its location on the vegetated slope within the Port-managed wetland habitat mitigation area. The cap would be required to support vegetation growth. Analytical data identified a small portion of the cleanup area with dioxin/furan exceedances to 0.5 foot bgs and a larger portion of the cleanup area with dioxin/furan exceedances to 2 or 4 feet bgs. Therefore, the smaller portion of the cleanup area located to the south would be excavated to 0.5 foot bgs. In the larger area, however, excavation would likely be required up to a minimum of 2 feet bgs (Figure 18.1) to allow for sufficient cap placement to maintain the existing topography and surface features and be protective of the direct contact pathway. Any contaminated soil excavated from the cleanup area would be disposed of off-site at a licensed disposal facility.

The soil located within the cleanup area between Des Moines Memorial Drive and the security fence would also be excavated, as needed, and capped. This alternative would result in a soil excavation volume of approximately 1,900 cubic yards.

The soil cap design may include placement of an indicator layer, such as a geosynthetic fabric or mesh, at the top of the contaminated soil horizon to indicate the contact between any remaining, underlying contaminated soil and the imported cap material. These types of construction details would be developed during the cap design process. Data density within the LL Parcel Shallow Soil Cleanup Area is limited and any additional data collection necessary to determine cap extent would be collected during remedial design.

Alternatively, a remediation level based on location or physical identification may be used to determine the extent of the cap and institutional controls. Because of the sensitive nature of the LL Shallow Soil Cleanup Area as a mitigation habitat area, accessibility, and the negative environmental impact that excavation, capping, and re-vegetation may cause, the extent of the cap may be based on both compliance with cleanup levels and a net environmental benefit determination. Additional shallow soil data would be collected prior to design and evaluated in a supplemental pre-design characterization report in support of the development of the Draft CAP. Figure 18.1 presents the approximate extent of the area to be capped within the LL Parcel Shallow Soil Cleanup Area based on existing data.

Because contamination at concentrations greater than cleanup levels would remain in place with a soil capping technology, institutional controls to manage disturbance of contaminated soil remaining on-site would be required. Institutional controls would likely include required maintenance of the new vegetated cap surface to prevent erosion of surface and subsurface soil and implementation of a worker health and safety program for activities conducted in these areas. Cap maintenance and monitoring would be required throughout the lifespan of the LL Parcel Shallow Soil Cleanup Area cap. These institutional controls are considered appropriate to manage risk to site workers at the LL Parcel Shallow Soil Cleanup Area but would not address any sub-cap terrestrial ecological risk.

Capping of the LL Parcel Sediment Cleanup Area would be designed to encapsulate the current sediment contamination in place, providing a clean surface for benthic biota and eliminating the potential for aquatic exposure or transport of contaminated sediments. The sediment cap would provide a chemical attenuation later and a physical barrier between the contaminated sediments and the overlying water column.

Appendix P provides the results of the sediment leaching and numerical cap modeling evaluation. The cap modeling evaluated the potential for the underlying capped sediments to leach contamination to pore water and to surface water resulting in exceedances of the human health surface water standards. The modeling results indicate that a medium grain sand cap approximately 1.5 feet thick with organic carbon content of approximately 0.06 percent would provide sufficient protection from the leaching of COC contamination. Because of the soft, unconsolidated nature of the lake sediments, an additional 6 inches of sand is included in the sand cap volume and cost estimates to provide a sufficient thickness to allow for the mixing of surface sediments and sand during the placement of the first thin lift. Engineering design would evaluate factors such as rates of placement, natural sand carbon content or cap material amendments, lift thickness, and consolidation of underlying sediments. Based on current sediment chemical data, it is assumed that the cap would be placed throughout the lake subsurface footprint. Placement of the cap would make the lake slightly shallower over the entire footprint of the lake and would enhance[23] a small area of wetland on the west shore by converting some of the open water acreage to wetland.

Due to the unconsolidated and flocculent nature of the lake sediments, non-conventional construction techniques would be implemented to place the sediment cap. Typically, with dense sediments or a competent sediment surface that consists of sand and gravel, caps can be placed with clamshell buckets as a single lift. Because of the soft, flocculent sediments in Lora Lake, the sand cap would likely be placed with thin lifts to minimize resuspension of contaminated sediments and gradually increase the surface sediment competency. The cap materials would likely be applied via a controlled surface placement technology such as hydraulic spraying or a conveyor method (telebelt) that releases the cap material at or above the water surface, allowing the sand to fall through the water column and gradually build up at the sediment surface and preventing the sudden discharge of material or sediment resuspension. The thin cap layers would likely be placed in approximate 6-inch lifts of sand, but the actual lift thicknesses would be

[23] Enhancement is the manipulation of the physical, chemical, or biological characteristics of a wetland to heighten, intensify, or improve specific function(s) or to change the growth stage or composition of the vegetation present. Enhancement is undertaken for specific purposes such as water quality improvement, flood water retention, or wildlife habitat. Enhancement results in a change in wetland function(s) and can lead to a decline in other wetland functions, but does not result in a gain in wetland acres (WSDOE et al. 2006).

determined in design. The Alternative 2 cost estimate presented in Appendix Q assumes that the sediment cap would be placed with the aid of a telebelt and flexifloats in the lake with mounted conveyors for sand placement beyond the reach of the telebelt. Depth sounding would likely be used during cap placement to identify low points and final cap thickness. Temporary silt control and BMPs during capping operations, potential water quality monitoring, and post-cap compliance monitoring and maintenance would be required during construction. If determined necessary during design, placement of a geotextile could be considered as part of the sediment cap to provide a separation between the imported cap material and the underlying contaminated sediments and to control sediment resuspension during cap placement. Cap thickness and the technical evaluation for placement of the cap would be further evaluated and developed during design, including the thicknesses and optimal time duration between lifts. Because Alternative 2 does not address existing lake surface water concerns of elevated temperature and suppressed dissolved oxygen, additional mitigation requirements may be required. The need for such mitigation would be determined during design and coordination with the resource agencies during permitting of the remedial action.

Alternative 2 would require the construction of a temporary construction access road and a construction equipment staging area along the north side of the lake. This road would allow for truck and equipment access to the lake. Construction of the road would likely result in the removal of a small stand of alder trees in the Lora Lake buffer and disturb a small area of wetland vegetation along the lake fringe. Following alternative construction, the road would be removed and the area would be re-vegetated and restored, but there would be a temporary loss of wetland and buffer functions because of the time it would take for the plant community to fully reestablish. Resource agencies may require mitigation for this temporary loss of wetland and buffer function.

A Compliance Monitoring Plan would be developed that meets the requirements of WAC 173-340-410 and would have the following components:

- **Protection Monitoring:** To confirm that human health and the environment are adequately protected during construction and any required operation and maintenance period.
- **Performance Monitoring:** To confirm that the cleanup action has attained cleanup standards, remediation levels, and other performance standards such as construction quality control measurements, or permitting requirements. Performance monitoring would be conducted to confirm that the sediment cap is constructed to design depth.
- **Confirmation Monitoring:** To confirm the long-term effectiveness of the remedial action once remediation levels, performance standards, and cleanup levels have been attained. Sediment cap monitoring would likely include cap surface sampling for chemical analysis for a multiple-year duration.

Following completion of Alternative 2 in Lora Lake, the sediment contamination would be addressed. It is possible that recontamination of the lake sediments from stormwater inputs to the lake could occur, but these inputs would not be attributable to the historical or current operations at the Site.

18.3.3 Alternative 3

Alternative 3 consists of soil excavation in the LL Parcel Shallow Soil Cleanup Area and open water filling of Lora Lake to rehabilitate the wetland and isolate the contaminated sediments.

This alternative includes excavation and off-site disposal of soil within the LL Parcel Shallow Soil Cleanup Area with dioxin/furan TEQ concentrations greater than 5.2 pg/g. The soil excavation in the LL Parcel Shallow Soil Cleanup Area would be protective of human health and of wildlife ecological risk and exposure by eliminating the direct contact pathway. Excavation at the LL Parcel Shallow Soil Cleanup Area would likely extend to approximately 0.5 to 4 feet bgs for removal of contamination, as determined during design. This would result in the removal of approximately 2,300 cubic yards of contaminated soil. The excavation area would include the soil outside of the security fence and below the sidewalk, as shown in Figure 18.2. The vertical and horizontal extent of contamination has not been bound analytically, and could be confirmed during the design phase following additional data collection for greater delineation of contaminant extent in these areas. Because of limited accessibility and the sensitive nature of the LL Parcel Shallow Soil Cleanup Area that includes a wetland and a wetland buffer, the extent of excavation would be based on a remediation level or an assessment of net environmental benefit. Additional shallow soil data would be collected prior to design and evaluated in a supplemental pre-design characterization report in support of the development of the Draft CAP. This net environmental benefit approach to excavation would be designed to be a balance of cleanup level or remediation level compliance, receptor protection relative to the detected COC concentrations, and overall net benefit to the remaining wetland and wetland buffer areas located to the east of the LL Parcel Shallow Soil Cleanup Area. The LL Parcel Shallow Soil Cleanup Area would require backfilling and reconstruction to match existing conditions in accordance with the NRMP (Parametrix 2001).

Alternative 3 also includes isolation of the Lora Lake sediments through open water filling of Lora Lake to rehabilitate[24] the wetland. Filling the open water of Lora Lake would isolate the current sediment contamination in place, eliminating the potential for aquatic exposure or transport of dioxin/furan-contaminated sediments. The fill material would provide a physical barrier between the contaminated sediments and water flowing into Miller Creek, also addressing the benthic and human exposure pathway.

Alternative 3 would convert the existing open water area to a flow-through depressional wetland system,[25] rehabilitating the hydrogeomorphic conditions that existed prior to historical peat mining that created the lake. The rehabilitated wetland would be capable of supporting emergent and woody vegetation and would create aquatic habitat that is consistent with the goals of the NRMP. This wetland rehabilitation is viewed favorably by

[24] Rehabilitation is the manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural or historic functions (and processes) of a degraded wetland. Rehabilitation results in a gain in wetland function but does not result in a gain in wetland acres. This is distinguished from re-establishment, which results in rebuilding a former wetland and results in a gain in wetland acres and functions (WSDOE et al. 2006).

[25] Depressional wetland systems are wetlands that are present in topographic depressions (i.e., low, closed elevation areas) and support surface water.

resource agencies and is considered a preferred form of compensatory mitigation for ecological impacts (WSDOE et al. 2006). The rehabilitated wetland would be designed to:

- increase vegetated wetland habitat, plant species diversity, and microtopographic variations, which could encourage and support a more diverse assemblage of terrestrial species,
- allow for persistent vegetation growth, which improves primary productivity functions, shading, and sediment trapping functions,
- remove habitat for non-native fish species comprising pumpkinseed, sunfish and largemouth bass, which compete with native salmonid species in the Miller Creek system and prey on juvenile salmonids,
- eliminate a source of warm water/low dissolved oxygen inputs to Miller Creek,
- decrease the avian habitat functions in the current open water wetland that pose aircraft safety concerns,
- preserve the flow-through characteristics and flood de-synchronization functions of the Lora Lake system.

Filling of Lora Lake would consist of the placement of sand in the lake to an elevation such that there would no longer be any open water, which is optimal for wetland habitat creation. This action would require filling the lake over the entire lake footprint (approximately 120,000 square feet) to depths between approximately 2 feet and 13 feet, based on existing bathymetry. Because of the unconsolidated and flocculent nature of the lake sediments, the initial layers of the fill material would be applied via a controlled surface placement technology such as with a telebelt, as described above, for the placement of the thin-lift sand cap. The subsequent fill layers to the surface would likely be placed with the controlled placement of the sand fill material directly into the lake from a truck at the shoreline or with floating equipment.

The numerical cap model results, presented in Appendix P, indicate that an 18-inch-thick sand cap with an organic carbon content of 0.06 percent would sufficiently contain and attenuate contamination detected in the Lora Lake sediments. Under this alternative, both conditions would be satisfied. The proposed fill would be up to 13 feet thick, much greater than the model required 18 inches. The organic carbon content of the existing surface sediment was measured to be approximately 8 percent, and the fill material would be tested to ensure an organic carbon content of at least 0.06 percent, as required by the model.

Additionally, an evaluation of potential horizontal transport of dioxins/furans in groundwater from the lake sediments to Miller Creek surface water was conducted through a comparison of the LL Apartments Parcel groundwater BIOSCREEN-AT modeling results (Section 5.2.2.2) to the conditions at the LL Parcel. For the LL Apartments Parcel, the model was run with the MTCA default soil organic carbon content of 0.1 percent (consistent with the measured LL Apartments Parcel RI soil organic carbon content) and a dioxin/furan TEQ concentration of 38.3 pg/L (the maximum dioxin/furan TEQ concentration detected in groundwater at the LL Apartments Parcel during the RI at

MW-1 within the Central Source Area). The model results show that the groundwater dioxin/furan TEQ concentration of 38.3 pg/L attenuates to less than the surface water criterion of 0.005 pg/L between 90 and 150 feet downgradient of MW-1.

The maximum sediment dioxin/furan TEQ concentration detected in Lora Lake was 217 pg/g at station LL-SED2. Using the mean value of the current Lora Lake surface sediment TOC data (8 percent), a dioxin 2,3,7,8-TCDD organic carbon partitioning coefficient of 12,500,000 L/kg, and the maximum surface sediment TEQ concentration (217 pg/g) as inputs for a conservative equilibrium partitioning calculation, the resulting sediment pore water dioxin/furan TEQ concentration that could theoretically be available to migrate with horizontal groundwater flow is 0.217 pg/L. This result is two orders of magnitude less than the MW-1 maximum groundwater TEQ concentration of 38.3 pg/L.

The distance between the LL-SED2 sampling location and Miller Creek is approximately 220 feet. This distance is greater than the distance at which the source concentration from MW-1 was shown to attenuate to less than the surface water criterion (90–150 feet downgradient). Therefore, in comparison, even if it was assumed that the MW-1 maximum groundwater TEQ concentration of 38.3 pg/L was located at LL-SED2, rather than the pore water concentration of 0.217 pg/L (calculated as described above from the in-situ surface sediment at LL-SED2), any potential horizontal groundwater transport of dioxins/furans in sediment pore water, following filling of the lake, would attenuate to less than the surface water criterion of 0.005 pg/L prior to reaching Miller Creek.

The sand fill material selected to fill the lake after the initial fill layers are placed would be designed to optimize the continued hydraulic connectivity of groundwater to Miller Creek. Prior to and following construction, the groundwater flow and hydraulic connectivity between the lake area and Miller Creek would be measured to minimize and avoid adverse effects on the base flow conditions in Miller Creek. Following the placement of fill material, topsoil would be placed on the converted surface for the wetland rehabilitation. Engineering design will evaluate the conveyance of stormwater, the reconfiguration of the stormwater outfall and associated stormwater engineering, the selection of the fill material, the seasonal groundwater fluctuation in the fill material and Miller Creek, and the flow-through characteristics and flood de-synchronization functions of the Lora Lake system. Temporary silt control and BMPs would be required during lake filling operations to ensure that Miller Creek is not adversely impacted by the placement of the sand/fill material.

Institutional controls that would be implemented with Alternative 3 following filling of the lake would likely include limits to future excavation/grading in the rehabilitated wetland in order to protect the direct contact pathway. This institutional control would be implemented to protect future worker direct contact.

Alternative 3 would require the construction of a temporary construction access road and construction equipment staging area along the north side of the lake. This road would allow for truck and equipment access to the lake. Construction of the road would likely result in the removal of a small stand of alder trees in the Lora Lake buffer and disturb a small area of wetland vegetation along the lake fringe. Following alternative construction, the road would be removed and the area would be re-vegetated and restored, but there would be a temporary loss of wetland and buffer functions because of the time it would take for the plant community to fully reestablish. Although it would take time for the wetland functions and downstream water quality conditions to improve following the fill placement, Alternative 3 is viewed favorably by the resource agencies as providing a long-term ecological benefit to the Miller Creek Relocation Reach. Based on input from the resource agencies, it is expected that Alternative 3 will be considered self-mitigating, meaning that the benefits of rehabilitating the wetland offset the short-term, construction impacts and no additional mitigation would be necessary.

A Compliance Monitoring Plan would be developed that meets the requirements of WAC 173-340-410 and would have the following components:

- **Protection Monitoring:** To confirm that human health and the environment are adequately protected during construction and any required operation and maintenance period.
- **Performance Monitoring:** To confirm that the cleanup action has attained cleanup standards, remediation levels, and other performance standards such as construction quality control measurements or permitting requirements. Performance monitoring would be conducted to confirm that soil excavation has attained cleanup levels or remediation levels.
- **Confirmation Monitoring:** To confirm the long-term effectiveness of the remedial action once remediation levels, performance standards, and cleanup levels have been attained. Long-term monitoring of the Lora Lake sediment cap will be conducted to track performance. No long-term monitoring associated with soil excavation would be anticipated.

18.3.4 Alternative 4

Alternative 4 is a full removal alternative that consists of excavation of soil and dredging sediments with COCs that exceed site cleanup levels.

This alternative includes excavation and off-site disposal of soil within the LL Parcel Shallow Soil Cleanup Area with dioxin/furan TEQ concentrations greater than 5.2 pg/g, consistent with Alternative 3. Excavation at the LL Parcel Shallow Soil Cleanup Area would likely extend to approximately 0.5 to 4 feet bgs and result in the removal of approximately 3,700 cubic yards. Following construction, the area would be reconstructed to match existing conditions in accordance with the NRMP (Parametrix 2001).

This alternative also includes dredging of Lora Lake sediments to remove sediments with COC contamination greater than cleanup levels. The dredge depth was estimated based on the existing surface and subsurface sediment chemical data collected during the RI. The dredge depth was determined to be 3 feet, which includes the potential overdredge of sediments, associated with dredge residuals. This dredge depth would likely extend to the underlying native peat or similar sediments and would deepen the lake by a few feet. Due to the soft flocculent nature of the sediments and the shallow bathymetry of the lake, dredging of lake sediments would likely be conducted hydraulically. The cost estimate presented in Appendix Q assumes hydraulic dredging based on lake sediment conditions. Hydraulic dredging consists of a flexible suction pipe connected to a pump, with a mechanical agitator or cutter head located at the open end of the pipe. The agitator disrupts the sediment at front of the pipe and the water and loose sediment is sucked up through the pipe to a slurry dewatering and handling area. It is assumed that the dredged material would have approximately 50 percent water content, requiring approximately 29,000 cubic yards of sediment slurry to be dredged over the entire footprint of the lake. Hydraulically dredged sediments would be pumped to geobags, or similar, located at a temporary containment facility within 500 feet of the lake, likely the DMCA, for sediment settling prior to disposal. Geobags, or tubes, made of high-strength permeable textiles are a commonly used sediment dewatering method: dredged sediments and water are pumped into the bag with a flocculent added to enhance sediment settling. Water drains out through the permeable bag walls, while the sediments are trapped within. When the sediments settle/dewater, the sediment-filled bags are transported off-site for disposal and the water is pumped back into the lake. The sediment slurry water drained from the geobags would likely be contained, sampled for turbidity, and treated if necessary before being pumped back to the lake so that the lake level remained at a sufficient depth to float dredging construction equipment. Sediment dredging would also require temporary silt control and BMPs during dredge operations, water quality monitoring during and following dredging, and the handling and transport of the dewatered dredge spoils via truck from the site to a licensed disposal facility.

The Alternative 4 construction effort would be difficult to achieve without significant disturbance to the surrounding wetland aquatic habitat mitigation area. BMPs during dredging would be implemented to minimize sediment resuspension and transport from the dredge area. Due to the nature of the sediments, it is expected that settling of contaminated sediment onto the post-dredged surface following completion of dredging activities would occur. Sediment sampling of the post-dredged surface would likely be required to document the lake bottom conditions following dredging. Thin capping of the post-dredge sediment surface would be implemented with Alternative 4 to address dredge residuals with COC concentrations that exceed cleanup levels. Because Alternative 4 does not address temperature and dissolved oxygen requirements, additional mitigation requirements may be required and would be determined during design based on discussions with the resource agencies,

The institutional controls required with implementation of Alternative 4 may be limited to those determined during design to be necessary for any site contamination that would remain beneath existing area impermeable surfaces at concentrations greater than cleanup levels. These institutional controls would be implemented to protect future worker direct contact.

Alternative 4 would require the construction of a temporary construction access road and construction equipment staging area along the north side of the lake. This road and area would allow for truck and equipment access to the lake. Dredge slurry and return dewatering water would be transported to and from the dewatering area, potentially located in the DMCA, via pipelines that would be installed underneath the construction access road. Construction of the road would likely result in the removal of a small stand of alder trees in the Lora Lake buffer and disturb a small area of wetland vegetation along the lake fringe. Following alternative construction, the road would be removed and the area would be re-vegetated and restored, but there would be a temporary loss of wetland and buffer functions because of the time it would take for the plant community to fully reestablish. Mitigation for this temporary loss of wetland and buffer function would likely be required.

A Compliance Monitoring Plan would be developed that meets the requirements of WAC 173-340-410. It would have the following components:

- **Protection Monitoring:** To confirm that human health and the environment are adequately protected during construction and any required operation and maintenance period.
- **Performance Monitoring:** To confirm that the cleanup action has attained cleanup standards, remediation levels, and other performance standards such as construction quality control measurements or permitting requirements. Performance monitoring would be conducted to confirm that soil excavation has attained cleanup levels or remediation levels.
- **Confirmation Monitoring:** To confirm that the long-term effectiveness of the remedial action once remediation levels, performance standards, and cleanup levels have been attained. No long-term monitoring associated with soil excavation or dredging would be anticipated, as Alternative 4 would likely remove all contaminated soil and sediment from the LL Parcel.

Following completion of Alternative 4, contaminated sediment exposure pathways would be addressed. It is possible that recontamination of the lake sediments from stormwater inputs to the lake could occur, but these inputs would not be attributable to the historical or current operations at the Lora Lake Apartments Site.

19.0 Lora Lake Parcel Alternatives Evaluation and Disproportionate Cost Analysis

In this section, the alternatives developed for the LL Parcel in Section 18.0 are evaluated against the MTCA requirements for a cleanup remedy per WAC 173-340-360. The MTCA requirements are introduced in the first section below, followed by the alternatives evaluation that compares each alternative based on its ability to comply with the MTCA requirements.

19.1 MODEL TOXICS CONTROL ACT REQUIREMENTS AND DISPROPORTIONATE COST ANALYSIS EVALUATION CRITERIA

This section provides a summary of the requirements and criteria that each remedial alternative is evaluated against in accordance with MTCA. Each of the proposed remedial alternatives is screened relative to mandatory “MTCA Threshold Requirements” and “Other MTCA Requirements” for evaluation. A DCA is conducted to identify the alternative that is “permanent to the maximum extent practicable,” using DCA evaluation criteria. Based on these evaluations, the Port will recommend a Preferred Remedial Alternative to WSDOE.

19.1.1 Model Toxics Control Act Threshold Requirements

MTCA WAC 173-340-360(2) states that all cleanup actions will meet the minimum requirements for a cleanup action, including the MTCA Threshold Requirements, and when multiple cleanup action components are implemented for a single site, the overall cleanup action shall also meet the minimum requirements discussed below:

- **Protect Human Health and the Environment.** Protection of human health and the environment shall be achieved through implementation of the selected remedial action.
- **Comply with Cleanup Standards.** Cleanup standards, as defined by MTCA, consist of cleanup levels for hazardous substances present at a site, the location, or point of compliance where the cleanup levels must be met, and any regulatory requirements that may apply to the site due to the type of action being implemented and/or the location of the site. All selected cleanup alternatives must meet cleanup standards defined for the site.
- **Comply with Applicable State and Federal Laws.** MTCA WAC 173-340-710 states that cleanup standards shall comply with legally applicable ARARs. ARARs applicable to this Site are detailed in Tables 15.1 through 15.3 and consist of chemical-specific ARARs applicable to the contamination types present at the Site, location-specific ARARs that apply to the physical location of the Site, and action-specific ARARs that apply to the construction components of the remedy.
- **Provide for Compliance Monitoring.** MTCA requires that all selected cleanup alternatives provide for compliance monitoring as described in WAC 173-340-410. Compliance monitoring consists of protection monitoring,

performance monitoring, and confirmation monitoring. Protection monitoring is performed during remedial implementation to monitor short-term risks and confirm protection of human health and the environment during construction activities. Performance monitoring will assess short-term remedy effectiveness and confirm compliance with the site cleanup levels immediately following remedial implementation. Confirmation monitoring will evaluate long-term effectiveness of the remedial action following attainment of the cleanup standards.

19.1.2 Other Model Toxics Control Act Requirements

Cleanup alternatives that meet the Threshold Requirements must also fulfill Other MTCA Requirements described in WAC 173-340-360(2)(b):

- **Use Permanent Solutions to the Maximum Extent Practicable.** The use of permanent solutions to the maximum extent practicable for a cleanup action is analyzed according to the DCA procedure described in WAC 173-340-360(3). Preference is given to alternatives that implement permanent solutions, defined in MTCA as actions that can meet cleanup standards “without further action being required at the site being cleaned up or any other site involved with the cleanup action, other than the approved disposal of any residue from the treatment of hazardous substances (WAC 173-340-200).”

  The DCA process is conducted to identify the alternative that uses permanent solutions to the maximum extent practicable.

- **Provide for a Reasonable Restoration Time Frame.** Restoration time frame is defined in MTCA as “the period of time needed to achieve the required cleanup levels at the points of compliance established for the site.” Preference is given to alternatives that provide for a reasonable restoration time frame. For alternatives that rely on natural attenuation and degradation over time to meet cleanup standards, a restoration time frame of 10 years or less is typically accepted as “reasonable.”

- **Consideration of Public Concerns.** Public involvement must be initiated according to the requirements set forth in WAC 173-340-600. Public concerns are taken into account at each step in the formal process under MTCA. Public comment was received on the RI/FS Work Plans, and the Draft RI/FS, and have been taken into account by WSDOE in preparation of a responsiveness summary (WSDOE 2015), and the draft Cleanup Action Plan. WSDOE’s decision on the Preferred Remedial Alternative, considering public comment, will be presented in the CAP.

19.1.3 Model Toxics Control Act Disproportionate Cost Analysis

The MTCA DCA is used to evaluate whether a cleanup action uses permanent solutions to the maximum extent practicable as determined by the level of attainment of specific criteria defined in WAC 173-340-360(3)(f). The environmental benefits of each alternative are scored using seven evaluation criteria. Additionally, the cost of each alternative is estimated. For each alternative, a “Cost per Unit Benefit Ratio” is calculated by dividing the total cost for the alternative (in millions) by the total benefit score for that alternative. A lower Cost per Unit Benefit Ratio value indicates the most benefit for the associated cost. The alternative with the lowest Cost per Unit Benefit Ratio provides the highest level of environmental benefit and permanence per dollar spent.

As stated in MTCA, the cost of an individual alternative is determined disproportionate "if the incremental costs of the alternative over that of a lower cost alternative exceed the incremental degree of benefits achieved by the alternative over that of the other lower cost alternative" (WAC 173-340-360(3)(e)(i); WSDOE 2007).

Evaluation of disproportionate cost allows comparison of each alternative to the most permanent alternative presented, as determined by attainment of MTCA criteria. This analysis can be qualitative or quantitative. If multiple alternatives possess equivalent benefits, the lower-cost alternative will be selected. The seven DCA criteria defined in MTCA (WAC 173-340-360(f)) are as follows:

- **Protectiveness.** Overall protectiveness of human health and the environment, including the degree to which existing risks are reduced, the time required to reduce these risks and the overall improvement in environmental quality.
- **Permanence.** The degree to which the alternative permanently reduces the toxicity, mobility, or volume of hazardous substances.
- **Cost.** The cost to implement the alternative consists of construction, net present value of any long-term costs, and agency oversight costs that are recoverable.
- **Effectiveness over the Long-term.** Long-term effectiveness consists of the degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on-site at levels greater than cleanup levels, and the effectiveness of controls in place to control risk while contaminants remain on-site.
- **Management of Short-term Risks.** Short-term risks comprise the risk to human health and the environment associated with the alternative during construction and implementation and the effectiveness of measures taken to control those risks.
- **Technical and Administrative Implementability.** The ability of the alternative to be implemented is based on whether the alternative is technically possible, meets administrative and regulatory requirements, and if all necessary services, supplies, and facilities are readily available.
- **Consideration of Public Concerns.** Whether the community has concerns regarding the alternative and if so, to what extent the alternative addresses those concerns.

19.2 ALTERNATIVES EVALUATION

In the following sections, the proposed remedial alternatives for the LL Parcel are evaluated for compliance with the MTCA Threshold Requirements, the ability to meet a reasonable restoration time frame, and compliance with the LL Parcel RAOs defined in Section 15.1. The alternative assessment under the Other MTCA Requirement “Uses Permanent Solutions to the Maximum Extent Practicable” is reported as a part of the discussion of the DCA analysis, which is conducted in Table 19.1 and summarized in Table 19.2 and in the following sections. The DCA analysis conducted in Table 19.1 scores each alternative relative to achievement of the MTCA criteria stated in WAC 173-340-360(3). The alternatives are evaluated relative to their ability to comply with the criteria listed; generally, they are not compared to each other but rather to the criteria. Because some alternatives provide a similar degree of compliance with a given criterion, the associated evaluation statements may be the same or similar.

The Other MTCA Requirement “Consideration of Public Concern” is not included in the detailed alternatives analysis that follows, as no public comments received on the Draft RI/FS resulted in revision of alternatives proposed in this report. Public comments received on the Draft RI/FS have been considered in the remedy selection process conducted in the CAP. WSDOE formally responded to all received public comments in a responsiveness summary (WSDOE 2015). This summary documents how each of the public comments received in writing during the public comment period was considered.

19.2.1 Alternative 1

With Alternative 1, engineering controls and institutional controls would be applied to the LL Parcel Cleanup Areas to manage contaminant exposure through administrative and limited engineering controls. Although there would be no mass removal, the pathways of human exposure would be addressed by managing the exposure routes. Alternative 1 consists of applying engineering controls at the LL Parcel Sediment Cleanup Area to manage contaminant exposure routes by controlling sediment movement and fish passage from Lora Lake to Miller Creek. Institutional controls would be implemented to manage risk at the LL Parcel Shallow Soil Cleanup Area.

19.2.1.1 Model Toxics Control Act Threshold Requirements

- **Protection of Human Health and the Environment:** Alternative 1 would provide for protection of human health through control of the direct contact exposure pathway by implementing institutional controls at the LL Parcel Shallow Soil Cleanup Area and engineering controls in Lora Lake. The institutional controls on the LL Parcel Shallow Soil Cleanup Area would protect site workers by requiring that all soil disturbance work be conducted under a site-specific Health and Safety Plan. Protection of the general public from direct contact with contaminated soil between Des Moines Memorial Drive and the site security fence relies on institutional controls, which would likely include signage. No physical barrier would exist, and this alternative relies on the public to comply with the institutional controls. Additionally, Alternative 1 does not prevent wildlife ecological exposure to contaminated soil. The engineering controls would likely manage sediment transport and fish migration from Lora Lake to Miller Creek.

- **Compliance with Cleanup Standards:** Although Alternative 1 would be protective of human health through control of the direct contact exposure pathway with implementation of institutional controls and access restrictions, Alternative 1 would not comply with Cleanup Standards for the LL Parcel Shallow Soil Cleanup Area for the protection of terrestrial receptors. The remedy in the LL Parcel Shallow Soil Cleanup Area provides no reduction of contaminant toxicity or volume and contaminants would remain on-site consistent with current conditions. Engineering controls would eliminate fish access to the lake, eliminating the human health exposure pathway of consumption of fish in Miller Creek that have been exposed to Lora Lake sediments.
- **Compliance with Applicable State and Federal Laws:** Alternative 1 would comply with all applicable state and federal laws and MTCA cleanup regulations through engineering and institutional controls, with the exception of compliance with ecological cleanup standards in the LL Parcel Shallow Soil Cleanup Area. Habitat ecological functions and temperature and dissolved oxygen requirements are required to be supported at the LL Parcel as part of the NRMP and could require mitigation efforts to replace disrupted aquatic habitat.
- **Provides for Compliance Monitoring:** Alternative 1 does not meet the requirements for compliance monitoring because cleanup levels will not be met.

19.2.1.2 Remedial Action Objectives

Through engineering controls and institutional controls, Alternative 1 complies with most LL Parcel RAOs. Alternative 1 only partially protects human health from exposure to site contamination through institutional controls to manage direct soil contact for Port workers. Port workers and the general public would not be as aggressively protected from exposure to site contamination from direct contact with contaminated soil located between Des Moines Memorial Drive and the site security fence, and would instead be provided notification and warnings of the presence of the contamination rather than a physical barrier. Additionally, Alternative 1 does not reduce wildlife ecological risk or exposure to contaminated soil. Human health exposure from consumption of fish in Miller Creek that have been exposed to contaminants in Lora Lake sediments would be reduced through implementation of engineering controls at the lake.

Alternative 1 does not fully address the RAO to eliminate the migration of contaminants by erosion, because the shallow soil contamination at the LL Parcel would not be capped and could have the potential to migrate; however, the potential for erosion and migration of the soil from the LL Parcel Shallow Soil Cleanup Area is low because the soil is well vegetated. Implementation of Alternative 1 is consistent with the FAA use restrictions.

19.2.1.3 Restoration Time Frame

Alternative 1 would partially address exposure pathways and comply with most RAOs through implementation of engineering and institutional controls remedy within 2.5 years of the effective date of the Consent Decree. Exposure pathways are managed through use of these institutional controls immediately following implementation. Contaminants in site soil are expected to remain on-site at concentrations greater than cleanup levels in perpetuity.

19.2.1.4 Disproportionate Cost Analysis

Alternative 1 has the lowest cost per unit benefit ratio because of the low construction and long-term costs; however, Alternative 1 received low benefit scoring for overall protectiveness, permanence, long-term effectiveness, and implementability. Additionally, Alternative 1 does not comply with all MTCA Threshold Requirements, or achieve all RAOs. Because of these reasons, Alternative 1 cannot be selected for implementation at the LL Parcel. Refer to Tables 19.1 and 19.2 for additional details.

19.2.2 Alternative 2

Alternative 2 consists of capping the LL Parcel Shallow Soil Cleanup Area and the LL Parcel Sediment Cleanup Area, which addresses exposure routes through pathway control. Approximately 1,900 cubic yards of soil would be excavated from the LL Parcel Shallow Soil Cleanup Area and disposed of off-site at a licensed facility to support placement of the soil cap. Institutional controls would be implemented for both the soil and sediment caps regarding cap disturbance and long-term maintenance.

19.2.2.1 MTCA Threshold Requirements

- **Protection of Human Health and the Environment:** Alternative 2 provides protection of human health and the environment through soil and sediment capping. Implementation of Alternative 2 would provide an immediate reduction of risk through direct contact pathway control. Contamination would remain on-site at concentrations greater than cleanup levels, but would be contained with caps, minimizing risk to human health and the environment. Institutional controls would be implemented to manage routes of exposure during disturbance and maintenance activities.
- **Compliance with Cleanup Standards:** Alternative 2 complies with all MTCA Cleanup Standards through containment of site COCs that remain on-site at concentrations greater than cleanup levels. Contaminant exposure pathways are eliminated in soil and sediment through limited excavation and capping.
- **Compliance with Applicable State and Federal Laws:** Alternative 2 complies with all applicable state and federal laws outlined in Section 15.2 and in Tables 15.1 to 15.3 through contaminant capping.
- **Provides for Compliance Monitoring:** Alternative 2 meets the requirements for compliance monitoring by implementing protection monitoring during implementation and performance monitoring following completion of capping to ensure cap effectiveness.

19.2.2.2 Remedial Action Objectives

All LL Parcel RAOs would be met with Alternative 2, which proposes capping contaminated soil and sediment and implementing institutional controls. Alternative 2 protects human receptors from exposure to site contamination that exceeds applicable cleanup levels by eliminating the risk of direct contact with contaminated soil and the potential human exposure pathway from consumption of fish obtained in Miller Creek that have been exposed to contaminants in Lora Lake surface sediments. The institutional controls are considered appropriate to manage risk to site workers at the LL Parcel Shallow Soil Cleanup Area but would not address any sub-cap terrestrial ecological risk. Re-vegetation of the capped soil prevents erosion of surface soil and is consistent with the required wetland mitigation functions in the NRMP. In addition, capping of Lora Lake sediment addresses the sediment leaching to surface water pathway.

Implementation of Alternative 2 would not provide an ecological benefit to Miller Creek regarding temperature and dissolved oxygen without the implementation of additional mitigation measures. Because Alternative 2 is not expected to have a large or beneficial effect on water temperatures or dissolved oxygen levels, the resource agencies may require additional wetland mitigation measures.

19.2.2.3 Restoration Time Frame

Alternative 2 would address exposure pathways and comply with all RAOs through implementation of containment technologies and institutional controls within 2.5 years of the effective date of the Consent Decree. Exposure pathways are managed through the use of these containment remedies and controls immediately following implementation. Contaminants would remain on-site in soil and sediment indefinitely due to the persistent nature of dioxins/furans and metals, but the risk of exposure would be managed by implemented containment remedies and institutional controls.

19.2.2.4 Disproportionate Cost Analysis

Alternative 2 received the third lowest cost per unit benefit ratio in the DCA. Alternative 2 received a cost per unit benefit ratio of 0.21, Alternative 3 received a cost per unit benefit ratio of 0.20 and Alternative 4 received a cost per unit benefit ratio of 0.33. Alternative 2 received moderate benefit scoring in the DCA (protectiveness, implementability, permanence, and long-term effectiveness; refer to Tables 19.1 and 19.2) and has the lowest construction, long-term and oversight costs between Alternatives 2, 3, and 4, but did not have the lowest cost per unit benefit ratio because the cost of Alternative 3 is proportionate to the increased benefit of the alternative that is more implementable, protective, permanent, and effective over the long-term.

19.2.3 Alternative 3

Alternative 3 consists of excavation and off-site disposal of contaminated soil and isolation of contaminated sediments through filling of the open water of Lora Lake to rehabilitate the wetlands. Approximately 2,300 cubic yards of contaminated soil would be excavated from the LL Parcel Shallow Soil Cleanup Area to the dioxin/furan TEQ cleanup level of 5.2 pg/g. The LL Parcel Sediment Cleanup Area would be addressed through isolation of the contaminated sediments to prevent direct exposure through filling of the lake to a level approximately equal to the existing lake surface. Following filling of the lake, topsoil would be added and vegetated to rehabilitate the hydrogeomorphic conditions that existed prior to the historical peat mining that created the lake.

19.2.3.1 Model Toxics Control Act Threshold Requirements

- **Protection of Human Health and the Environment:** Alternative 3 provides protection of human health and the environment through contaminant mass removal and contaminant isolation, which manage routes of exposure. Implementation of Alternative 3 would provide an immediate reduction of risk through source removal and pathway control by isolating contaminated sediment beneath several feet of fill. Sediment contamination would remain on-site at concentrations greater than cleanup levels, but would be isolated beneath the fill.
- **Compliance with Cleanup Standards:** Alternative 3 complies with all MTCA Cleanup Standards through contaminant removal and isolation of site COCs that are greater than cleanup levels to address exposure pathways. Lake filling would eliminate current exposure pathways to the Lora Lake sediments.
- **Compliance with Applicable State and Federal Laws:** Alternative 3 complies with all applicable state and federal laws that are outlined in Section 15.2 and in Tables 15.1 to 15.3 through contaminant mass removal and sediment isolation.
- **Provides for Compliance Monitoring:** Alternative 3 meets the requirements for compliance monitoring through implementation of protection monitoring during implementation and performance monitoring to confirm that soil excavation has attained cleanup levels or remediation levels. Long-term confirmation monitoring of the sediment cap is anticipated to involve porewater sampling above the sediment cap within the wetland fill to confirm contaminants are not leaching through the cap.

19.2.3.2 Remedial Action Objectives

All LL Parcel RAOs would be met with Alternative 3, which proposes excavation of contaminated soil and open water filling of Lora Lake to rehabilitate the wetland. Alternative 3 protects human receptors from exposure to site contamination that exceeds applicable cleanup levels by eliminating the risk of direct contact with contaminated soil through excavation. Filling Lora Lake to rehabilitate the wetland would prevent fish exposure to contaminated sediments, thereby managing the potential human exposure pathway from consumption of fish obtained in Miller Creek that had been exposed to contaminants in Lora Lake surface sediments. Alternative 3 also addresses the pathway of dioxins/furans, arsenic, and lead in sediments leaching to surface water by isolating the contamination below a thick layer of fill (2 feet to 13 feet) that significantly exceeds the thickness identified as protective by the numerical cap model (2 feet, refer to Appendix P). Input from the resource agencies favors Alternative 3 because it rehabilitates the wetland and restores the historical form and functions. Additionally, Alternative 3 is viewed as having an ecological benefit on the Miller Creek Relocation Reach by lowering stream temperatures and increasing dissolved oxygen.

Excavation of the contaminated shallow soil and re-vegetation of the surface would prevent contaminated shallow soil from eroding and mobilizing to Lora Lake. With Alternative 3, the contaminants would be remediated in a method that is consistent with the required wetland mitigation functions.

19.2.3.3 Restoration Time Frame

Alternative 3 would address exposure pathways and comply with all RAOs through implementation of the mass removal and isolation remedy within 2.5 years of the effective date of the Consent Decree. Exposure pathways are managed through the use of these containment remedies and controls immediately following implementation. Contaminants in soil would be removed from the Site as part of the remedy, but contaminants would remain on-site in sediment in perpetuity due to the persistent nature of dioxins/furans and metals. The risk of exposure to contaminated sediments would be eliminated by the placement of 2 to13 feet of fill material in Lora Lake.

19.2.3.4 Disproportionate Cost Analysis

With the exception of Alternative 1, which does not meet the MTCA requirements for a cleanup action and cannot be selected for implementation at the Site, Alternative 3 received the lowest cost per unit benefit ratio and the highest total benefit score. Alternative 3 scored higher than the other alternatives for implementability because it is viewed more favorably by the resource agencies due to the net ecological benefit it provides to Miller Creek and the rehabilitation of the wetland to its historical form and functions. Alternative 3 scored lower than Alternative 4 for protectiveness, permanence, and long-term effectiveness because it isolates sediment contamination below a thick layer of fill rather than removing the contamination from the Site (Tables 19.1 and 19.2). The short-term risks are greater with this alternative than Alternative 1 and similar to Alternative 2 due to off-site transportation of contaminated soil. The short-term risks with this alternative are lower than Alternative 4 because contaminated sediments are not handled and transported for off-site disposal.

19.2.4 Alternative 4

Alternative 4 consists of excavation and off-site disposal of contaminated soil and dredging of Lora Lake. Approximately 2,300 cubic yards of contaminated soil would be excavated from the LL Parcel Shallow Soil Cleanup Area to the dioxin/furan TEQ cleanup level of 5.2 pg/g. Dredging of the LL Parcel Sediment Cleanup Area would remove all current bottom sediments with dioxin/furan, arsenic, and lead contamination to be trucked off-site for landfill disposal.

Due to the nature of the sediments, contaminated sediments will be resuspended during dredging with settling of contaminated sediment onto the post-dredged surface following completion of dredging activities. Because of the resuspension of contaminated sediments, capping of the post-dredge sediment surface would be implemented to contain dredging residuals remaining at concentrations greater than cleanup levels.

19.2.4.1 Model Toxics Control Act Threshold Requirements

- **Protection of Human Health and the Environment:** Alternative 4 provides a high degree of protection to human health and the environment through mass removal of nearly all soil and sediment with COCs at concentrations exceeding cleanup levels. It is expected that some contamination would remain within the lake due to redistribution of dredging residuals, and would be capped. Dredging also has the risk of spreading contamination downstream, into Miller Creek.
- **Compliance with Cleanup Standards:** Alternative 4 complies with all MTCA Cleanup Standards by removing all COCs in soil. Dioxin/furan contamination in Lora Lake sediments would be dredged and the current human health exposure pathway would be eliminated.
- **Compliance with Applicable State and Federal Laws:** Alternative 4 complies with all applicable state and federal laws that are outlined in Section 15.2 and in Tables 15.1 to 15.3 through contaminant mass removal.
- **Provides for Compliance Monitoring:** Alternative 4 meets the requirements for compliance monitoring through implementation of protection monitoring during the remedy implementation and performance monitoring following dredging to confirm the post-dredged surface has attained cleanup levels. No long-term confirmation monitoring is anticipated for soil or sediment with this alternative, because compliance with cleanup standards would be confirmed by performance monitoring during implementation.

19.2.4.2 Remedial Action Objectives

All LL Parcel RAOs would be achieved with Alternative 4, which proposes full excavation of contaminated soil and dredging of contaminated sediments. Alternative 4 protects human receptors from exposure to site COCs that exceed applicable cleanup levels by eliminating the risk of direct contact with contaminated soil. Dredging would reduce dioxin/furan concentrations in the lake to levels comparable to concentrations in underlying native sediment. Significant technical challenges are associated with dredging of the lake, which would require a considerable amount of adjacent land area for dredge spoils and handling and dewatering. These construction impacts could negatively impact surrounding habitat mitigation areas.

Based on discussions with the resource agencies regarding the Lora Lake cleanup alternatives relative to temperature and dissolved oxygen issued in both Lora Lake and Miller Creek and the potential influence and effects on the wetland conditions, it is anticipated that Alternative 4 would not provide an ecological benefit to Miller Creek without additional mitigation measures. Because Alternative 4 does not address temperature and dissolved oxygen requirements, the resource agencies may require additional mitigation measures.

19.2.4.3 Restoration Time Frame

Alternative 4 would address exposure pathways and comply with all RAOs through implementation of mass removal within 2.5 years of the effective date of the Consent Decree. Exposure pathways are managed through the use of excavation and dredging. Soil source removal activities substantially reduce the level of long-term risk at the Site by eliminating the majority of site soil contamination. Contaminants would potentially remain on-site in sediments following dredging due to resuspension and settling onto the post-dredge surface, but the risk of exposure would be eliminated by placement of a sediment cap.

19.2.4.4 Disproportionate Cost Analysis

Alternative 4 received the fourth lowest (i.e., highest) cost per unit benefit ratio compared to all of the alternatives in the DCA, because of the substantial cost of the alternative (Tables 19.1 and 19.2). Alternative 4 scored high in the categories of overall protectiveness, permanence, and long-term effectiveness due the contaminant mass that would be removed from the Site, but scored poorly in the cost, implementability, and short-term risk categories, resulting in a high cost per unit benefit ratio. Alternative 4 received low scores in the implementability and short-term risk categories because of the difficulty and high risks associated with sediment water management and the high volume of handling, management, and disposal of contaminated dredged material.

19.3 REMEDIAL ALTERNATIVES EVALUATION SUMMARY

Based on the evaluation presented in Tables 19.1 and 19.2 and in the text above, including the overall benefit provided by the alternative, compliance with the MTCA Threshold Requirements, and Other MTCA Requirements including restoration time frame, Alternative 3 is selected as the Preferred Remedial Alternative for recommendation to WSDOE. Section 20.0 describes the Preferred Remedial Alternative in greater detail.

20.0 Recommendation of the Preferred Remedial Alternative for the Lora Lake Parcel

In this section, the Preferred Remedial Alternative proposed by the Port to WSDOE for selection and implementation at the LL Parcel is described in greater detail. This section explains how the Preferred Remedial Alternative complies with MTCA, LL Parcel RAOs, and associated ARARs for the lowest cost per unit of benefit,[26] providing the highest level of environmental benefit and permanence per dollar spent, and making it the most permanent to the maximum extent practicable remedy proposed.

20.1 DESCRIPTION OF THE PREFERRED REMEDIAL ALTERNATIVE

The Preferred Remedial Alternative recommended for selection is Alternative 3. Alternative 3 is the highest ranking remedial alternative discussed in Sections 18.0 and 19.0, and is presented in Figure 20.1. The Preferred Remedial Alternative is a comprehensive final remedy for the LL Parcel that is compliant with the applicable remedy selection requirements under MTCA.

The Preferred Remedial Alternative comprises the following individual technologies: contaminant mass removal, contaminant mass isolation, and institutional controls. Together, the individual technologies eliminate or manage the exposure pathways associated with all contamination on the LL Parcel. The Preferred Remedial Alternative contains the following components:

- **LL Parcel Shallow Soil Cleanup Area:** Excavation and off-site disposal of contaminated soil. Excavation at the LL Parcel Shallow Soil Cleanup Area would likely extend to approximately 0.5 to 4 feet bgs for removal of contamination. Specific excavation limits would be determined during design. The horizontal extent of contamination to the east has not been fully analytically bound. The extent of excavation may be based on both compliance with cleanup levels and a net environmental benefit determination. Additional shallow soil data would be collected prior to design and evaluated in a supplemental pre-design characterization report in support of the development of the Draft CAP. Following excavation, clean fill would be placed and vegetation would be re-established in the excavated areas per the NRMP (Parametrix 2001). Excavation would manage the direct contact pathway through mass removal and provide for vegetation growth in accordance with the NRMP and FAA restrictions.
- **LL Parcel Sediment Cleanup Area:** Isolation of the Lora Lake sediments through open water filling of Lora Lake to rehabilitate the wetland. Filling of Lora Lake would isolate the current sediment contamination in place below a thick section of clean fill, eliminating the potential for aquatic exposure or transport of dioxin/furan-contaminated sediments. The fill material would provide a physical barrier between the contaminated sediments and water flowing into

[26] Of the proposed remedial alternatives that comply with the minimum requirements for a cleanup action, as discussed in Section 19.0.

Miller Creek, addressing the benthic and human exposure pathways. The depth of the fill that would be placed in the lake is in excess of the necessary cap thickness determined by the numerical cap modeling (Appendix P) to be protective of the sediment to surface water pathway and the sediment to groundwater pathway (see section 18.3.3). Filling of Lora Lake would consist of placing sand in the lake to an elevation that converts all of the open water area to a depressional wetland system, rehabilitating the hydrogeomorphic conditions that existed prior to the excavation and mining conducted in the 1940s and 1950s that created the lake.

- **Institutional Controls:** In all areas where contamination would remain contained in place following completion of the remedial action, institutional controls would be developed to manage future exposure pathways. Institutional controls are anticipated to prevent dredging or excavation of the filled lake. Additional institutional controls may be implemented as determined necessary during design.

20.1.1 Excavation and Off-site Disposal

Based on existing data, the excavation of contaminated soil with dioxin/furan TEQ concentrations greater than 5.2 pg/g in the LL Parcel Shallow Soil Cleanup Area is estimated to cover approximately 31,000 square feet ranging from 0.5 to 4 feet bgs. Excavation of this volume would result in the removal of approximately 2,300 cubic yards of contaminated soil. Figure 20.1 presents the approximate depths of excavation for the different areas of the parcel that would be excavated. These excavation depths were determined based on all existing soil data. Excavated contaminated soil with dioxin/furan TEQ concentrations greater than 5.2 pg/g would be transported off-site for disposal at a licensed disposal facility. The excavation area would extend outside of the security fence to the edge of the pavement along Des Moines Memorial Drive and include the sidewalk.

The vertical and horizontal limits of soil dioxin/furan contamination have not been completely defined. Given that the LL Shallow Soil Cleanup Area is a special use landscape and mitigation area with limited accessibility and sensitive use restrictions, the extent of excavation may be based on both compliance with cleanup levels and a net environmental benefit determination. Additional shallow soil data would be collected prior to design and evaluated in a supplemental pre-design characterization report in support of the development of the Draft CAP

20.1.2 Open Water Filling of Lora Lake to Rehabilitate the Wetland

Filling Lora Lake to rehabilitate the wetland would isolate the current sediment contamination in place. Filling Lora Lake with sand to an elevation such that there would no longer be any open water is an optimal condition for wetland habitat rehabilitation. This action would require filling the lake over the entire lake footprint to depths between approximately 2 and up to 13 feet, based on existing bathymetry. The Preferred Remedial Alternative would convert the existing open water area to a flow-through depressional wetland system, rehabilitating the hydrogeomorphic conditions that existed prior to historical peat mining. The rehabilitated wetland would be capable of supporting emergent and woody vegetation and would create aquatic habitat that is consistent with the goals of the NRMP. This wetland rehabilitation is considered a preferred form of compensatory mitigation for ecological impacts (WSDOE et al. 2006) and, of all the remedial alternatives evaluated, would provide the maximum ecological benefit to the Miller Creek Basin. The rehabilitated wetland would be designed to:

- increase vegetated wetland habitat, plant species diversity, and microtopographic variations, which could encourage and support a more diverse assemblage of terrestrial species,
- allow for persistent vegetation growth, which improves primary productivity functions, shading, and sediment trapping functions,
- remove habitat for non-native fish species including pumpkinseed, sunfish and largemouth bass, which compete with native salmonid species in the Miller Creek system and which prey on juvenile salmonids,
- eliminate warm water/low dissolved oxygen inputs to Miller Creek by replacing the lake with a more complex vegetated wetland system,
- decrease the avian habitat functions in the current open water wetland that pose aircraft safety concerns,
- preserve the flow-through characteristics and flood de-synchronization functions of the Lora Lake system.

Because of the unconsolidated and flocculent nature of the lake sediments, the initial layers of the fill material would be applied with thin (e.g., 6-inch) lifts of sand via a controlled surface placement technology. The initial layers would be placed on the surface of the lake sediments via the use of a telescopic belt conveyor, or telebelt, and flexifloats, with mounted conveyors for sand placement beyond the reach of the telebelt. The subsequent fill layers to the surface would likely be placed with the controlled placement of the sand fill material directly into the lake from a truck at the shoreline or on a floating barge. The telebelt and construction equipment staging area would be limited to a focused area along the north side of the lake to minimize, to the extent possible, temporary impact to the existing site vegetation. The depth of the fill that would be placed in the lake is significantly thicker than what was determined as a necessary cap thickness with the numerical cap modeling (Appendix P).

The sand fill material selected to fill the lake after the initial fill layers are placed would be designed to optimize the continued hydraulic connectivity of groundwater to Miller Creek. Following the placement of fill material, topsoil would be placed on the converted surface for wetland rehabilitation and riparian vegetation plantings. Engineering design would evaluate the stormwater conveyance, the reconfiguration of the stormwater outfall, associated stormwater engineering, selection of and specifications of fill material, and the flow-through characteristics and flood de-synchronization functions of the Lora Lake system.

The subsurface sediments in Lora Lake, which consist of silty organic sediments and peat, contain high levels of organic carbon. Following the completion of lake filling, the organic carbon rich sediments currently present in the lake that act to adsorb dioxins/furans would remain in place. The strong adsorption to sediment and soil, low water solubilities, and high Koc values combined with the high organic carbon content of Lora Lake sediments and the soils/sediments located between the lake and Miller Creek indicate that the rate of dioxin/furan transport from the lake surface sediments to groundwater, should any such transport occur, would be extremely low.

The surface sediment data collected from Miller Creek had extremely low dioxin/furan TEQ concentrations (i.e., less than 1 pg/g) which do not indicate leaching conditions. Moreover, as described in detail in Section 18.3.3 above and in the numerical cap modeling Appendix P, using the maximum sediment dioxin/furan TEQ concentration detected in Lora Lake of 217 pg/g at LL-SED2, a dioxin 2,3,7,8-TCDD organic carbon partitioning coefficient of 12,500,000 L/kg, and the mean value of the current Lora Lake surface sediment TOC (8 percent) in a conservative equilibrium partitioning calculation, the resulting sediment pore water dioxin/furan TEQ concentration that could theoretically migrate with horizontal groundwater flow is 0.217 pg/L This result is two orders of magnitude less than the MW-1 maximum groundwater TEQ concentration of 38.3 pg/L.

The distance between the LL-SED2 sampling location and Miller Creek is approximately 220 feet. This distance is greater than the distance at which the source concentration from MW-1 was shown to attenuate to less than the surface water criterion (90–150 feet downgradient). Therefore, even if it was assumed that the MW-1 maximum groundwater TEQ concentration of 38.3 pg/L was located at LL-SED2, rather than the pore water concentration of 0.217 pg/L, any potential horizontal groundwater transport of dioxins/furans in sediment pore water, following filling of the lake, would attenuate to less than the surface water criterion of 0.005 pg/L prior to reaching Miller Creek.

The Preferred Remedial Alternative would require the construction of a temporary construction access road and construction equipment staging area along the north side of the lake. This road would allow for truck and equipment access to the lake. Construction of the road would likely result in the removal of a small stand of alder trees in the Lora Lake buffer and disturb a small area of wetland vegetation along the lake fringe. Following alternative construction, the road would be removed and area would be re-vegetated and restored.

20.2 COMPLIANCE MONITORING REQUIREMENTS

Compliance monitoring requirements associated with remedy implementation consist of protection monitoring during construction activities, performance monitoring to ensure remedy construction in accordance with the project plans and design, and confirmation monitoring following remedy completion to confirm the long-term effectiveness of the remedy.

20.2.1 Protection Monitoring

Protection monitoring during remedy construction would be conducted to confirm protection of human health and the environment during the construction and operation and maintenance activities required at the Site. Protection monitoring requirements would be described in worker site-specific Health and Safety Plans covering the worker activities both during construction and during any future operations and maintenance of the constructed remedy, such as maintenance activities.

20.2.2 Performance Monitoring

Performance monitoring activities would be conducted during remedy construction, and would include the following:

- Analytical testing to confirm the soil excavation extent as determined necessary during the design process.
- Quality control monitoring for construction activities, such as survey confirmation of excavation extent.
- Any additional sampling or testing as may be required for substantive compliance with ARARs.

20.2.3 Confirmation Monitoring

Following remedy completion, confirmation monitoring may be performed to ensure the wetland rehabilitation is functioning as intended, and that contaminants in lake sediments are adequately contained by the sediment cap.

20.3 COMPLIANCE WITH THE MODEL TOXICS CONTROL ACT

The Preferred Remedial Alternative for the LL Parcel meets the minimum requirements for selection of a cleanup action under MTCA WAC 173-340-360(2)(a) because it is protective of human health and the environment, complies with cleanup standards, complies with applicable state and federal laws, and provides for compliance monitoring.

The preferred remedy is more protective of human health and the environment than Alternatives 1 and 2 because the dioxin/furan contaminant mass in soil in excess of 5.2 pg/g would either be removed for landfill disposal or be capped in a manner that preserves the mitigation habitat conditions and environmental net benefit, while impacted sediments would be isolated by a thick cover that also enhances natural resources. Additionally, the preferred sediment remedy is more protective of human health and the environment than Alternatives 1 and 2 because filling the lake to the existing lake surface completely isolates the contamination from surface water and direct benthic contact, and the wetland habitat is rehabilitated to improve the wetland functions and downstream water quality conditions.

The shallow soil remedy that would be implemented with the Preferred Remedial Alternative is the same remedy that would be implemented for Alternative 4. Alternative 4 receives higher scores for permanence than the Preferred Remedial Alternative because sediment contamination is removed for off-site disposal. Although in the Preferred Remedial Alternative contaminant mass would remain on-site in sediments in perpetuity, the contamination would be isolated below the lake fill and rehabilitated wetland. The Preferred Remedial Alternative relies on institutional controls to prevent future excavation of the filled lake. These institutional controls are fully consistent with the existing STIA and 3rd Runway Mitigation Area restrictive covenants, in which future development on the

LL Parcel is prohibited and the LL Parcel will be maintained as a protected wetland aquatic habitat area in perpetuity. Risks to site workers during construction would be mitigated through BMPs and the use of appropriate personal protective equipment. The Preferred Remedial Alternative ranks higher than Alternative 4 for short-term risk management and implementability because the Preferred Remedial Alternative requires much less disturbance, movement, and potential redistribution of contaminated material than Alternative 4. In Alternative 4, a large volume of material would be hydraulically dredged and pumped to geobags. The sediment slurry water would likely be contained, sampled for turbidity, and pumped back to the lake, and the geobags with the sediment would be handled for off-site disposal. Dredging would also cause substantial temporary impacts to the surrounding site. Despite the potential environmental risks associated with those actions, dredging is not anticipated to successfully remove all contamination because of the flocculent nature of the sediments. The Preferred Remedial Alternative ranked the highest for the Technical and Administrative Implementability criteria because it was viewed more favorably than the other alternatives by the resource agencies due to the net environmental benefit it provides to Miller Creek and the rehabilitation of the wetland to its historical form and function.

The Preferred Remedial Alternative also meets the Other MTCA Requirements for selection under MTCA WAC 173-340-360(2)(b), such as using permanent solutions to the maximum extent practicable, providing for a reasonable restoration time frame, and consideration of public concerns. The Preferred Remedial Alternative utilizes permanent solutions to the maximum extent practicable, based on a balance between permanence and cost as determined by the DCA. Excavation of the LL Parcel Shallow Soil Cleanup Area is a permanent solution because no further action is required for this area. Open water filling the lake to rehabilitate the wetland is a permanent solution to the maximum extent practicable because isolation of the sediment contamination is a permanent action, as determined in the DCA. The Preferred Remedial Alternative provides for a reasonable restoration time frame through implementation of the remedy within 2.5 years of the effective date of the Consent Decree. With the Preferred Remedial Alternative, exposure pathways are managed through the use of excavation, isolation, and controls immediately following implementation. Soil source removal activities reduce the level of long-term risk on the Lora Lake Parcel by reducing or eliminating soil contamination.

The Draft RI/FS document was provided to the public through a public comment process in coordination with WSDOE. Public comments received on the Draft RI/FS were considered in the remedy selection process conducted in the CAP. WSDOE formally responded to all received public comments in a responsiveness summary (WSDOE 2015). This summary documents how each of the public comments received in writing during the public comment period were considered.

20.4 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The Preferred Remedial Alternative complies with all applicable ARARs that are in Tables 15.1 to 15.3. Chemical-specific ARARs are met through compliance with applicable cleanup level criteria. Location-specific ARARs are met through compliance with all applicable state, federal, local, and STIA regulations in place for the physical location of the Site. Applicable action-specific ARARs would be met through implementation of construction activities in compliance with all applicable construction related requirements such as health and safety restrictions, site use and other local permits, and disposal requirements for excavated soil.

20.5 COMPLIANCE WITH REMEDIAL ACTION OBJECTIVES

The Preferred Remedial Alternative achieves the LL Parcel RAOs through the following actions:

- The Preferred Remedial Alternative protects human receptors from exposure to site contamination that exceeds applicable cleanup levels by eliminating the risk of direct contact with contamination through excavation of soil and isolation of the Lora Lake sediments through open water filling to rehabilitate the wetland.
- The Preferred Remedial Alternative prevents fish exposure to contaminated sediments by filling Lora Lake and converting the open water habitat to a rehabilitated depressional wetland, thereby managing the potential human exposure pathway that could have resulted from consumption of fish obtained in Miller Creek that had been exposed to contaminants in surface sediments. The Preferred Remedial Alternative addresses the pathway of dioxins/furans, arsenic, and lead in sediments leaching to surface water by isolating the contamination. The equilibrium partitioning calculations and BIOSCREEN-AT modeling results present how the sediment to groundwater pathway is protective.
- The Preferred Remedial Alternative prevents migration of contaminants from the site surface soils by erosion through excavation of the contaminated shallow soil and re-vegetation of the surface.
- The Preferred Remedial Alternative complies with the mitigation area requirements. Based on input from resource agencies, the Preferred Remedial Alternative is viewed positively because it rehabilitates the wetland and restores the historical form and functions. Additionally, the Preferred Remedial Alternative has an ecological benefit on the Miller Creek Relocation Reach by replacing a source of warm water/low dissolved oxygen inputs to Miller Creek, lowering stream temperatures and increasing dissolved oxygen. As a result of these outcomes, the Preferred Remedial Alternative is considered to be self-mitigating, meaning the benefits of rehabilitating the wetland offset the short-term construction impacts, and it is assumed that no additional mitigation would be needed.

20.6 SITE OWNERSHIP AND ACCESS

The LL Parcel is currently owned by the Port. The City of SeaTac owns a portion of the Des Moines Memorial Drive Right-of-Way to the west of the LL Parcel. WSDOT owns the SR 518 right-of-way immediately north of the LL Parcel. Proposed remedial actions would take place, for the most part, on Port-owned property; however, depending on the excavation extent determined in design, the City of SeaTac right-of-way and sidewalk may require limited excavation. No contamination is thought to lie beneath Des Moines Memorial Drive along the LL Parcel, but institutional controls could be implemented to manage any contaminated soil remaining in-place beneath the roadway. The necessity of construction access to this area not owned by the Port would be determined during the design process.

The LL Parcel is expected to remain Port property in perpetuity because it is located within the FAA RPZ-Controlled Activity Area and the FAA RPZ-Extended Object Free Area, which require that the area be kept clear of objects including structures, equipment, and terrain, except for those objects necessary for air navigation or aircraft ground-maneuvering purposes. FAA restrictions prohibit any future development that is inconsistent with the area rules as long as STIA is an operating airport.

20.7 INSTITUTIONAL CONTROLS

The Preferred Remedial Alternative includes select institutional controls to manage potential future exposure pathways and ensure the longevity of the proposed remedial action.

Institutional controls for the LL Parcel may include the following:

- **Requirements for Soil Disturbance in the Filled Lora Lake Wetland Area.** Controls limiting and/or managing worker health and safety for any potential fill-disturbing activities associated with the maintenance of the Lora Lake mitigation area by Port workers.

20.8 SUMMARY OF THE ESTIMATED REMEDY COSTS

Estimated remedial costs for the recommended Preferred Remedial Alternative are presented in Appendix Q. The costs associated with remedy implementation consist of capital construction costs, confirmation monitoring following remedy completion, long-term sediment cap performance monitoring, and agency oversight that would include periodic reviews of the constructed remedy. The estimated costs for remedy construction are as follows:

- Agency oversight, planning, and permitting costs associated with remedy implementation are estimated to be $0.3 million.
- Construction capital costs that include excavation, lake filling, wetland hydroseeding, and repair of disturbed areas for the LL Parcel are estimated to be approximately $2.5 million.
  - Wetland mitigation costs for the temporary impacts from the construction access road and staging are estimated to be $0, because the site is considered self-mitigating.
  - Costs associated with long-term monitoring of the sediment remedy will be determined in the Compliance Monitoring Plan when the scope of monitoring is determined. For this estimate, the costs associated with long-

term monitoring are assumed to be within the -30 percent to +50 percent accuracy of the remedial cost estimate.

The total project cost for the Preferred Remedial Alternative, which includes an additional $1.5 million contingency cost, is estimated to be $4.3 million.

21.0 References

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Port of Seattle
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Remedial Investigation/ Feasibility Study

Volume I

Tables

FINAL

Table 2.1
Vertical Groundwater Gradients of Shallow/Deep Well Pairs

Monitoring Well	Screen Interval (ft bgs)	Ground Surface Elevation (ft NAVD88)	Top of Well Casing Elevation (ft NAVD88)	Screen Midpoint Elevation (ft NAVD88)	Water Level Date	Water Level (ft bTOC)	Water Elevation (ft NAVD88)	Vertical Gradient[1]
MW-1	10–20	305.10	304.67	290.10	August/September 2010	17.38	287.29	0.0200
MW-16	37.25–47.25	298.42	298.15	256.17		11.54	286.61	
MW-1	10–20	305.10	304.67	290.10	January 2011	14.11	290.56	0.0486
MW-16	37.25–47.25	298.42	298.15	256.17		9.24	288.91	
MW-1	10–20	305.10	304.67	290.10	April 2011	14.51	290.16	0.0283
MW-16	37.25–47.25	298.42	298.15	256.17		8.95	289.20	
MW-4	11–26	298.72	297.97	280.22	August/September 2010	16.88	281.09	-0.0369
MW-17	42–52	298.22	297.98	251.22		15.82	282.16	
MW-4	11–26	298.72	297.97	280.22	January 2011	14.71	283.26	-0.0155
MW-17	42–52	298.22	297.98	251.22		14.27	283.71	
MW-4	11–26	298.72	297.97	280.22	April 2011	14.91	283.06	-0.0145
MW-17	42–52	298.22	297.98	251.22		14.50	283.48	
MW-5	13–28	299.21	298.55	278.71	August/September 2010	21.00	277.55	-0.1337
MW-15	47.25–57.25	299.92	299.63	247.67		17.93	281.70	
MW-5	13–28	299.21	298.55	278.71	January 2011	19.19	279.36	-0.1537
MW-15	47.25–57.25	299.92	299.63	247.67		15.50	284.13	
MW-5	13–28	299.21	298.55	278.71	April 2011	19.40	279.15	-0.1624
MW-15	47.25–57.25	299.92	299.63	247.67		15.44	284.19	

Note:
1 Upward (-), downward (+).

Abbreviations:
ft Feet
bgs Below ground surface
NAVD88 North American Vertical Datum of 1988
bTOC Below top of casing

Table 3.1
Summary of Investigations

Analyte	Number of Samples			
	Soil	Groundwater	Sediment	Air
GeoScience Management Focused Subsurface Investigation—2007[1]				
Metals	4	4		
Total Petroleum Hydrocarbons	10	9		
Semivolatile Organic Compounds	4	6		
Volatile Organic Compounds	2	5		
Benzene, Toluene, Ethylbenzene, Xylenes	2	5		
Dioxins/Furans	2	1		
Polychlorinated Biphenyls	2	4		
AECOM Soil, Groundwater, and Sub-slab Air Investigation—2008[1]				
Metals	42	7		
Total Petroleum Hydrocarbons	42	7		
Semivolatile Organic Compounds	42	7		
Volatile Organic Compounds	42	7		5
Benzene, Toluene, Ethylbenzene, Xylenes	42	7		5
Dioxins/Furans	42	7		
Polychlorinated Biphenyls	22			
AECOM Supplemental Groundwater Investigations—August and December 2008				
Metals		13		
Total Petroleum Hydrocarbons		13		
Semivolatile Organic Compounds		13		
Dioxins/Furans		13		
Floyd|Snider Remedial Investigation (LL Apartments Parcel, LL Parcel, and DMCA)—2010–2011[1,2]				
Metals	151	47	17	
Total Petroleum Hydrocarbons	135	57		
Semivolatile Organic Compounds	146	57	17	
Volatile Organic Compounds	136	57	9	
Benzene, Toluene, Ethylbenzene, Xylenes	112	57		
Dioxins/Furans	155	47	17	

Notes:
Blank cells indicate that the medium was not sampled for a parameter.
1 Soil and sediment samples include both surface and subsurface samples.
2 Groundwater samples include monitoring wells located on the Lora Lake Apartments Parcel and downgradient wells in the DMCA.

Abbreviations:
DMCA Dredged Material Containment Area
LL Lora Lake

Table 4.1
Frequency of Detections for Lora Lake Apartments Parcel Soil Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Depth of Maximum Detect (feet)	Number of Non-detects	% Non-detect	Minimum Non-detected Value	Maximun Non-detected Value
Conventionals													
Moisture	%	8	8	100%	6	14	LLP-03	7/25/2007	6–7	0	0%	--	--
Total Organic Carbon	%	43	43	100%	0.029	14.5	PSB-21	8/25/2010	6–7	0	0%	--	--
Total Solids	%	99	99	100%	24.5	95.5	PSB-12	7/28/2010	8–10	0	0%	--	--
Metals													
Antimony	mg/kg	42	42	100%	0.05	3.51	LL-08	4/3/2008	2–4	0	0%	--	--
Arsenic	mg/kg	163	60	37%	0.89	11.2	MW-2	3/18/2008	0–0.5	103	63%	2	20
Barium	mg/kg	2	2	100%	49	51	LLP-04	7/25/2007	14.5–15.5	0	0%	--	--
Beryllium	mg/kg	42	42	100%	0.14	0.323	MW-3	3/18/2008	6.5–8	0	0%	--	--
Cadmium	mg/kg	44	42	95%	0.031	4.49	MW-5	3/17/2008	0–0.5	2	5%	0.56	0.56
Chromium	mg/kg	44	44	100%	18.9	52.9	MW-6	3/18/2008	0–0.5	0	0%	--	--
Copper	mg/kg	42	42	100%	6.13	72.6	MW-5	3/17/2008	0–0.5	0	0%	--	--
Lead	mg/kg	161	128	80%	1.82	2,880	PSB-11	7/30/2010	2–4	33	20%	1	2.14
Mercury	mg/kg	44	41	93%	0.01	0.215	MW-6	3/18/2008	0–0.5	3	7%	0.02	0.28
Nickel	mg/kg	42	42	100%	21.7	44.6	MW-4	3/17/2008	14–15.5	0	0%	--	--
Selenium	mg/kg	44	16	36%	0.3	1.1	MW-4 MW-3	3/17/2008 3/18/2008	9–10.5 0–0.5	28	64%	1	11
Silver	mg/kg	44	42	95%	0.015	0.188	MW-4	3/17/2008	0–0.5	2	5%	0.56	0.56
Thallium	mg/kg	42	42	100%	0.03	0.096	MW-5	3/17/2008	0–0.5	0	0%	--	--
Zinc	mg/kg	42	42	100%	18.8	641	MW-5	3/17/2008	0–0.5	0	0%	--	--
Total Petroleum Hydrocarbons													
Gasoline Range Hydrocarbons	mg/kg	140	19	14%	0.65	1,900	LLP-04	7/25/2007	14.5–15.5	121	86%	2.6	440
Diesel Range Hydrocarbons	mg/kg	171	63	37%	1.4	8,900	MW-1	10/25/2007	14–15	108	63%	5	95
Heavy Oil Range Hydrocarbons[1]	mg/kg	171	79	46%	12	17,000	LLP-04	7/25/2007	14.5–15.5	92	54%	10	380
Semivolatile Organic Compounds													
1,2-Diphenylhydrazine	µg/kg	2	0	--	--	--	--	--	--	2	100%	190	740
1-Methylnaphthalene	µg/kg	2	1	50%	4,300	4,300	LLP-04	7/25/2007	14.5–15.5	1	50%	15	15
2,3,4,6-Tetrachlorophenol	µg/kg	2	0	--	--	--	--	--	--	2	100%	190	740
2,3,5,6-Tetrachlorophenol	µg/kg	2	0	--	--	--	--	--	--	2	100%	190	740
2,4,5-Trichlorophenol	µg/kg	46	0	--	--	--	--	--	--	46	100%	5.3	740
2,4,6-Trichlorophenol	µg/kg	46	0	--	--	--	--	--	--	46	100%	5.3	740
2,4-Dichlorophenol	µg/kg	46	0	--	--	--	--	--	--	46	100%	5.3	740
2,4-Dimethylphenol	µg/kg	45	0	--	--	--	--	--	--	45	100%	27	1,000
2,4-Dinitrophenol	µg/kg	46	0	--	--	--	--	--	--	46	100%	110	5,700
2-Chloronaphthalene	µg/kg	46	0	--	--	--	--	--	--	46	100%	5.3	740
2-Chlorophenol	µg/kg	46	0	--	--	--	--	--	--	46	100%	5.3	740
2-Methylnaphthalene	µg/kg	46	9	20%	2.4	12,000	MW-1	10/25/2007	14–15	37	80%	5.3	200
2-Methylphenol	µg/kg	46	0	--	--	--	--	--	--	46	100%	5.3	740
2-Nitrophenol	µg/kg	46	0	--	--	--	--	--	--	46	100%	5.3	740
3- & 4-Methylphenol	µg/kg	3	0	--	--	--	--	--	--	3	100%	190	740
4,6-Dinitro-o-cresol	µg/kg	46	0	--	--	--	--	--	--	46	100%	53	3,700
4-Chloro-3-methylphenol	µg/kg	46	0	--	--	--	--	--	--	46	100%	5.3	740
4-Methylphenol	µg/kg	43	4	9%	1.6	39	LL-08	4/3/2008	2–4	39	91%	5.3	290
4-Nitrophenol	µg/kg	46	0	--	--	--	--	--	--	46	100%	53	2,900
Acenaphthene	µg/kg	46	8	17%	2.2	1,200	MW-1	10/25/2007	14–15	38	83%	5.3	99
Acenaphthylene	µg/kg	46	13	28%	1.2	450	MW-1	10/25/2007	14–15	33	72%	5.3	200
Aniline	µg/kg	2	0	--	--	--	--	--	--	2	100%	190	740

Table 4.1
Frequency of Detections for Lora Lake Apartments Parcel Soil Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Depth of Maximum Detect (feet)	Number of Non-detects	% Non-detect	Minimum Non-detected Value	Maximun Non-detected Value
Semivolatile Organic Compounds (continued)													
Anthracene	µg/kg	46	15	33%	1.6	2,300	MW-1	10/25/2007	14–15	31	67%	5.3	200
Benzidine	µg/kg	2	0	--	--	--	--	--	--	2	100%	1900	7,400
Benzo(b)fluoranthene	µg/kg	46	27	59%	2	880	LLP-04	7/25/2007	14.5–15.5	19	41%	5.3	200
Benzo(g,h,i)perylene	µg/kg	46	26	57%	2.2	320	MW-1	10/25/2007	14–15	20	43%	5.3	55
Benzo(k)fluoranthene	µg/kg	46	19	41%	1.5	260	MW-1	10/25/2007	14–15	27	59%	5.3	200
Benzoic acid	µg/kg	27	5	19%	110	270	LL-01	4/3/2008	0–0.5	22	81%	110	5,700
Benzyl alcohol	µg/kg	46	5	11%	2.7	51	LL-07	4/3/2008	0–0.5	41	89%	11	740
bis(2-chloroethoxy)methane	µg/kg	46	0	--	--	--	--	--	--	46	100%	5.3	740
bis(2-ethylhexyl)phthalate	µg/kg	46	32	70%	7.1	470	MW-5	3/17/2008	6.5–8	14	30%	53	2,900
Butyl benzyl phthalate	µg/kg	46	6	13%	4.4	49	LL-08	4/3/2008	2–4	40	87%	5.3	740
Carbazole	µg/kg	2	0	--	--	--	--	--	--	2	100%	190	740
Dibenzofuran	µg/kg	46	7	15%	1.5	1,000	MW-1	10/25/2007	14–15	39	85%	5.3	740
Diethylphthalate	µg/kg	46	4	9%	5.5	7.3	LL-07	4/3/2008	0–0.5	42	91%	5.3	740
Dimethyl phthalate	µg/kg	46	1	2%	740	740	LLP-04	7/25/2007	14.5–15.5	45	98%	5.3	290
Di-n-butyl phthalate	µg/kg	46	5	11%	8.2	330	MW-5	3/17/2008	0–0.5	41	89%	11	740
Di-n-octyl phthalate	µg/kg	46	0	--	--	--	--	--	--	46	100%	5.3	740
Fluoranthene	µg/kg	46	31	67%	2.6	3,000	MW-1	10/25/2007	14–15	15	33%	5.3	55
Fluorene	µg/kg	46	12	26%	1.1	2,700	MW-1	10/25/2007	14–15	34	74%	5.3	200
Hexachlorobutadiene	µg/kg	71	0	--	--	--	--	--	--	71	100%	5.5	740
Hexachlorocyclopentadiene	µg/kg	46	0	--	--	--	--	--	--	46	100%	29	1,500
Isophorone	µg/kg	46	0	--	--	--	--	--	--	46	100%	5.3	740
Naphthalene	µg/kg	90	25	28%	0.17	7,900	LLP-04	7/25/2007	14.5–15.5	65	72%	1.1	200
N-Nitrosodimethylamine	µg/kg	2	0	--	--	--	--	--	--	2	100%	190	740
N-Nitroso-di-n-propylamine	µg/kg	46	0	--	--	--	--	--	--	46	100%	5.3	740
N-Nitrosodiphenylamine	µg/kg	46	1	2%	1,900	1,900	LLP-04	7/25/2007	14.5–15.5	45	98%	5.3	290
Pentachlorophenol	µg/kg	157	69	44%	8.5	15,000	MW-4	3/17/2008	0–0.5	88	56%	5.9	3,700
Phenanthrene	µg/kg	46	32	70%	1.7	8,800	MW-1	10/25/2007	14–15	14	30%	5.3	55
Phenol	µg/kg	46	1	2%	5.1	5.1	MW-1	10/25/2007	7–8	45	98%	16	850
Pyrene	µg/kg	46	35	76%	1.5	2,700	MW-1	10/25/2007	14–15	11	24%	5.3	9.9
Total HPAH	µg/kg	45	34	76%	7	10,350	MW-1	10/25/2007	14–15	11	24%	5.3	9.9
Total LPAH	µg/kg	45	33	73%	1.7	18,950	MW-1	10/25/2007	14–15	12	27%	5.3	21
Total PAH	µg/kg	45	35	78%	5.5	29,300	MW-1	10/25/2007	14–15	10	22%	5.3	9.9
Carcinogenic Polycyclic Aromatic Hydrocarbons													
Benzo(a)pyrene	µg/kg	158	28	18%	1.9	630	MW-1	10/25/2007	14–15	130	82%	5.3	390
Benzo(a)anthracene	µg/kg	158	35	22%	2	890	MW-1	10/25/2007	14–15	123	78%	5.3	390
Benzofluoranthenes (total)	µg/kg	157	42	27%	2	1,030	LLP-04	7/25/2007	14.5–15.5	115	73%	5.3	390
Chrysene	µg/kg	158	53	34%	1.6	1,500	MW-1	10/25/2007	14–15	105	66%	5.3	390
Dibenzo(a,h)anthracene	µg/kg	158	12	8%	1.8	88	LLP-04	7/25/2007	14.5–15.5	146	92%	5.3	390
Indeno(1,2,3-cd)pyrene	µg/kg	158	27	17%	1.6	370	MW-1	10/25/2007	14–15	131	83%	5.3	390
Summed cPAH TEQ[2,3]	µg/kg	158	56	35%	0.022	870	MW-1	10/25/2007	14–15	102	65%	0	0
Summed cPAH TEQ with One-half of the Reporting Limit[2,4]	µg/kg	158	56	35%	3.8	880	MW-1	10/25/2007	14–15	102	65%	4	270
Volatile Organic Compounds													
1,1,1,2-Tetrachloroethane	µg/kg	44	0	--	--	--	--	--	--	44	100%	1.1	110
1,1,1-Trichloroethane	µg/kg	44	1	2%	0.28	0.28	LL-12	4/3/2008	0–0.5	43	98%	1.1	110
1,1,2,2-Tetrachloroethane	µg/kg	44	0	--	--	--	--	--	--	44	100%	1.1	110

Table 4.1
Frequency of Detections for Lora Lake Apartments Parcel Soil Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Depth of Maximum Detect (feet)	Number of Non-detects	% Non-detect	Minimum Non-detected Value	Maximun Non-detected Value
Volatile Organic Compounds (continued)													
1,1,2-Trichloroethane	µg/kg	44	0	--	--	--	--	--	--	44	100%	1.1	110
1,1-Dichloroethane	µg/kg	44	0	--	--	--	--	--	--	44	100%	1.1	110
1,1-Dichloroethene	µg/kg	44	0	--	--	--	--	--	--	44	100%	1.1	110
1,1-Dichloropropene	µg/kg	44	0	--	--	--	--	--	--	44	100%	1.1	110
1,2,3-Trichlorobenzene	µg/kg	44	0	--	--	--	--	--	--	44	100%	1.1	110
1,2,3-Trichloropropane	µg/kg	44	0	--	--	--	--	--	--	44	100%	1.1	110
1,2,4-Trichlorobenzene	µg/kg	90	1	1%	0.35	0.35	MW-5	3/17/2008	0–0.5	89	99%	1.1	740
1,2,4-Trimethylbenzene	µg/kg	44	7	16%	0.097	18,000	LLP-04	7/25/2007	14.5–15.5	37	84%	11	31
1,2-Dibromo-3-chloropropane	µg/kg	44	0	--	--	--	--	--	--	44	100%	5.6	560
1,2-Dibromoethane	µg/kg	44	0	--	--	--	--	--	--	44	100%	1.1	110
1,2-Dichlorobenzene	µg/kg	89	0	--	--	--	--	--	--	89	100%	1.1	740
1,2-Dichloroethane	µg/kg	146	0	--	--	--	--	--	--	146	100%	0.4	110
1,2-Dichloropropane	µg/kg	44	0	--	--	--	--	--	--	44	100%	1.1	110
1,3,5-Trimethylbenzene	µg/kg	44	2	5%	0.13	7,400	LLP-04	7/25/2007	14.5–15.5	42	95%	1.1	39
1,3-Dichlorobenzene	µg/kg	89	0	--	--	--	--	--	--	89	100%	1.1	740
1,3-Dichloropropane	µg/kg	44	0	--	--	--	--	--	--	44	100%	1.1	110
1,4-Dichlorobenzene	µg/kg	89	8	9%	0.14	20	MW-5	3/17/2008	0–0.5	81	91%	1.1	740
2,2-Dichloropropane	µg/kg	44	0	--	--	--	--	--	--	44	100%	1.1	110
2,4-Dinitrotoluene	µg/kg	46	0	--	--	--	--	--	--	46	100%	5.3	740
2,6-Dinitrotoluene	µg/kg	46	0	--	--	--	--	--	--	46	100%	5.3	740
2-Chloroethyl vinyl ether	µg/kg	2	0	--	--	--	--	--	--	2	100%	11	1,100
2-Chlorotoluene	µg/kg	44	0	--	--	--	--	--	--	44	100%	1.1	110
2-Hexanone	µg/kg	44	0	--	--	--	--	--	--	44	100%	5.6	560
2-Nitroaniline	µg/kg	46	0	--	--	--	--	--	--	46	100%	11	740
3,3'-Dichlorobenzidine	µg/kg	46	0	0%	--	--	--	--	--	46	100%	53	7,400
3-Nitroaniline	µg/kg	46	0	0%	--	--	--	--	--	46	100%	11	740
4-Bromophenyl phenyl ether	µg/kg	46	0	0%	--	--	--	--	--	46	100%	5.3	740
4-Chloroaniline	µg/kg	46	0	0%	--	--	--	--	--	46	100%	5.3	740
4-Chlorophenyl phenyl ether	µg/kg	46	0	0%	--	--	--	--	--	46	100%	5.3	740
4-Chlorotoluene	µg/kg	44	0	0%	--	--	--	--	--	44	100%	1.1	110
4-Nitroaniline	µg/kg	46	0	0%	--	--	--	--	--	46	100%	11	740
Acetone	µg/kg	44	42	95%	3	410	MW-5	3/17/2008	0–0.5	2	5%	20	560
Benzene	µg/kg	141	2	1%	0.96	1.7	MW-5	3/17/2008	0–0.5	139	99%	0.5	1,100
bis(2-chloroethyl)ether	µg/kg	46	0	0%	--	--	--	--	--	46	100%	5.3	740
bis(2-chloroisopropyl)ether	µg/kg	46	0	0%	--	--	--	--	--	46	100%	5.3	740
Bromobenzene	µg/kg	44	0	0%	--	--	--	--	--	44	100%	1.1	110
Bromochloromethane	µg/kg	44	0	0%	--	--	--	--	--	44	100%	1.1	110
Bromodichloromethane	µg/kg	44	0	0%	--	--	--	--	--	44	100%	1.1	110
Bromoform	µg/kg	44	0	0%	--	--	--	--	--	44	100%	1.1	110
Bromomethane	µg/kg	44	0	0%	--	--	--	--	--	44	100%	2.8	560
Carbon disulfide	µg/kg	44	18	41%	0.059	2.2	MW-2	3/18/2008	1.5–2	26	59%	1.1	110
Carbon tetrachloride	µg/kg	44	0	0%	--	--	--	--	--	44	100%	1.1	110
Chlorobenzene	µg/kg	44	0	0%	--	--	--	--	--	44	100%	1.1	110
Chloroethane	µg/kg	44	0	0%	--	--	--	--	--	44	100%	1.1	110
Chloroform	µg/kg	44	0	0%	--	--	--	--	--	44	100%	1.1	110
Chloromethane	µg/kg	44	0	0%	--	--	--	--	--	44	100%	1.1	110

Table 4.1
Frequency of Detections for Lora Lake Apartments Parcel Soil Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Depth of Maximum Detect (feet)	Number of Non-detects	% Non-detect	Minimum Non-detected Value	Maximun Non-detected Value
Volatile Organic Compounds (continued)													
cis-1,2-Dichloroethene	µg/kg	146	0	0%	--	--	--	--	--	146	100%	0.4	110
cis-1,3-Dichloropropene	µg/kg	44	0	0%	--	--	--	--	--	44	100%	1.1	110
Cymene	µg/kg	44	7	16%	0.11	5,500	LLP-04	7/25/2007	14.5–15.5	37	84%	11	39
Dibromochloromethane	µg/kg	44	0	0%	--	--	--	--	--	44	100%	1.1	110
Dibromomethane	µg/kg	44	0	0%	--	--	--	--	--	44	100%	1.1	110
Dichlorodifluoromethane	µg/kg	44	21	48%	0.14	12	MW-6	3/18/2008	0–0.5	23	52%	1.1	110
Ethylbenzene	µg/kg	141	8	6%	0.23	1,400	LLP-04	7/25/2007	14.5–15.5	133	94%	0.5	1,100
Hexachlorobenzene	µg/kg	46	1	2%	1.7	1.7	LL-01	4/3/2008	1.5–2	45	98%	5.3	740
Hexachloroethane	µg/kg	46	0	0%	--	--	--	--	--	46	100%	5.3	740
Iodomethane	µg/kg	2	0	0%	--	--	--	--	--	2	100%	5.6	560
iso-Propylbenzene	µg/kg	44	1	2%	1,500	1,500	LLP-04	7/25/2007	14.5–15.5	43	98%	1.1	39
Methyl ethyl ketone	µg/kg	44	22	50%	1.5	26	MW-6	3/18/2008	0–0.5	22	50%	15	560
Methyl iso butyl ketone	µg/kg	44	1	2%	0.95	0.95	MW-5	3/17/2008	0–0.5	43	98%	5.6	560
Methylene Chloride	µg/kg	44	20	45%	0.34	6.4	MW-6	3/18/2008	0–0.5	24	55%	5.6	560
Methyl-tert-butyl ether	µg/kg	2	0	0%	--	--	--	--	--	2	100%	1.1	110
n-Butylbenzene	µg/kg	44	2	5%	5.7	2,700	LLP-04	7/25/2007	14.5–15.5	42	95%	11	39
Nitrobenzene	µg/kg	46	0	0%	--	--	--	--	--	46	100%	5.3	740
n-Propylbenzene	µg/kg	44	1	2%	2,800	2,800	LLP-04	7/25/2007	14.5–15.5	43	98%	1.1	39
Pyridine	µg/kg	2	0	0%	--	--	--	--	--	2	100%	190	740
sec-Butylbenzene	µg/kg	44	2	5%	9.6	1,600	LLP-04	7/25/2007	14.5–15.5	42	95%	11	39
Styrene	µg/kg	44	1	2%	0.12	0.12	MW-5	3/17/2008	0–0.5	43	98%	1.1	110
tert-Butylbenzene	µg/kg	44	1	2%	120	120	LLP-04	7/25/2007	14.5–15.5	43	98%	1.1	39
Tetrachloroethene	µg/kg	146	3	2%	0.6	0.9	MW-12	8/2/2010	5.5–7.5	143	98%	0.4	110
Toluene	µg/kg	141	43	30%	0.22	620	LLP-04	7/25/2007	14.5–15.5	98	70%	0.5	1100
trans-1,2-Dichloroethene	µg/kg	146	0	0%	--	--	--	--	--	146	100%	0.4	110
trans-1,3-Dichloropropene	µg/kg	44	0	0%	--	--	--	--	--	44	100%	1.1	110
Trichloroethene	µg/kg	146	1	1%	0.8	0.8	PSB-11	7/30/2010	1.5–2	145	99%	0.4	110
Trichlorofluoromethane	µg/kg	44	4	9%	0.21	2.7	MW-3	3/18/2008	14–15.5	40	91%	1.1	110
Vinyl acetate	µg/kg	2	0	0%	--	--	--	--	--	2	100%	5.6	560
Vinyl chloride	µg/kg	44	0	0%	--	--	--	--	--	44	100%	1.1	110
m,p-Xylene	µg/kg	141	23	16%	0.18	8,400	LLP-04	7/25/2007	14.5–15.5	118	84%	0.5	2,200
o-Xylene	µg/kg	141	16	11%	0.17	4,100	LLP-04	7/25/2007	14.5–15.5	125	89%	0.5	69
Dioxins/Furans													
2,3,7,8-TCDD	pg/g	165	88	53%	0.098	446	PSB-11	7/30/2010	1.5–2	77	47%	0.0197	0.84
1,2,3,7,8-PeCDD	pg/g	165	119	72%	0.108	1,540	PSB-11	7/30/2010	1.5–2	46	28%	0.0161	1.27
1,2,3,4,7,8-HxCDD	pg/g	165	125	76%	0.15	2,670	PSB-11	7/30/2010	1.5–2	40	24%	0.0146	1.47
1,2,3,6,7,8-HxCDD	pg/g	165	136	82%	0.0966	24,600	PSB-11	7/30/2010	1.5–2	29	18%	0.0142	1.86
1,2,3,7,8,9-HxCDD	pg/g	165	132	80%	0.0946	8,970	PSB-11	7/30/2010	1.5–2	33	20%	0.0154	1.66
1,2,3,4,6,7,8-HpCDD	pg/g	165	160	97%	1.38	922,000	PSB-11	7/30/2010	1.5–2	5	3%	0.546	2.42
Total OCDD	pg/g	165	164	99%	6.68	6,050,000	PSB-11	7/30/2010	1.5–2	1	1%	4.58	4.58
2,3,7,8-TCDF	pg/g	165	97	59%	0.2	36.9	PSB-11	7/30/2010	1.5–2	68	41%	0.0142	0.51
1,2,3,7,8-PeCDF	pg/g	165	86	52%	0.0999	174	PSB-11	7/30/2010	1.5–2	79	48%	0.0118	1.04
2,3,4,7,8-PeCDF	pg/g	165	117	71%	0.0429	849	PSB-11	7/30/2010	1.5–2	48	29%	0.0114	1.07
1,2,3,4,7,8-HxCDF	pg/g	165	127	77%	0.0614	5,050	PSB-11	7/30/2010	1.5–2	38	23%	0.00876	1.06
2,3,4,6,7,8-HxCDF	pg/g	165	126	76%	0.109	3,680	PSB-11	7/30/2010	1.5–2	39	24%	0.00993	1.23
1,2,3,7,8,9-HxCDF	pg/g	165	74	45%	0.266	805	PSB-11	7/30/2010	1.5–2	91	55%	0.0119	2.88

Table 4.1
Frequency of Detections for Lora Lake Apartments Parcel Soil Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Depth of Maximum Detect (feet)	Number of Non-detects	% Non-detect	Minimum Non-detected Value	Maximun Non-detected Value
Dioxins/Furans (continued)													
1,2,3,4,6,7,8-HpCDF	pg/g	165	154	93%	0.53	257,000	PSB-11	7/30/2010	1.5–2	11	7%	0.0321	0.887
1,2,3,6,7,8-HxCDF	pg/g	165	125	76%	0.119	2,230	PSB-11	7/30/2010	1.5–2	40	24%	0.00899	11
1,2,3,4,7,8,9-HpCDF	pg/g	165	128	78%	0.185	9,580	PSB-11	7/30/2010	1.5–2	37	22%	0.023	1.3
Total OCDF	pg/g	165	153	93%	1.4	1,380,000	PSB-11	7/30/2010	1.5–2	12	7%	0.186	4.66
Summed Dioxin/Furan TEQ[5,6]	pg/g	165	164	99%	0.00417	21,200	PSB-11	7/30/2010	1.5–2	1	1%	0	0
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[5,7]	pg/g	165	164	99%	0.0402	21,200	PSB-11	7/30/2010	1.5–2	1	1%	0.034	0.034
Polychlorinated Biphenyls													
PCB Aroclor 1016	µg/kg	4	0	0%	--	--	--	--	--	4	100%	5.5	7.1
PCB Aroclor 1221	µg/kg	4	0	0%	--	--	--	--	--	4	100%	11	15
PCB Aroclor 1232	µg/kg	4	0	0%	--	--	--	--	--	4	100%	5.5	12
PCB Aroclor 1242	µg/kg	4	1	25%	14	14	LL-08	4/3/2008	2–4	3	75%	5.5	7.1
PCB Aroclor 1248	µg/kg	4	0	0%	--	--	--	--	--	4	100%	5.5	7.1
PCB Aroclor 1254	µg/kg	4	1	25%	39	39	LL-08	4/3/2008	2–4	3	75%	5.5	80
PCB Aroclor 1260	µg/kg	4	2	50%	8.9	51	LL-08	4/3/2008	2–4	2	50%	5.5	7.1
PCBs (Total, Aroclors)	µg/kg	6	2	33%	8.9	104	LL-08	4/3/2008	2–4	4	67%	11	80
Miscellaneous													
2,3-Dichloroaniline	µg/kg	2	0	0%	--	--	--	--	--	2	100%	190	740
Di(2-ethylhexyl)adipate	µg/kg	2	0	0%	--	--	--	--	--	2	100%	190	740
m-Dinitrobenzene	µg/kg	2	0	0%	--	--	--	--	--	2	100%	190	740
o-Dinitrobenzene	µg/kg	2	0	0%	--	--	--	--	--	2	100%	190	740
p-Dinitrobenzene	µg/kg	2	0	0%	--	--	--	--	--	2	100%	190	740

Notes:

-- Indicates not applicable.
1 Heavy oil-range hydrocarbons includes motor oil-range, lube oil-range, and residual-range hydrocarbons.
2 Calculation of cPAH TEQ concentrations was performed using the California Environmental Protection Agency 2005 Toxic Equivalency Factors as presented in Table 708-2 of WAC 173-340-900 (WSDOE 2007).
3 Calculated using detected cPAH concentrations.
4 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.
5 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).
6 Calculated using detected dioxin/furan concentrations.
7 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:

HPAH High molecular weight polycyclic aromatic hydrocarbon
LPAH Low molecular weight polycyclic aromatic hydrocarbon
ND Non-detect
OCDD Octachlorodibenzo-p-dioxin
OCDF Octachlorodibenzofuran
PAH Polycyclic aromatic hydrocarbon
PCB Polychlorinated biphenyl
TEQ Toxic equivalency quotient
WAC Washington Administrative Code
WSDOE Washington State Department of Ecology

Table 4.2
Frequency of Detections for Lora Lake Apartments Parcel Groundwater Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value All Data	Maximum Detected Value All Data	Location of Maximum Detect All Data	Date of Maximum Detect All Data	Maximum Detected Value 2010/2011 RI Data	Location of Maximum Detect 2010/2011 RI Data	Date of Maximum Detect 2010/2011 RI Data	Number of Non-detects	% Non-Detect	Minimum Non-detect Value	Maximum Non-detect Value
Conventionals															
pH	pH	67	67	100%	5.9	7.85	MW-17	9/13/2010	7.85	MW-17	9/13/2010	0	0%	--	--
Total Organic Carbon	mg/L	5	5	100%	0.33	14	MW-6	12/3/2008	--	--	--	0	0%	--	--
Total Suspended Solids	mg/L	59	31	53%	1.1	103	MW-15	9/13/2010	103	MW-15	9/13/2010	28	47%	1	5
Turbidity	ntu	7	7	100%	1.3	66	MW-1	3/28/2008	--	--	--	0	0%	--	--
Dissolved Metals															
Arsenic	µg/L	46	38	83%	0.2	65	LLP-04	7/25/2007	11.9	MW-1	1/21/2011	8	17%	0.2	3
Barium	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	25	25
Cadmium	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	4	4
Chromium	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	10	10
Lead	µg/L	46	1	2%	1.2	1.2	LLP-04	7/25/2007	--	--	--	45	98%	0.1	1
Mercury	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	0.5	0.5
Selenium	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	5	5
Silver	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	10	10
Total Metals															
Antimony	µg/L	18	16	89%	0.03	0.341	MW-4	3/27/2008	--	--	--	2	11%	0.05	0.05
Arsenic	µg/L	20	15	75%	0.22	14.2	MW-1	4/29/2011	--	--	--	3	15%	0.5	1.39
Beryllium	µg/L	18	3	17%	0.008	0.035	MW-6	3/28/2008	--	--	--	15	83%	0.02	0.04
Cadmium	µg/L	18	15	83%	0.01	0.178	MW-6	12/3/2008	--	--	--	3	17%	0.02	0.02
Chromium	µg/L	18	3	17%	1.15	3.16	MW-6	3/28/2008	--	--	--	15	83%	0.2	0.91
Copper	µg/L	18	9	50%	0.19	12.6	MW-6	3/28/2008	--	--	--	9	50%	0.23	0.57
Lead	µg/L	20	9	45%	0.017	0.324	MW-6	3/28/2008	--	--	--	11	55%	0.02	1
Mercury	µg/L	18	7	39%	0.01	0.2	MW-2 MW-5 MW-4	3/28/2008 3/27/2008 3/27/2008	--	--	--	11	61%	0.2	0.2
Nickel	µg/L	18	18	100%	0.99	14.8	MW-6	3/28/2008	--	--	--	0	0%	--	--
Selenium	µg/L	18	0	0%					--	--	--	18	100%	1	2
Silver	µg/L	18	1	6%	0.153	0.153	MW-6	12/3/2008	--	--	--	17	94%	0.02	0.059
Thallium	µg/L	18	0	0%					--	--	--	18	100%	0.02	0.04
Zinc	µg/L	18	10	56%	0.7	9.6	MW-5	3/27/2008	--	--	--	8	44%	1.04	2.5
Total Petroleum Hydrocarbons															
Gasoline Range Hydrocarbons	mg/L	63	12	19%	0.017	2.1	MW-1	11/7/2007	0.46	MW-1	1/21/2011	51	81%	0.1	0.5
Diesel Range Hydrocarbons	mg/L	81	14	17%	0.013	11	MW-1	11/7/2007	0.18	MW-1	1/21/2011	67	83%	0.1	0.26
Heavy Oil Range Hydrocarbons[1]	mg/L	81	13	16%	0.2	8.3	MW-1	3/28/2008	0.53	MW-1	1/21/2011	68	84%	0.2	0.52
Semivolatile Organic Compounds															
1,2-Diphenylhydrazine	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	1.8	2
1-Methylnaphthalene	µg/L	4	1	25%	1.3	1.3	LLP-04	7/25/2007	--	--	--	3	75%	0.18	0.19
2,3,4,6-Tetrachlorophenol	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	1.8	2
2,3,5,6-Tetrachlorophenol	µg/L	4	1	25%	68	68	LLP-04	7/25/2007	--	--	--	3	75%	1.8	1.9
2,4,5-Trichlorophenol	µg/L	13	5	38%	0.033	19	MW-1	11/7/2007	--	--	--	8	62%	0.48	9.4
2,4,6-Trichlorophenol	µg/L	13	2	15%	0.31	1.5	MW-1	3/28/2008	--	--	--	11	85%	0.48	9.4
2,4-Dichlorophenol	µg/L	13	1	8%	1.9	1.9	MW-1	11/7/2007	--	--	--	12	92%	0.48	9.4
2,4-Dimethylphenol	µg/L	13	3	23%	1.7	26	LLP-04	7/25/2007	--	--	--	10	77%	1.8	20
2,4-Dinitrophenol	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	3.8	24
2-Chloronaphthalene	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.19	9.4
2-Chlorophenol	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.48	9.4
2-Methylnaphthalene	µg/L	21	7	33%	0.0067	1.6	LLP-04	7/25/2007	--	--	--	14	67%	0.016	1

Table 4.2
Frequency of Detections for Lora Lake Apartments Parcel Groundwater Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value All Data	Maximum Detected Value All Data	Location of Maximum Detect All Data	Date of Maximum Detect All Data	Maximum Detected Value 2010/2011 RI Data	Location of Maximum Detect 2010/2011 RI Data	Date of Maximum Detect 2010/2011 RI Data	Number of Non-detects	% Non-Detect	Minimum Non-detect Value	Maximum Non-detect Value
Semivolatile Organic Compounds (continued)															
2-Nitrophenol	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.48	9.4
3- & 4-Methylphenol	µg/L	4	1	25%	5.4	5.4	LLP-04	7/25/2007	--	--	--	3	75%	1.8	1.9
4,6-Dinitro-o-cresol	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	1.9	24
4-Chloro-3-methylphenol	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.48	9.4
4-Methylphenol	µg/L	9	3	33%	0.12	4.4	MW-1	11/7/2007	--	--	--	6	67%	0.48	9.4
4-Nitrophenol	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	1.8	24
Acenaphthene	µg/L	21	2	10%	0.23	1.1	LLP-04	7/25/2007	--	--	--	19	90%	0.016	9.4
Acenaphthylene	µg/L	21	1	5%	9.3	9.3	LLP-04	7/25/2007	--	--	--	20	95%	0.016	9.4
Aniline	µg/L	5	0	0%	--	--	--	--	--	--	--	5	100%	1.8	24
Anthracene	µg/L	21	3	14%	0.025	0.23	MW-1	11/7/2007	--	--	--	18	86%	0.016	9.4
Benzidine	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	18	20
Benzo(b)fluoranthene	µg/L	21	9	43%	0.036	0.83	MW-1	3/28/2008	--	--	--	12	57%	0.016	9.4
Benzo(g,h,i)perylene	µg/L	21	6	29%	0.022	0.37	MW-1	3/28/2008	--	--	--	15	71%	0.016	9.4
Benzo(k)fluoranthene	µg/L	21	6	29%	0.027	0.37	MW-1	3/28/2008	--	--	--	15	71%	0.016	9.4
Benzoic acid	µg/L	9	7	78%	1.2	15	MW-1	11/7/2007	--	--	--	2	22%	4.8	24
Benzyl alcohol	µg/L	13	4	31%	0.21	1.3	MW-1	11/7/2007	--	--	--	9	69%	1.8	25
bis(2-chloroethoxy)methane	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.19	9.4
bis(2-ethylhexyl)phthalate	µg/L	13	8	62%	0.13	14	MW-1	11/7/2007	--	--	--	5	38%	0.99	2
Butyl benzyl phthalate	µg/L	13	1	8%	2	2	MW-1	11/7/2007	--	--	--	12	92%	0.19	9.4
Carbazole	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	1.8	2
Dibenzofuran	µg/L	21	0	0%	--	--	--	--	--	--	--	21	100%	0.016	9.4
Diethylphthalate	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.19	9.4
Dimethyl phthalate	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.19	9.4
Di-n-butyl phthalate	µg/L	13	1	8%	7.7	7.7	MW-1	11/7/2007	--	--	--	12	92%	0.19	9.4
Di-n-octyl phthalate	µg/L	13	5	38%	0.024	0.059	MW-4	3/27/2008	--	--	--	8	62%	0.46	9.4
Fluoranthene	µg/L	21	7	33%	0.052	0.85	MW-1	3/28/2008	--	--	--	14	67%	0.016	9.4
Fluorene	µg/L	21	3	14%	0.25	0.91	LLP-05	7/25/2007	--	--	--	18	86%	0.016	9.4
Hexachlorobutadiene	µg/L	25	0	0%	--	--	--	--	--	--	--	25	100%	0.19	9.4
Hexachlorocyclopentadiene	µg/L	5	0	0%	--	--	--	--	--	--	--	5	100%	1.8	9.4
Isophorone	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.19	9.4
Naphthalene	µg/L	33	22	67%	0.0078	33	LLP-04	7/25/2007	--	--	--	11	33%	0.011	2
N-Nitrosodimethylamine	µg/L	5	0	0%	--	--	--	--	--	--	--	5	100%	1.8	24
N-Nitroso-di-n-propylamine	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.19	9.4
N-Nitrosodiphenylamine	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.19	9.4
Pentachlorophenol	µg/L	80	20	25%	0.29	150	MW-1	11/7/2007	1.4	MW-5	1/21/2011	60	75%	0.25	9.7
Phenanthrene	µg/L	21	8	38%	0.022	2.4	MW-1	12/5/2007	--	--	--	13	62%	0.016	1
Phenol	µg/L	13	2	15%	2.2	3.1	LLP-04	7/25/2007	--	--	--	11	85%	0.48	9.4
Pyrene	µg/L	21	8	38%	0.047	2.6	MW-1	3/28/2008	--	--	--	13	62%	0.016	9.4
Total HPAH	µg/L	21	11	52%	0.325	7.49	MW-1	12/5/2007	--	--	--	10	48%	0.016	9.4
Total LPAH	µg/L	21	19	90%	0.0078	30.26	LLP-04	7/25/2007	--	--	--	2	10%	0.016	1
Total PAH	µg/L	21	19	90%	0.0078	30.955	LLP-04	7/25/2007	--	--	--	2	10%	0.016	1
Carcinogenic Polycyclic Aromatic Hydrocarbons															
Benzo(a)pyrene	µg/L	75	11	15%	0.0057	0.72	MW-1	3/28/2008	0.021	MW-1	1/21/2011	64	85%	0.01	9.4
Benzo(a)anthracene	µg/L	75	10	13%	0.0058	0.6	MW-1	3/28/2008	0.017	MW-1	1/21/2011	65	87%	0.01	9.4
Benzofluoranthenes (total)	µg/L	75	13	17%	0.012	1.2	MW-1	3/28/2008	0.031	MW-1	1/21/2011	62	83%	0.01	9.4
Chrysene	µg/L	75	12	16%	0.008	0.75	MW-1	3/28/2008	0.026	MW-1	1/21/2011	63	84%	0.01	9.4

Table 4.2
Frequency of Detections for Lora Lake Apartments Parcel Groundwater Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value All Data	Maximum Detected Value All Data	Location of Maximum Detect All Data	Date of Maximum Detect All Data	Maximum Detected Value 2010/2011 RI Data	Location of Maximum Detect 2010/2011 RI Data	Date of Maximum Detect 2010/2011 RI Data	Number of Non-detects	% Non-Detect	Minimum Non-detect Value	Maximum Non-detect Value
Carcinogenic Polycyclic Aromatic Hydrocarbons (continued)															
Summed cPAH TEQ[2,3]	µg/L	75	15	20%	0.0013	0.95	MW-1	3/28/2008	0.027	MW-1	1/21/2011	60	80%	0	0
Summed cPAH TEQ with One-half of the Reporting Limits[2,4]	µg/L	75	15	20%	0.0078	1	MW-1	3/28/2008	0.028	MW-1	1/21/2011	60	80%	0.0071	7.6
Volatile Organic Compounds															
1,1,1,2-Tetrachloroethane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
1,1,1-Trichloroethane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
1,1,2,2-Tetrachloroethane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
1,1,2-Trichloroethane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
1,1-Dichloroethane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
1,1-Dichloroethene	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
1,1-Dichloropropene	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
1,2,3-Trichlorobenzene	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	2
1,2,3-Trichloropropane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
1,2,4-Trichlorobenzene	µg/L	25	0	0%	--	--	--	--	--	--	--	25	100%	0.19	9.4
1,2,4-Trimethylbenzene	µg/L	12	6	50%	0.17	50	LLP-04	7/25/2007	--	--	--	6	50%	0.2	2
1,2-Dibromo-3-chloropropane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	1	2
1,2-Dibromoethane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	2
1,2-Dichlorobenzene	µg/L	25	0	0%	--	--	--	--	--	--	--	25	100%	0.19	9.4
1,2-Dichloroethane	µg/L	66	7	11%	0.026	0.62	LLP-04	7/25/2007	0.07	MW-5	8/13/2010	59	89%	0.02	0.5
1,2-Dichloropropane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
1,3,5-Trimethylbenzene	µg/L	12	4	33%	0.21	13	LLP-04	7/25/2007	--	--	--	8	67%	0.2	2
1,3-Dichlorobenzene	µg/L	25	0	0%	--	--	--	--	--	--	--	25	100%	0.19	9.4
1,3-Dichloropropane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
1,4-Dichlorobenzene	µg/L	25	0	0%	--	--	--	--	--	--	--	25	100%	0.19	9.4
2,2-Dichloropropane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
2,4-Dinitrotoluene	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.19	9.4
2,6-Dinitrotoluene	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.19	9.4
2-Chloroethyl vinyl ether	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	1	2
2-Chlorotoluene	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	2
2-Hexanone	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	2	20
2-Nitroaniline	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.19	24
3,3'-Dichlorobenzidine	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	1.9	24
3-Nitroaniline	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.95	24
4-Bromophenyl phenyl ether	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.19	9.4
4-Chloroaniline	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.19	9.4
4-Chlorophenyl phenyl ether	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.19	9.4
4-Chlorotoluene	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	2
4-Nitroaniline	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.95	24
Acetone	µg/L	12	1	8%	17	17	LLP-04	7/25/2007	--	--	--	11	92%	5	20
Benzene	µg/L	66	1	2%	0.72	0.72	LLP-04	7/25/2007	--	--	--	65	98%	0.2	1
bis(2-chloroethyl)ether	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.19	9.4
bis(2-chloroisopropyl)ether	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.19	9.4
Bromobenzene	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	2
Bromochloromethane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
Bromodichloromethane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5

Table 4.2
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Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value All Data	Maximum Detected Value All Data	Location of Maximum Detect All Data	Date of Maximum Detect All Data	Maximum Detected Value 2010/2011 RI Data	Location of Maximum Detect 2010/2011 RI Data	Date of Maximum Detect 2010/2011 RI Data	Number of Non-detects	% Non-Detect	Minimum Non-detect Value	Maximum Non-detect Value
Volatile Organic Compounds (continued)															
Bromomethane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.5	2
Carbon disulfide	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
Carbon tetrachloride	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
Chlorobenzene	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
Chloroethane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.5	2
Chloroform	µg/L	12	1	8%	0.63	0.63	LLP-08	7/25/2007	--	--	--	11	92%	0.2	0.5
Chloromethane	µg/L	12	1	8%	0.15	0.15	MW-1	12/5/2007	--	--	--	11	92%	0.2	0.5
cis-1,2-Dichloroethene	µg/L	66	7	11%	0.028	0.97	LLP-04	7/25/2007	0.26	MW-1	1/21/2011	59	89%	0.02	0.5
cis-1,3-Dichloropropene	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
Cymene	µg/L	12	4	33%	0.43	2.8	LLP-04	7/25/2007	--	--	--	8	67%	0.2	2
Dibromochloromethane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
Dibromomethane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
Dichlorodifluoromethane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
Dichloromethane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	1	2
Ethylbenzene	µg/L	66	9	14%	0.13	4.8	LLP-04	7/25/2007	3.1	MW-1	1/21/2011	57	86%	0.2	1
Hexachlorobenzene	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.19	9.4
Hexachloroethane	µg/L	6	0	0%	--	--	--	--	--	--	--	6	100%	0.46	9.4
Iodomethane	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	1	2
iso-Propylbenzene	µg/L	12	6	50%	0.17	3	LLP-04	7/25/2007	--	--	--	6	50%	0.2	2
Methyl ethyl ketone	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	5	20
Methyl iso butyl ketone	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	2	20
Methyl-Tert-Butyl Ether	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	0.2	0.4
n-Butylbenzene	µg/L	12	2	17%	0.25	0.63	MW-1	12/5/2007	--	--	--	10	83%	0.2	2
Nitrobenzene	µg/L	13	0	0%	--	--	--	--	--	--	--	13	100%	0.19	9.4
n-Propylbenzene	µg/L	12	5	42%	0.24	2.9	LLP-04	7/25/2007	--	--	--	7	58%	0.2	2
Pyridine	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	1.8	2
sec-Butylbenzene	µg/L	12	5	42%	0.25	3.3	LLP-05	7/25/2007	--	--	--	7	58%	0.2	2
Styrene	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
tert-Butylbenzene	µg/L	12	1	8%	0.35	0.35	LLP-05	7/25/2007	--	--	--	11	92%	0.2	2
Tetrachloroethene	µg/L	66	7	11%	0.024	0.47	LLP-04	7/25/2007	0.035	MW-13	8/12/2010	59	89%	0.02	0.5
Toluene	µg/L	66	4	6%	0.12	8.1	LLP-04	7/25/2007	--	--	--	62	94%	0.2	1
trans-1,2-Dichloroethene	µg/L	66	6	9%	0.041	0.89	LLP-04	7/25/2007	0.11	MW-1	8/13/2010	60	91%	0.02	0.5
trans-1,3-Dichloropropene	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
Trichloroethene	µg/L	66	7	11%	0.12	1.8	LLP-04	7/25/2007	0.17	MW-1	8/13/2010	59	89%	0.02	0.5
Trichlorofluoromethane	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
Vinyl acetate	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	5	10
Vinyl chloride	µg/L	12	0	0%	--	--	--	--	--	--	--	12	100%	0.2	0.5
m,p-Xylene	µg/L	66	9	14%	0.33	31	LLP-04	7/25/2007	5.6	MW-1	1/21/2011	57	86%	0.4	1
o-Xylene	µg/L	66	7	11%	0.18	19	LLP-04	7/25/2007	9.2	MW-1	1/21/2011	59	89%	0.2	1
Dioxins/Furans															
2,3,7,8-TCDD	pg/L	65	4	6%	2.27	19.5	MW-1	3/28/2008	3.34	MW-1	1/21/2011	61	94%	0.148	9.66
1,2,3,7,8-PeCDD	pg/L	65	7	11%	1.05	60.6	MW-1	3/28/2008	9.29	MW-1	1/21/2011	58	89%	0.224	24.2
1,2,3,4,7,8-HxCDD	pg/L	65	7	11%	2.64	13.9	MW-1	11/7/2007	5.19	MW-1	1/21/2011	58	89%	0.162	24.2
1,2,3,6,7,8-HxCDD	pg/L	65	7	11%	15.9	213	MW-1	3/28/2008	46.6	MW-1	1/21/2011	58	89%	0.143	24.2
1,2,3,7,8,9-HxCDD	pg/L	65	8	12%	6.43	147	MW-1	3/28/2008	20.6	MW-1	1/21/2011	57	88%	0.156	24.2
1,2,3,4,6,7,8-HpCDD	pg/L	65	22	34%	2.62	6,380	MW-1	3/28/2008	920	MW-1	1/21/2011	43	66%	1	15.6

Table 4.2
Frequency of Detections for Lora Lake Apartments Parcel Groundwater Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value All Data	Maximum Detected Value All Data	Location of Maximum Detect All Data	Date of Maximum Detect All Data	Maximum Detected Value 2010/2011 RI Data	Location of Maximum Detect 2010/2011 RI Data	Date of Maximum Detect 2010/2011 RI Data	Number of Non-detects	% Non-Detect	Minimum Non-detect Value	Maximum Non-detect Value
Dioxins/Furans (continued)															
Total OCDD	pg/L	65	35	54%	6.65	109,000	MW-1	3/28/2008	16200	MW-1	1/21/2011	30	46%	2.34	82.7
2,3,7,8-TCDF	pg/L	65	1	2%	9.7	9.7	MW-1	3/28/2008	--	--	--	64	98%	0.147	9.66
1,2,3,7,8-PeCDF	pg/L	65	6	9%	1.67	14.6	MW-1	4/29/2011	14.6	MW-1	4/29/2011	59	91%	0.103	24.2
2,3,4,7,8-PeCDF	pg/L	65	5	8%	2.5	13.7	MW-1	11/7/2007	4.51	MW-1	1/21/2011	60	92%	0.101	24.2
1,2,3,4,7,8-HxCDF	pg/L	65	7	11%	1.86	57.7	MW-1	11/7/2007	5.06	MW-1	1/21/2011	58	89%	0.106	24.2
1,2,3,6,7,8-HxCDF	pg/L	65	6	9%	0.716	20.7	MW-1	3/28/2008	6.06	MW-1	4/29/2011	59	91%	0.102	24.2
1,2,3,7,8,9-HxCDF	pg/L	65	3	5%	1.63	2.11	MW-1	4/29/2011	2.11	MW-1	4/29/2011	62	95%	0.132	24.2
2,3,4,6,7,8-HxCDF	pg/L	65	8	12%	1.24	31	MW-1	11/7/2007	17.4	MW-1	1/21/2011	57	88%	0.114	24.2
1,2,3,4,6,7,8-HpCDF	pg/L	65	11	17%	3.5	758	MW-1	3/28/2008	126	MW-1	1/21/2011	54	83%	0.159	23.6
1,2,3,4,7,8,9-HpCDF	pg/L	65	8	12%	4.13	39	MW-1	11/7/2007	11.7	MW-1	1/21/2011	57	88%	0.216	24.2
Total OCDF	pg/L	65	17	26%	1.64	3,590	MW-1	3/28/2008	384	MW-1	1/21/2011	48	74%	0.295	47.3
Summed Dioxin/Furan TEQ[5,6]	pg/L	65	38	58%	0.000519	234	MW-1	3/28/2008	37.6	MW-1	1/21/2011	27	42%	0	0
Summed Dioxin/Furan TEQ with One-half of the Detection Limits[5,7]	pg/L	65	38	58%	0.605	234	MW-1	3/28/2008	38.3	MW-1	1/21/2011	27	42%	0.28	30
Polychlorinated Biphenyls															
PCBs (Total, Aroclors)	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	0.093	0.92
Miscellaneous															
2,3-Dichloroaniline	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	1.8	2
Di(2-ethylhexyl)adipate	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	1.8	2
Hardness as CaCO3	mg/L	8	8	100%	60	127	MW-9	8/19/2008	--	--	--	0	0%	--	--
m-Dinitrobenzene	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	1.8	2
o-Dinitrobenzene	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	1.8	2
p-Dinitrobenzene	µg/L	4	0	0%	--	--	--	--	--	--	--	4	100%	1.8	2

Notes:
-- Indicates not applicable or not available.
1 Heavy oil-range TPH includes lube oil-range and residual-range TPH.
2 Calculation of cPAH TEQ concentrations was performed using the California Environmental Protection Agency 2005 Toxic Equivancy Factors as presented in Table 708-2 of WAC 173-340-900 (WSDOE 2007)
3 Calculated using detected cPAH concentrations.
4 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.
5 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).
6 Calculated using detected dioxin/furan concentrations.
7 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:
HPAH High molecular weight polycyclic aromatic hydrocarbon
LPAH Low molecular weight polycyclic aromatic hydrocarbon
OCDD Octachlorodibenzo-p-dioxin
OCDF Octachlorodibenzofuran
PAH Polycyclic aromatic hydrocarbon
PCB Polychlorinated biphenyl
RI Remedial Investigation
TEQ Toxic equivalency quotient
TPH Total petroleum hydrocarbons
WAC Washington Administrative Code
WSDOE Washington State Department of Ecology

Table 4.3
Frequency of Detections for Lora Lake Surface Sediment Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Depth of Maximum Detect	Number of Non-detects	% Non-detect	Minimum Non-detect Value[1]	Maximum Non-detect Value[1]
Conventionals													
Total Organic Carbon	%	12	12	100%	0.903	10.6	LL-SED2	03/29/2011	0–15 cm	0	0%	0.02	0.2
Total Solids	%	12	12	100%	15.4	82.8	LL-SED5	03/29/2011	0–15 cm	0	0%	0.01	0.01
Metals													
Arsenic	mg/kg	6	6	100%	7	70	LL-SED3	03/29/2011	0–15 cm	0	0%	6	20
Lead	mg/kg	6	6	100%	48	492	LL-SED4	03/29/2011	0–15 cm	0	0%	2	10
Semivolatile Organic Compounds													
Pentachlorophenol	µg/kg	6	2	33%	33	50	LL-SED1	03/29/2011	0–15 cm	4	67%	7.3	33, 330 [2]
Carcinogenic Polycyclic Aromatic Hydrocarbons													
Benzo(a)pyrene	µg/kg	6	6	100%	30	130	LL-SED1	03/29/2011	0–15 cm	0	0%	4.6	7.8
Benzo(a)anthracene	µg/kg	6	6	100%	20	97	LL-SED1	03/29/2011	0–15 cm	0	0%	4.6	7.8
Benzofluoranthenes (total)	µg/kg	6	6	100%	73	300	LL-SED1	03/29/2011	0–15 cm	0	0%	4.6	7.8
Chrysene	µg/kg	6	6	100%	39	180	LL-SED1	03/29/2011	0–15 cm	0	0%	4.6	7.8
Dibenzo(a,h)anthracene	µg/kg	6	6	100%	5.8	25	LL-SED1	03/29/2011	0–15 cm	0	0%	4.6	7.8
Indeno(1,2,3-cd)pyrene	µg/kg	6	6	100%	19	100	LL-SED1	03/29/2011	0–15 cm	0	0%	4.6	7.8
Summed cPAH TEQ[3,4]	µg/kg	6	6	100%	43	180	LL-SED1	03/29/2011	0–15 cm	0	0%	--	--
Summed cPAH TEQ with One-half of the Reporting Limit[3,5]	µg/kg	6	6	100%	43	180	LL-SED1	03/29/2011	0–15 cm	0	0%	--	--
Volatile Organic Compounds													
Tetrachloroethene	µg/kg	6	0	0%	--	--	--	--	--	6	100%	1.5	13
Trichloroethene	µg/kg	6	0	0%	--	--	--	--	--	6	100%	1.5	13
cis-1,2-Dichloroethene	µg/kg	6	0	0%	--	--	--	--	--	6	100%	1.5	13
trans-1,2-Dichloroethene	µg/kg	6	0	0%	--	--	--	--	--	6	100%	1.5	13
1,2-Dichloroethane	µg/kg	6	0	0%	--	--	--	--	--	6	100%	1.5	13
Dioxins/Furans													
2,3,7,8-TCDD	pg/g	6	5	83%	4.28	10.4	LL-SED3	03/29/2011	0–15 cm	1	17%	0.269	0.269
1,2,3,7,8-PeCDD	pg/g	6	6	100%	1.26	25.7	LL-SED2	03/29/2011	0–15 cm	0	0%	2.5	2.5
1,2,3,4,7,8-HxCDD	pg/g	6	6	100%	2.03	60.3	LL-SED2	03/29/2011	0–15 cm	0	0%	2.5	2.5
1,2,3,6,7,8-HxCDD	pg/g	6	6	100%	7.46	217	LL-SED2	03/29/2011	0–15 cm	0	0%	2.5	2.5
1,2,3,7,8,9-HxCDD	pg/g	6	6	100%	3.88	135	LL-SED2	03/29/2011	0–15 cm	0	0%	2.5	2.5
1,2,3,4,6,7,8-HpCDD	pg/g	6	6	100%	202	7,500	LL-SED2	03/29/2011	0–15 cm	0	0%	2.5	2.5
Total OCDD	pg/g	6	6	100%	2,110	68,500	LL-SED1	03/29/2011	0–15 cm	0	0%	5	5
2,3,7,8-TCDF	pg/g	6	5	83%	7.09	14.3	LL-SED3	03/29/2011	0–15 cm	1	17%	0.185	0.185
1,2,3,7,8-PeCDF	pg/g	6	6	100%	0.518	12.2	LL-SED4	03/29/2011	0–15 cm	0	0%	2.5	2.5
2,3,4,7,8-PeCDF	pg/g	6	6	100%	0.894	18.5	LL-SED2	03/29/2011	0–15 cm	0	0%	2.5	2.5
1,2,3,4,7,8-HxCDF	pg/g	6	6	100%	8.09	139	LL-SED2	03/29/2011	0–15 cm	0	0%	2.5	2.5
2,3,4,6,7,8-HxCDF	pg/g	6	6	100%	2.75	64.4	LL-SED2	03/29/2011	0–15 cm	0	0%	2.5	2.5
1,2,3,7,8,9-HxCDF	pg/g	6	6	100%	0.645	12.2	LL-SED2	03/29/2011	0–15 cm	0	0%	2.5	2.5
1,2,3,4,6,7,8-HpCDF	pg/g	6	6	100%	41.9	1,480	LL-SED2	03/29/2011	0–15 cm	0	0%	2.5	2.5
1,2,3,6,7,8-HxCDF	pg/g	6	6	100%	2.3	49	LL-SED2	03/29/2011	0–15 cm	0	0%	2.5	2.5
1,2,3,4,7,8,9-HpCDF	pg/g	6	6	100%	4.2	93.6	LL-SED1	03/29/2011	0–15 cm	0	0%	2.5	2.5

Table 4.3
Frequency of Detections for Lora Lake Surface Sediment Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Depth of Maximum Detect	Number of Non-detects	% Non-detect	Minimum Non-detect Value[1]	Maximum Non-detect Value[1]
Dioxins/Furans (continued)													
Total OCDF	pg/g	6	6	100%	114	4,050	LL-SED2	03/29/2011	0–15 cm	0	0%	5	5
Summed Dioxin/Furan TEQ[6,7]	pg/g	6	6	100%	7.41	217	LL-SED2	03/29/2011	0–15 cm	0	0%	--	--
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[6,8]	pg/g	6	6	100%	7.55	217	LL-SED2	03/29/2011	0–15 cm	0	0%	--	--

Notes:

-- Indicates not applicable or not available.
1 If all results were detected, the minimum and maximum reporting limits are shown.
2 Initial sample analysis was performed at a 10:1 dilution with a reporting limit of 33 µg/kg; an additional extract volume was analyzed due to suspected interference with a resulting reporting limit of 330 µg/kg.
3 Calculation of cPAH TEQ concentrations was performed using the California Environmental Protection Agency 2005 Toxic Equivancy Factors as presented in Table 708-2 of WAC 173-340-900 (WSDOE 2007).
4 Calculated using detected cPAH concentrations.
5 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.
6 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).
7 Calculated using detected dioxin/furan concentrations.
8 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:

cm Centimeter
cPAH Carcinogenic polycyclic aromatic hydrocarbon
OCDD Octachlorodibenzo-p-dioxin
OCDF Octachlorodibenzofuran
TEQ Toxic equivalency quotient
WAC Washington Administrative Code
WSDOE Washington State Department of Ecology

Table 4.4
Frequency of Detections for Miller Creek Surface Sediment Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Depth of Maximum Detect	Number of Non-detects	% Non-detect	Minimum Non-detect Value[1]	Maximum Non-detect Value[1]
Conventionals													
Total Organic Carbon	%	3	3	100%	0.146	0.536	MC-SED1	03/29/2011	0–10 cm	0	0%	0.02	0.02
Total Solids	%	3	3	100%	77.2	85.2	MC-SED3	03/29/2011	0–10 cm	0	0%	0.01	0.01
Metals													
Arsenic	mg/kg	3	1	33%	8	8	MC-SED1	03/29/2011	0–10 cm	2	67%	6	6
Lead	mg/kg	3	3	100%	4	12	MC-SED1	03/29/2011	0–10 cm	0	0%	2	3
Semivolatile Organic Compounds													
Pentachlorophenol	µg/kg	3	0	0%	--	--	--	--	--	3	100%	6.5	7.5
Carcinogenic Polycyclic Aromatic Hydrocarbons													
Benzo(a)pyrene	µg/kg	3	0	0%	--	--	--	--	--	3	100%	4.6	4.9
Benzo(a)anthracene	µg/kg	3	0	0%	--	--	--	--	--	3	100%	4.6	4.9
Benzofluoranthenes (total)	µg/kg	3	0	0%	--	--	--	--	--	3	100%	4.6	4.9
Chrysene	µg/kg	3	0	0%	--	--	--	--	--	3	100%	4.6	4.9
Dibenzo(a,h)anthracene	µg/kg	3	0	0%	--	--	--	--	--	3	100%	4.6	4.9
Indeno(1,2,3-cd)pyrene	µg/kg	3	0	0%	--	--	--	--	--	3	100%	4.6	4.9
Summed cPAH TEQ[2,3]	µg/kg	3	0	0%	--	--	--	--	--	3	100%	0	0
Summed cPAH TEQ with One-half of the Reporting Limit[2,4]	µg/kg	3	0	0%	--	--	--	--	--	3	100%	3.2	3.5
Volatile Organic Compounds													
Tetrachloroethene	µg/kg	3	0	0%	--	--	--	--	--	3	100%	1.2	1.3
Trichloroethene	µg/kg	3	0	0%	--	--	--	--	--	3	100%	1.2	1.3
cis-1,2-Dichloroethene	µg/kg	3	0	0%	--	--	--	--	--	3	100%	1.2	1.3
trans-1,2-Dichloroethene	µg/kg	3	0	0%	--	--	--	--	--	3	100%	1.2	1.3
1,2-Dichloroethane	µg/kg	3	0	0%	--	--	--	--	--	3	100%	1.2	1.3
Dioxins/Furans													
2,3,7,8-TCDD	pg/g	3	0	0%	--	--	--	--	--	3	100%	0.158	0.209
1,2,3,7,8-PeCDD	pg/g	3	0	0%	--	--	--	--	--	3	100%	0.204	0.334
1,2,3,4,7,8-HxCDD	pg/g	3	0	0%	--	--	--	--	--	3	100%	0.282	0.336
1,2,3,6,7,8-HxCDD	pg/g	3	0	0%	--	--	--	--	--	3	100%	0.352	0.441
1,2,3,7,8,9-HxCDD	pg/g	3	0	0%	--	--	--	--	--	3	100%	0.31	0.378
1,2,3,4,6,7,8-HpCDD	pg/g	3	3	100%	1.03	7.83	MC-SED1	03/29/2011	0–10 cm	0	0%	2.5	2.5
Total OCDD	pg/g	3	3	100%	5.93	52.6	MC-SED1	03/29/2011	0–10 cm	0	0%	5	5
2,3,7,8-TCDF	pg/g	3	0	0%	--	--	--	--	--	3	100%	0.0986	0.152
1,2,3,7,8-PeCDF	pg/g	3	0	0%	--	--	--	--	--	3	100%	0.152	0.215
2,3,4,7,8-PeCDF	pg/g	3	0	0%	--	--	--	--	--	3	100%	0.155	0.221
1,2,3,4,7,8-HxCDF	pg/g	3	0	0%	--	--	--	--	--	3	100%	0.178	0.208
2,3,4,6,7,8-HxCDF	pg/g	3	0	0%	--	--	--	--	--	3	100%	0.177	0.22
1,2,3,7,8,9-HxCDF	pg/g	3	0	0%	--	--	--	--	--	3	100%	0.16	0.203
1,2,3,4,6,7,8-HpCDF	pg/g	3	2	67%	0.536	1.37	MC-SED1	03/29/2011	0–10 cm	1	33%	0.301	0.301
1,2,3,6,7,8-HxCDF	pg/g	3	0	0%	--	--	--	--	--	3	100%	0.173	0.206
1,2,3,4,7,8,9-HpCDF	pg/g	3	0	0%	--	--	--	--	--	3	100%	0.202	0.333

Table 4.4
Frequency of Detections for Miller Creek Surface Sediment Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Depth of Maximum Detect	Number of Non-detects	% Non-detect	Minimum Non-detect Value[1]	Maximum Non-detect Value[1]
Dioxins/Furans (continued)													
Total OCDF	pg/g	3	1	33%	3.22	3.22	MC-SED1	03/29/2011	0–10 cm	2	67%	0.646	0.868
Summed Dioxin/Furan TEQ[5,6]	pg/g	3	3	100%	0.0121	0.109	MC-SED1	03/29/2011	0–10 cm	0	0%	--	--
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[5,7]	pg/g	3	3	100%	0.327	0.442	MC-SED1	03/29/2011	0–10 cm	0	0%	--	--

Notes:

-- Indicates not applicable or not available.
1 If all results were detected, the minimum and maximum reporting limits are shown.
2 Calculation of cPAH TEQ concentrations was performed using the California Environmental Protection Agency 2005 Toxic Equivalency Factors as presented in Table 708-2 of WAC 173-340-900 (WSDOE 2007).
3 Calculated using detected cPAH concentrations.
4 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.
5 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).
6 Calculated using detected dioxin/furan concentrations.
7 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:

cm Centimeter
cPAH Carcinogenic polycyclic aromatic hydrocarbon
OCDD Octachlorodibenzo-p-dioxin
OCDF Octachlorodibenzofuran
TEQ Toxic equivalency quotient
WAC Washington Administrative Code
WSDOE Washington State Department of Ecology

Table 4.5
Frequency of Detections for Lora Lake Subsurface Sediment Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Depth of Maximum Detect	Number of Non-detects	% Non-detect	Minimum Non-detect Value[1]	Maximum Non-detect Value[1]
Conventionals													
Total Organic Carbon	%	8	8	100%	4.22	26.1	LL-SED2	03/15/2011	56–112 cm	0	0%	0.02	0.216
Total Solids	%	8	8	100%	5.7	41.3	LL-SED1	03/15/2011	0–56 cm	0	0%	0.01	0.01
Metals													
Arsenic	mg/kg	8	7	88%	9	80	LL-SED2 LL-SED2 LL-SED2	03/15/2011 03/15/2011 03/15/2011	0–56 cm 56–112 cm 112–168 cm	1	13%	40	40
Lead	mg/kg	8	4	50%	29	450	LL-SED3	03/15/2011	0–36 cm	4	50%	10	20
Semivolatile Organic Compounds													
Pentachlorophenol	µg/kg	8	0	0%	--	--	--	--	--	8	100%	25	110
Carcinogenic Polycyclic Aromatic Hydrocarbons													
Benzo(a)pyrene	µg/kg	8	4	50%	55	400	LL-SED2	03/15/2011	0–56 cm	4	50%	15	15
Benzo(a)anthracene	µg/kg	8	4	50%	37	270	LL-SED2	03/15/2011	0–56 cm	4	50%	15	15
Benzofluoranthenes (total)	µg/kg	8	4	50%	140	1,100	LL-SED2	03/15/2011	0–56 cm	4	50%	15	15
Chrysene	µg/kg	8	5	63%	18	620	LL-SED2	03/15/2011	0–56 cm	3	38%	15	15
Dibenzo(a,h)anthracene	µg/kg	8	3	38%	5.8	74	LL-SED2	03/15/2011	0–56 cm	5	63%	8.4	15
Indeno(1,2,3-cd)pyrene	µg/kg	8	4	50%	38	280	LL-SED2	03/15/2011	0–56 cm	4	50%	15	15
Summed cPAH TEQ[2,3]	µg/kg	8	5	63%	0.18	580	LL-SED2	03/15/2011	0–56 cm	3	38%	0	0
Summed cPAH TEQ with One-half of the Reporting Limit[2,4]	µg/kg	8	5	63%	11	580	LL-SED2	03/15/2011	0–56 cm	3	38%	11	11
Dioxins/Furans													
2,3,7,8-TCDD	pg/g	8	4	50%	1.48	15	LL-SED3	03/15/2011	0–36 cm	4	50%	0.217	0.93
1,2,3,7,8-PeCDD	pg/g	8	4	50%	2.46	25.9	LL-SED3	03/15/2011	0–36 cm	4	50%	0.294	1.16
1,2,3,4,7,8-HxCDD	pg/g	8	4	50%	6.53	58.9	LL-SED3	03/15/2011	0–36 cm	4	50%	0.296	1.05
1,2,3,6,7,8-HxCDD	pg/g	8	6	75%	0.608	204	LL-SED3	03/15/2011	0–36 cm	2	25%	0.463	1.27
1,2,3,7,8,9-HxCDD	pg/g	8	4	50%	13.4	113	LL-SED3	03/15/2011	0–36 cm	4	50%	0.335	1.14
1,2,3,4,6,7,8-HpCDD	pg/g	8	7	88%	6.36	6,200	LL-SED3	03/15/2011	0–36 cm	1	13%	2.08	2.08
Total OCDD	pg/g	8	8	100%	14.8	53,800	LL-SED3	03/15/2011	0–36 cm	0	0%	5	5
2,3,7,8-TCDF	pg/g	8	4	50%	1.73	19.7	LL-SED3	03/15/2011	0–36 cm	4	50%	0.182	0.668
1,2,3,7,8-PeCDF	pg/g	8	4	50%	1.39	15.5	LL-SED3	03/15/2011	0–36 cm	4	50%	0.21	0.835
2,3,4,7,8-PeCDF	pg/g	8	4	50%	1.64	16.3	LL-SED3	03/15/2011	0–36 cm	4	50%	0.22	0.855
1,2,3,4,7,8-HxCDF	pg/g	8	6	75%	0.513	102	LL-SED3	03/15/2011	0–36 cm	2	25%	0.197	0.812
2,3,4,6,7,8-HxCDF	pg/g	8	4	50%	7.58	68.6	LL-SED3	03/15/2011	0–36 cm	4	50%	0.213	0.82
1,2,3,7,8,9-HxCDF	pg/g	8	4	50%	1.29	10.6	LL-SED3	03/15/2011	0–36 cm	4	50%	0.198	0.796
1,2,3,4,6,7,8-HpCDF	pg/g	8	7	88%	1.25	1,320	LL-SED3	03/15/2011	0–36 cm	1	13%	1.13	1.13
1,2,3,6,7,8-HxCDF	pg/g	8	4	50%	6.48	53.2	LL-SED3	03/15/2011	0–36 cm	4	50%	0.195	0.752
1,2,3,4,7,8,9-HpCDF	pg/g	8	4	50%	8.56	59.7	LL-SED3	03/15/2011	0–36 cm	4	50%	0.307	1.54

Table 4.5
Frequency of Detections for Lora Lake Subsurface Sediment Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Depth of Maximum Detect	Number of Non-detects	% Non-detect	Minimum Non-detect Value[1]	Maximum Non-detect Value[1]
Dioxins/Furans (continued)													
Total OCDF	pg/g	8	7	88%	3.61	3,280	LL-SED3	03/15/2011	0–36 cm	1	13%	3.08	3.08
Summed Dioxin/Furan TEQ[5,6]	pg/g	8	8	100%	0.00444	202	LL-SED3	03/15/2011	0–36 cm	0	0%	--	--
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[5,7]	pg/g	8	8	100%	0.657	202	LL-SED3	03/15/2011	0–36 cm	0	0%	--	--

Notes:

-- Indicates not applicable or not available.
1 If all results were detected, the minimum and maximum reporting limits are shown for non-TEQ calculated parameters.
2 Calculation of cPAH TEQ concentrations was performed using the California Environmental Protection Agency 2005 Toxic Equivancy Factors as presented in Table 708-2 of WAC 173-340-900 (WSDOE 2007).
3 Calculated using detected cPAH concentrations.
4 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.
5 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).
6 Calculated using detected dioxin/furan concentrations.
7 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:

cm Centimeter
cPAH Carcinogenic polycyclic aromatic hydrocarbon
OCDD Octachlorodibenzo-p-dioxin
OCDF Octachlorodibenzofuran
TEQ Toxic equivalency quotient
WAC Washington Administrative Code
WSDOE Washington State Department of Ecology

Table 4.6
Lora Lake and Miller Creek Sediment Bioassay Results

Surface Sediment Sample	Bioassay Testing Results
LL-SED1	No failures
LL-SED2 (Initial and Repeat Test)[1]	Failed CSL criterion for *Chironomus dilutus* survival
LL-SED3	Failed SCO criterion for *Chironomus dilutus* survival
LL-SED4	Failed SCO criterion for *Chironomus dilutus* survival
MC-SED1	Failed SCO criterion for *Chironomus dilutus* survival
MC-SED2	No failures
MC-SED3	Failed SCO criterion for *Chironomus dilutus* survival

Note:

1 The surface sediment sample from LL-SED2 was found to contain *Chaoborus sp*., a carnivorous midge that could have been responsible for the mortality of the *Chironomus dilutus* observed in this initial testing of this sample and possibly the reason the sediment was found to be toxic. Therefore, testing on this sample was repeated within the method holding time, following sieving of the sediment through a 0.5 mm sieve to remove any *Chaoborus sp.* larvae or eggs.

Table 4.7
Frequency of Detections for Lora Lake Parcel Soil Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Depth of Maximum Detect	Number of Non-detects	% Non-detect	Minimum Non-detect Value[1]	Maximum Non-detect Value[1]
Conventionals													
Total Organic Carbon	%	19	19	100%	0.072	8.78	LL-SB5	04/18/2011	0–0.5 ft	0	0%	0.02	0.154
Total Solids	%	19	19	100%	74	92.9	LL-SB1	04/19/2011	0–0.5 ft	0	0%	0.01	0.01
Metals													
Arsenic	mg/kg	19	13	68%	6	13	LL-SB2 LL-SB4	04/19/2011 04/19/2011	0–0.5 ft 0–0.5 ft	6	32%	5	6
Lead	mg/kg	19	18	95%	2	64	LL-SB5	04/18/2011	0–0.5 ft	1	5%	2	2
Total Petroleum Hydrocarbons													
Gasoline Range Hydrocarbons	mg/kg	19	1	5%	12	12	LL-SB2	04/19/2011	1.5–2 feet	18	95%	5.1	9.5
Diesel Range Hydrocarbons	mg/kg	19	2	11%	6.1	13	LL-SB5	04/18/2011	0–0.5 ft	17	89%	5.4	6.1
Heavy Oil Range Hydrocarbons	mg/kg	19	8	42%	16	150	LL-SB5	04/18/2011	0–0.5 ft	11	58%	11	12
Semivolatile Organic Compounds													
Pentachlorophenol	µg/kg	19	1	5%	24	24	LL-SB6	04/18/2011	0–0.5 ft	18	95%	6.5	8.7
Carcinogenic Polycyclic Aromatic Hydrocarbons													
Benzo(a)pyrene	µg/kg	19	6	32%	5.3	17	LL-SB5	04/18/2011	0–0.5 ft	13	68%	4.5	4.9
Benzo(a)anthracene	µg/kg	19	4	21%	5.9	12	LL-SB5	04/18/2011	0–0.5 ft	15	79%	4.5	4.9
Benzofluoranthenes (total)	µg/kg	19	6	32%	13	61	LL-SB5	04/18/2011	0–0.5 ft	13	68%	4.5	4.9
Chrysene	µg/kg	19	9	47%	4.9	37	LL-SB5	04/18/2011	0–0.5 ft	10	53%	4.5	4.9
Dibenzo(a,h)anthracene	µg/kg	19								19	100%	4.5	4.9
Indeno(1,2,3-cd)pyrene	µg/kg	19	4	21%	6.9	8	LL-SB6	04/18/2011	0–0.5 ft	15	79%	4.5	4.9
Summed cPAH TEQ[2,3]	µg/kg	19	9	47%	0.049	25	LL-SB5	04/18/2011	0–0.5 ft	10	53%	0	0
Summed cPAH TEQ with One-half of the Reporting Limit[2,4]	µg/kg	19	9	47%	3.3	26	LL-SB5	04/18/2011	0–0.5 ft	10	53%	3.2	3.5
Volatile Organic Compounds													
Tetrachloroethene	µg/kg	19	0	0%	--	--	--	--	--	19	100%	0.9	1.5
Trichloroethene	µg/kg	19	0	0%	--	--	--	--	--	19	100%	0.9	1.5
cis-1,2-Dichloroethene	µg/kg	19	0	0%	--	--	--	--	--	19	100%	0.9	1.5
trans-1,2-Dichloroethene	µg/kg	19	0	0%	--	--	--	--	--	19	100%	0.9	1.5
1,2-Dichloroethane	µg/kg	19	0	0%	--	--	--	--	--	19	100%	0.9	1.5
Benzene	µg/kg	19	0	0%	--	--	--	--	--	19	100%	25	47
Ethylbenzene	µg/kg	19	0	0%	--	--	--	--	--	19	100%	25	47
Toluene	µg/kg	19	0	0%	--	--	--	--	--	19	100%	25	47
m,p-Xylene	µg/kg	19	0	0%	--	--	--	--	--	19	100%	51	95
o-Xylene	µg/kg	19	0	0%	--	--	--	--	--	19	100%	25	47
Dioxins/Furans													
2,3,7,8-TCDD	pg/g	19	12	63%	0.317	7.82	LL-SB2	04/19/2011	0–0.5 ft	7	37%	0.119	0.208
1,2,3,7,8-PeCDD	pg/g	19	9	47%	0.637	7.97	LL-SB6	04/18/2011	0–0.5 ft	10	53%	0.198	0.381
1,2,3,4,7,8-HxCDD	pg/g	19	10	53%	0.524	15.9	LL-SB6	04/18/2011	0–0.5 ft	9	47%	0.214	0.364
1,2,3,6,7,8-HxCDD	pg/g	19	13	68%	0.828	46.6	LL-SB6	04/18/2011	0–0.5 ft	6	32%	0.28	0.367
1,2,3,7,8,9-HxCDD	pg/g	19	13	68%	0.653	30.3	LL-SB6	04/18/2011	0–0.5 ft	6	32%	0.241	0.32
1,2,3,4,6,7,8-HpCDD	pg/g	19	19	100%	1.17	1,330	LL-SB6	04/18/2011	0–0.5 ft	0	0%	2.5	2.5
Total OCDD	pg/g	19	19	100%	10.3	10,700	LL-SB6	04/18/2011	0–0.5 ft	0	0%	5	5
2,3,7,8-TCDF	pg/g	19	11	58%	0.286	1.49	LL-SB2	04/19/2011	0–0.5 ft	8	42%	0.105	0.267

Table 4.7
Frequency of Detections for Lora Lake Parcel Soil Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Depth of Maximum Detect	Number of Non-detects	% Non-detect	Minimum Non-detect Value[1]	Maximum Non-detect Value[1]
Dioxins/Furans (continued)													
1,2,3,7,8-PeCDF	pg/g	19	7	37%	0.33	0.785	LL-SB2	04/19/2011	0–0.5 ft	12	63%	0.129	0.333
2,3,4,7,8-PeCDF	pg/g	19	11	58%	0.366	2.02	LL-SB6	04/18/2011	0–0.5 ft	8	42%	0.135	0.284
1,2,3,4,7,8-HxCDF	pg/g	19	11	58%	0.496	17.2	LL-SB6	04/18/2011	0–0.5 ft	8	42%	0.155	0.26
2,3,4,6,7,8-HxCDF	pg/g	19	13	68%	0.411	7.35	LL-SB6	04/18/2011	0–0.5 ft	6	32%	0.172	0.234
1,2,3,7,8,9-HxCDF	pg/g	19	7	37%	0.247	1.55	LL-SB6	04/18/2011	0–0.5 ft	12	63%	0.16	0.331
1,2,3,4,6,7,8-HpCDF	pg/g	19	18	95%	0.365	173	LL-SB6	04/18/2011	0–0.5 ft	1	5%	0.22	0.22
1,2,3,6,7,8-HxCDF	pg/g	19	11	58%	0.405	5.74	LL-SB6	04/18/2011	0–0.5 ft	8	42%	0.156	0.251
1,2,3,4,7,8,9-HpCDF	pg/g	19	9	47%	1.11	8.16	LL-SB6	04/18/2011	0–0.5 ft	10	53%	0.218	0.49
Total OCDF	pg/g	19	14	74%	1.71	405	LL-SB6	04/18/2011	0–0.5 ft	5	26%	0.527	1.51
Summed Dioxin/Furan TEQ[5,6]	pg/g	19	19	100%	0.0148	40.4	LL-SB6	04/18/2011	0–0.5 ft	0	0%	--	--
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[5,7]	pg/g	19	19	100%	0.307	40.4	LL-SB6	04/18/2011	0–0.5 ft	0	0%	--	--

Notes:

-- Indicates not applicable or not available.
1 If all results were detected, the minimum and maximum reporting limits are shown.
2 Calculation of cPAH TEQ concentrations was performed using the California Environmental Protection Agency 2005 Toxic Equivancy Factors as presented in Table 708-2 of WAC 173-340-900 (WSDOE 2007).
3 Calculated using detected cPAH concentrations.
4 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.
5 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).
6 Calculated using detected dioxin/furan concentrations.
7 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:

cPAH Carcinogenic polycyclic aromatic hydrocarbon
ft Foot
OCDD Octachlorodibenzo-p-dioxin
OCDF Octachlorodibenzofuran
TEQ Toxic equivalency quotient
WAC Washington Administrative Code
WSDOE Washington State Department of Ecology

Table 4.8
Frequency of Detections for 1982 Dredged Material Containment Area Soil Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Depth of Maximum Detect	Number of Non-detects	% Non-detect	Minimum Non-detect Value[1]	Maximum Non-detect Value[1]
Conventionals													
Total Organic Carbon	%	15	15	100%	0.168	11.2	DMA-TP5	04/20/2011	1.5–2 ft	0	0%	0.02	0.02
Total Solids	%	15	15	100%	33.4	89.6	DMA-TP2	04/19/2011	3–4 ft	0	0%	0.01	0.01
Metals													
Arsenic	mg/kg	15	12	80%	6	60	DMA-TP4	04/20/2011	0–1.5 foot	3	20%	5	6
Lead	mg/kg	15	13	87%	2	165	DMA-TP3	04/20/2011	3–4 ft	2	13%	2	2
Total Petroleum Hydrocarbons													
Gasoline Range Hydrocarbons	mg/kg	15	3	20%	5.9	23	DMA-TP5	04/20/2011	1.5–2 ft	12	80%	3.5	23
Diesel Range Hydrocarbons	mg/kg	15	4	27%	14	21	DMA-TP5	04/20/2011	1.5–2 ft	11	73%	5.5	6
Heavy Oil Range Hydrocarbons	mg/kg	15	8	53%	18	120	DMA-TP5	04/20/2011	1.5–2 ft	7	47%	11	12
Semivolatile Organic Compounds													
Pentachlorophenol	µg/kg	15	2	13%	24	39	DMA-TP5	04/20/2011	1.5–2 ft	13	87%	6.9	18
Carcinogenic Polycyclic Aromatic Hydrocarbons													
Benzo(a)pyrene	µg/kg	15	4	27%	6.8	12	DMA-TP4 DMA-TP5	04/20/2011 04/20/2011	0–1.5 foot 1.5–2 ft	11	73%	4.4	4.9
Benzofluoranthenes (total)	µg/kg	15	6	40%	6.3	57	DMA-TP5	04/20/2011	1.5–2 ft	9	60%	4.4	4.7
Chrysene	µg/kg	15	7	47%	4.9	47	DMA-TP5	04/20/2011	1.5–2 ft	8	53%	4.4	4.7
Dibenzo(a,h)anthracene	µg/kg	15	0	0%	--	--	--	--	--	15	100%	4.4	4.9
Indeno(1,2,3-cd)pyrene	µg/kg	15	3	20%	5.5	13	DMA-TP5	04/20/2011	1.5–2 ft	12	80%	4.4	4.9
Summed cPAH TEQ[2,3]	µg/kg	15	7	47%	0.049	21	DMA-TP5	04/20/2011	1.5–2 ft	8	53%	0	0
Summed cPAH TEQ with One-half of the Reporting Limit[2,4]	µg/kg	15	7	47%	3.2	21	DMA-TP5	04/20/2011	1.5–2 ft	8	53%	3.1	3.3
Volatile Organic Compounds													
Tetrachloroethene	µg/kg	15	0	0%	--	--	--	--	--	15	100%	0.5	2.5
Trichloroethene	µg/kg	15	0	0%	--	--	--	--	--	15	100%	0.5	2.5
cis-1,2-Dichloroethene	µg/kg	15	0	0%	--	--	--	--	--	15	100%	0.5	2.5
trans-1,2-Dichloroethene	µg/kg	15	0	0%	--	--	--	--	--	15	100%	0.5	2.5
1,2-Dichloroethane	µg/kg	15	0	0%	--	--	--	--	--	15	100%	0.5	2.5
Benzene	µg/kg	15	0	0%	--	--	--	--	--	15	100%	17	120
Ethylbenzene	µg/kg	15	1	7%	50	50	DMA-TP1	04/19/2011	3–4.5 ft	14	93%	17	120
Toluene	µg/kg	15	5	33%	32	6500	DMA-TP5	04/20/2011	1.5–2 ft	10	67%	17	120
m,p-Xylene	µg/kg	15	0	0%	--	--	--	--	--	15	100%	35	230
o-Xylene	µg/kg	15	0	0%	--	--	--	--	--	15	100%	17	120
Dioxins/Furans													
2,3,7,8-TCDD	pg/g	15	8	53%	0.38	7.13	DMA-TP5	04/20/2011	1.5–2 ft	7	47%	0.102	0.204
1,2,3,7,8-PeCDD	pg/g	15	10	67%	0.224	10.6	DMA-TP5	04/20/2011	1.5–2 ft	5	33%	0.157	0.219
1,2,3,4,7,8-HxCDD	pg/g	15	10	67%	0.214	20.4	DMA-TP5	04/20/2011	1.5–2 ft	5	33%	0.134	0.21
1,2,3,6,7,8-HxCDD	pg/g	15	11	73%	0.641	79.2	DMA-TP5	04/20/2011	1.5–2 ft	4	27%	0.174	0.271
1,2,3,7,8,9-HxCDD	pg/g	15	11	73%	0.413	39.1	DMA-TP5	04/20/2011	1.5–2 ft	4	27%	0.149	0.234
1,2,3,4,6,7,8-HpCDD	pg/g	15	15	100%	1.09	1,910	DMA-TP5	04/20/2011	1.5–2 ft	0	--	2.5	2.5
Total OCDD	pg/g	15	15	100%	8.68	17,400	DMA-TP5	04/20/2011	1.5–2 ft	0	--	5	5
2,3,7,8-TCDF	pg/g	15	11	73%	0.33	6.99	DMA-TP5	04/20/2011	1.5–2 ft	4	27%	0.103	0.147

Table 4.8
Frequency of Detections for 1982 Dredged Material Containment Area Soil Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Depth of Maximum Detect	Number of Non-detects	% Non-detect	Minimum Non-detect Value[1]	Maximum Non-detect Value[1]
Dioxins/Furans (continued)													
1,2,3,7,8-PeCDF	pg/g	15	10	67%	0.239	5.09	DMA-TP5	04/20/2011	1.5–2 ft	5	33%	0.113	0.185
2,3,4,7,8-PeCDF	pg/g	15	11	73%	0.308	9.22	DMA-TP5	04/20/2011	1.5–2 ft	4	27%	0.123	0.2
1,2,3,4,7,8-HxCDF	pg/g	15	11	73%	0.316	29.8	DMA-TP5	04/20/2011	1.5–2 ft	4	27%	0.0961	0.214
2,3,4,6,7,8-HxCDF	pg/g	15	11	73%	0.348	23	DMA-TP5	04/20/2011	1.5–2 ft	4	27%	0.108	0.234
1,2,3,7,8,9-HxCDF	pg/g	15	10	67%	0.145	4.04	DMA-TP5	04/20/2011	1.5–2 ft	5	33%	0.0762	0.196
1,2,3,4,6,7,8-HpCDF	pg/g	15	15	100%	0.237	448	DMA-TP5	04/20/2011	1.5–2 ft	0	0%	2.5	2.5
1,2,3,6,7,8-HxCDF	pg/g	15	11	73%	0.256	16.3	DMA-TP5	04/20/2011	1.5–2 ft	4	27%	0.0986	0.225
1,2,3,4,7,8,9-HpCDF	pg/g	15	11	73%	0.309	25.2	DMA-TP5	04/20/2011	1.5–2 ft	4	27%	0.111	0.173
Total OCDF	pg/g	15	15	100%	0.522	1,150	DMA-TP4	04/20/2011	0–1.5 foot	0	0%	5	5
Summed Dioxin/Furan TEQ[5,6]	pg/g	15	15	100%	0.217	71.9	DMA-TP5	04/20/2011	1.5–2 ft	0	0%	--	--
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[5,7]	pg/g	15	15	100%	0.217	71.9	DMA-TP5	04/20/2011	1.5–2 ft	0	0%	--	--

Notes:

-- Indicates not applicable or not available.
1 If all results were detected, the minimum and maximum reporting limits are shown.
2 Calculation of cPAH TEQ concentrations was performed using the California Environmental Protection Agency 2005 Toxic Equivancy Factors as presented in Table 708-2 of WAC 173-340-900 (WSDOE 2007).
3 Calculated using detected cPAH concentrations.
4 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.
5 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).
6 Calculated using detected dioxin/furan concentrations.
7 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:

cPAH Carcinogenic polycyclic aromatic hydrocarbon
ft Feet
OCDD Octachlorodibenzo-p-dioxin
OCDF Octachlorodibenzofuran
TEQ Toxic equivalency quotient
WAC Washington Administrative Code
WSDOE Washington State Department of Ecology

Table 4.9
Frequency of Detections for 1982 Dredged Material Containment Area Groundwater Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Number of Non-detects	% Non-detect	Minimum Non-detect Value[1]	Maximum Non-detect Value[1]
Total Metals												
Arsenic	µg/L	3	3	100%	0.3	0.7	B-310	04/29/2011	0	0%	0.2	0.2
Lead	µg/L	3	0	0%	--	--	--	--	3	100%	0.1	0.1
Total Petroleum Hydrocarbons												
Gasoline Range Hydrocarbons	mg/L	3	0	0%	--	--	--	--	3	100%	0.25	0.25
Diesel Range Hydrocarbons	mg/L	3	0	0%	--	--	--	--	3	100%	0.1	0.1
Heavy Oil Range Hydrocarbons	mg/L	3	0	0%	--	--	--	--	3	100%	0.2	0.2
Semivolatile Organic Compounds												
Pentachlorophenol	µg/L	3	0	0%	--	--	--	--	3	100%	0.25	0.25
Carcinogenic Polycyclic Aromatic Hydrocarbons												
Benzo(a)pyrene	µg/L	3	0	0%	--	--	--	--	3	100%	0.01	0.01
Benzo(a)anthracene	µg/L	3	0	0%	--	--	--	--	3	100%	0.01	0.01
Benzofluoranthenes (total)	µg/L	3	0	0%	--	--	--	--	3	100%	0.01	0.01
Chrysene	µg/L	3	0	0%	--	--	--	--	3	100%	0.01	0.01
Dibenzo(a,h)anthracene	µg/L	3	0	0%	--	--	--	--	3	100%	0.01	0.01
Indeno(1,2,3-cd)pyrene	µg/L	3	0	0%	--	--	--	--	3	100%	0.01	0.01
Summed cPAH TEQ[2,3]	µg/L	3	0	0%	--	--	--	--	3	100%	0	0
Summed cPAH TEQ with One-half of the Reporting Limit[2,4]	µg/L	3	0	0%	--	--	--	--	3	100%	0.0071	0.0071
Volatile Organic Compounds												
Tetrachloroethene	µg/L	3	0	0%	--	--	--	--	3	100%	0.02	0.02
Trichloroethene	µg/L	3	0	0%	--	--	--	--	3	100%	0.02	0.02
cis-1,2-Dichloroethene	µg/L	3	0	0%	--	--	--	--	3	100%	0.02	0.02
trans-1,2-Dichloroethene	µg/L	3	0	0%	--	--	--	--	3	100%	0.02	0.02
1,2-Dichloroethane	µg/L	3	0	0%	--	--	--	--	3	100%	0.02	0.02
Benzene	µg/L	3	0	0%	--	--	--	--	3	100%	1	1
Ethylbenzene	µg/L	3	0	0%	--	--	--	--	3	100%	1	1
Toluene	µg/L	3	0	0%	--	--	--	--	3	100%	1	1
m,p-Xylene	µg/L	3	0	0%	--	--	--	--	3	100%	1	1
o-Xylene	µg/L	3	0	0%	--	--	--	--	3	100%	1	1
Dioxins/Furans												
2,3,7,8-TCDD	pg/L	3	0	0%	--	--	--	--	3	100%	1.09	1.32
1,2,3,7,8-PeCDD	pg/L	3	0	0%	--	--	--	--	3	100%	1.64	1.99
1,2,3,4,7,8-HxCDD	pg/L	3	0	0%	--	--	--	--	3	100%	1.77	2.37
1,2,3,6,7,8-HxCDD	pg/L	3	0	0%	--	--	--	--	3	100%	2.22	2.99
1,2,3,7,8,9-HxCDD	pg/L	3	0	0%	--	--	--	--	3	100%	1.95	2.62
1,2,3,4,6,7,8-HpCDD	pg/L	3	0	0%	--	--	--	--	3	100%	2.27	2.65
Total OCDD	pg/L	3	3	100%	12.8	27.5	B-310	04/29/2011	0	--	50	50
2,3,7,8-TCDF	pg/L	3	0	0%	--	--	--	--	3	100%	0.86	0.91
1,2,3,7,8-PeCDF	pg/L	3	0	0%	--	--	--	--	3	100%	1.13	1.4
2,3,4,7,8-PeCDF	pg/L	3	0	0%	--	--	--	--	3	100%	1.2	1.59
1,2,3,4,7,8-HxCDF	pg/L	3	0	0%	--	--	--	--	3	100%	1.26	1.9
2,3,4,6,7,8-HxCDF	pg/L	3	0	0%	--	--	--	--	3	100%	1.34	2.04

Table 4.9
Frequency of Detections for 1982 Dredged Material Containment Area Groundwater Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Number of Non-detects	% Non-detect	Minimum Non-detect Value[1]	Maximum Non-detect Value[1]
Dioxins/Furans (continued)												
1,2,3,7,8,9-HxCDF	pg/L	3	0	0%	--	--	--	--	3	100%	1.32	2.01
1,2,3,4,6,7,8-HpCDF	pg/L	3	0	0%	--	--	--	--	3	100%	1.7	2
1,2,3,6,7,8-HxCDF	pg/L	3	0	0%	--	--	--	--	3	100%	1.25	1.85
1,2,3,4,7,8,9-HpCDF	pg/L	3	0	0%	--	--	--	--	3	100%	2.74	3.01
Total OCDF	pg/L	3	0	0%	--	--	--	--	3	100%	3.89	4.25
Summed Dioxin/Furan TEQ[5,6]	pg/L	3	3	100%	0.00384	0.00825	B-310	04/29/2011	0	0%	--	--
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[5,7]	pg/L	3	3	100%	2.3	2.56	B-311	04/29/2011	0	0%	--	--

Notes:

-- Indicates not applicable or not available.
1 If all results were detected, the minimum and maximum reporting limits are shown.
2 Calculation of cPAH TEQ concentrations was performed using the California Environmental Protection Agency 2005 Toxic Equivancy Factors as presented in Table 708-2 of WAC 173-340-900 (WSDOE 2007).
3 Calculated using detected cPAH concentrations.
4 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.
5 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).
6 Calculated using detected dioxin/furan concentrations.
7 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:

cPAH Carcinogenic polycyclic aromatic hydrocarbon
OCDD Octachlorodibenzo-p-dioxin
OCDF Octachlorodibenzofuran
TEQ Toxic equivalency quotient
WAC Washington Administrative Code
WSDOE Washington State Department of Ecology

Table 5.1
Frequency of Detections for Lora Lake Apartments Parcel Air Analytical Results

Analyte	Unit	Number of Results[1]	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Number of Non-detects	% Non-detect	Minimum Non-detect Value	Maximum Non-detect Value
Semivolatile Organic Compounds												
1,4-Dioxane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Acrolein	µg/m³	5	1	20%	1	1	LL-SV-R	4/15/2008	4	80%	0.77	0.81
Acrylonitrile	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Hexachlorobutadiene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Naphthalene	µg/m³	5	1	20%	1.3	1.3	LL-SV-R	4/15/2008	4	80%	0.77	0.81
Volatile Organic Compounds												
1,1,1-Trichloroethane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
1,1,2,2-Tetrachloroethane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
1,1,2-Trichloroethane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
1,1-Dichloroethane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
1,1-Dichloroethene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
1,2,4-Trichlorobenzene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
1,2,4-Trimethylbenzene	µg/m³	5	2	40%	0.89	1.6	LL-SV-T	4/15/2008	3	60%	0.77	0.77
1,2-Dibromo-3-chloropropane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
1,2-Dibromoethane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
1,2-Dichlorobenzene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
1,2-Dichloroethane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
1,2-Dichloropropane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
1,3,5-Trimethylbenzene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
1,3-Dichlorobenzene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
1,4-Dichlorobenzene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
2-Hexanone	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Acetone	µg/m³	5	3	60%	11	13	LL-SV-R	4/15/2008	2	40%	7.7	7.7
Allyl chloride	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Benzene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Bromodichloromethane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Bromoform	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Bromomethane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Carbon disulfide	µg/m³	5	4	80%	0.96	6.4	LL-SV-F	4/14/2008	1	20%	0.76	0.76
Carbon tetrachloride	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Chlorobenzene	µg/m³	5	1	20%	3.3	3.3	LL-SV-Z	4/15/2008	4	80%	0.76	0.81
Chloroethane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Chloroform	µg/m³	5	1	20%	0.89	0.89	LL-SV-F	4/14/2008	4	80%	0.76	0.81
Chloromethane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
cis-1,2-Dichloroethene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
cis-1,3-Dichloropropene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Dibromochloromethane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Dichlorodifluoromethane	µg/m³	5	5	100%	6.4	420	LL-SV-F	4/14/2008	0	0%	--	--
Dichloromethane	µg/m³	5	5	100%	2.2	29	LL-SV-T	4/15/2008	0	0%	--	--
Ethanol	µg/m³	5	1	20%	9	9	LL-SV-F	4/14/2008	4	80%	7.6	8.1
Ethyl acetate	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Ethylbenzene	µg/m³	5	2	40%	0.92	1.6	LL-SV-T	4/15/2008	3	60%	0.77	0.77

Table 5.1
Frequency of Detections for Lora Lake Apartments Parcel Air Analytical Results

Analyte	Unit	Number of Results[1]	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Number of Non-detects	% Non-detect	Minimum Non-detect Value	Maximum Non-detect Value
Volatile Organic Compounds (continued)												
iso-Propylbenzene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Methyl ethyl ketone	µg/m³	5	3	60%	1.4	3.5	LL-SV-R	4/15/2008	2	40%	0.77	0.77
Methyl iso butyl ketone	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Methyl methacrylate	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Methyl-Tert-Butyl Ether	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
n-Propylbenzene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Styrene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Tetrachloroethene	µg/m³	5	2	40%	1.8	1.9	LL-SV-Z	4/15/2008	3	60%	0.76	0.81
Toluene	µg/m³	5	5	100%	2.5	5.3	LL-SV-T	4/15/2008	0	0%	--	--
trans-1,2-Dichloroethene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
trans-1,3-Dichloropropene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Trichloroethene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Trichlorofluoromethane	µg/m³	5	5	100%	1.2	1.3	LL-SV-F	4/14/2008	0	0%	--	--
Trichlorotrifluoroethane	µg/m³	5	1	20%	0.85	0.85	LL-SV-RB	4/15/2008	4	80%	0.76	0.81
Vinyl acetate	µg/m³	5	0	0%	--	--	--	--	5	100%	7.6	8.1
Vinyl chloride	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
m,p-Xylene	µg/m³	5	2	40%	1.6	3.4	LL-SV-T	4/15/2008	3	60%	1.5	1.5
o-Xylene	µg/m³	5	1	20%	1.2	12	LL-SV-T	4/15/2008	4	80%	0.76	0.77
Methane	%	5	0	0%	--	--	--	--	5	100%	0.15	0.15
Miscellaneous												
1,3-Butadiene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
4-Ethyltoluene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Acetonitrile	µg/m³	5	1	20%	0.78	0.78	LL-SV-F	4/14/2008	4	80%	0.76	0.81
alpha-Pinene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Benzyl Chloride	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Carbon Dioxide	%	5	4	80%	0.241	1.23	LL-SV-T	4/15/2008	1	20%	0.15	0.15
Cyclohexane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
d-Limonene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Freon 114	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
iso-Propanol	µg/m³	5	3	60%	0.86	1.1	LL-SV-R	4/15/2008	2	40%	0.77	0.77
n-Butyl Acetate	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
n-Heptane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
n-Hexane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
n-Nonane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
n-Octane	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Oxygen + Argon	%	5	5	100%	21.5	22.8	LL-SV-R	4/15/2008	0	0%	--	--
Propene	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81
Tetrahydrofuran	µg/m³	5	0	0%	--	--	--	--	5	100%	0.76	0.81

Notes:

-- Indicates not applicable or not available.

1 Samples LL-SV-D, LL-SV-H, and LL-SV-N did not meet QA/QC requirements for shroud helium concentrations, indicating leaks in the sampling apparatus and are therefore not included.

Table 5.2
Summary of LL Apartments Parcel, LL Parcel, and DMCA Applicable Cleanup Level Regulations

Medium	Parcel	Applicable Cleanup Levels
Soil	LL Apartments Parcel and LL Parcel	• MTCA Method B—human health via direct contact • MTCA protection of groundwater • Washington State background
	LL Parcel	• MTCA TEE Wildlife Ecological Indicator Concentrations
	DMCA	• MTCA Method C—human health via direct contact • MTCA protection of groundwater • Washington State background
Groundwater	LL Apartments Parcel, LL Parcel, and DMCA	• MTCA Method B—human health via drinking water consumption • State and federal MCLs
Sediment	LL Apartments and DMCA	• Not applicable
	Lora Lake and Miller Creek	• Sediment Management Standards—freshwater Sediment Cleanup Objectives and Cleanup Screening Levels (chemical and biological criteria) • Protection of human health via Sediment Management Standards' Sediment Cleanup Objectives and Cleanup Screening Levels, and surface water ARARs

Abbreviations:

ARAR	Applicable or Relevant and Appropriate Requirements
DMCA	Dredged Material Containment Area
LL	Lora Lake
MCL	Maximum contaminant level
MTCA	Model Toxics Control Act
TEE	Terrestrial Ecological Evaluation
WSDOE	Washington State Department of Ecology

Table 6.1
Site Contaminants of Concern

Analyte Group	Contaminant of Concern
Soil	
Metals	Arsenic
	Lead
Total Petroleum Hydrocarbons	Gasoline Range Hydrocarbons
	Diesel Range Hydrocarbons
	Heavy Oil Range Hydrocarbons
Semivolatile Organic Compounds	Pentachlorophenol
	Carcinogenic Polycyclic Aromatic Hydrocarbons
Volatile Organic Compounds	Ethylbenzene
	Toluene
Dioxins/Furans	Dioxins/Furans
Groundwater	
Metals	Arsenic
Total Petroleum Hydrocarbons	Gasoline Range Hydrocarbons
	Diesel Range Hydrocarbons
	Heavy Oil Range Hydrocarbons
Semivolatile Organic Compounds	Pentachlorophenol
	Carcinogenic Polycyclic Aromatic Hydrocarbons
Dioxins/Furans	Dioxins/Furans
Surface Sediment	
Metals	Arsenic
	Lead
Semivolatile Organic Compounds	Pentachlorophenol
	Carcinogenic Polycyclic Aromatic Hydrocarbons
Dioxins/Furans	Dioxins/Furans

Table 6.2
Groundwater ARARs for the Protection of Human Health—Drinking Water Highest Beneficial Use

Site Contaminant of Concern	Unit	PQL	State and Federal MCL	MTCA Method A/B (standard)[1,2,3]	MTCA Method B (adjusted)[1,4,5]	Proposed Groundwater Cleanup Level	
Arsenic	µg/L	0.2	10	5	--	**5**	MTCA Method A
Gasoline range TPH	µg/L	250	NA	1,000	--	**1,000**	MTCA Method A
Diesel range TPH	µg/L	100	NA	500	--	**500**	MTCA Method A
Heavy oil range TPH	µg/L	200	NA	500	--	**500**	MTCA Method A
cPAH TEQ	µg/L	0.01	0.2	0.012	0.12	**0.12**	MTCA Method B
Pentachlorophenol	µg/L	0.25	1	0.22	2.2	**1**	MCL
Dioxin/Furan TEQ	pg/L	<1 to 4	30	--	5.83	**6.7**	MTCA Method B

Notes:

BOLD Indicates the cleanup level proposed for use at the Lora Lake Apartments Site.

-- Indicates not applicable or not available.

1 MTCA Method B cleanup levels are based on protection of human health via consumption of drinking water.

2 The MTCA Method A cleanup level is presented for arsenic and is based on Washington State background.

3 The MTCA Method A cleanup level is presented for gasoline range TPH and is based on benzene not being detected in groundwater.

4 Adjusted MTCA Method B cleanup levels calculated using MTCA Equation 720(2). Per WAC 173-340-720(3)(b) and WAC-173-340-720(4) cleanup levels are adjusted per deferment to the state and federal MCL without exceeding the allowable risk level of 10^{-5}.

5 The calculation of the adjusted MTCA Method B cleanup levels and the proposed use of the adjusted MTCA Method B cleanup level and/or MCL consistent with WAC 173-340-720(3)(b) and WAC-173-340-720(4), and the approach summarized in Figure 3 of the “Focus on Developing Groundwater Cleanup Standards Under the Model Toxics Control Act” (WSDOE 01-09-049).

Abbreviations:

ARAR Applicable, relevant, and appropriate requirement
cPAH Carcinogenic polycyclic aromatic hydrocarbon
MCL Maximum contaminant level
MTCA Model Toxics Control Act
NA Not available
PQL Practical quantitation limit
TEQ Toxic equivalency quotient
WAC Washington Administrative Code
WSDOE Washington State Department of Ecology

Table 6.3
Frequency of Detections for Lora Lake Apartments 2010 to 2011 Groundwater Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Number of Non-detects	% Non-detect	Minimum Non-detect Value[1]	Maximum Non-detect Value[1]
Conventionals												
pH	pH	54	54	100%	5.9	7.85	MW-17	9/13/2010	0	0%	--	--
Total Suspended Solids	mg/L	54	30	56%	1.1	103	MW-15	9/13/2010	24	44%	1	1.1
Dissolved Metals												
Arsenic	µg/L	44	38	86%	0.2	14.2	MW-1	4/29/2011	6	14%	0.2	0.2
Lead	µg/L	44							44	100%	0.1	1
Total Petroleum Hydrocarbons												
Gasoline Range Hydrocarbons	mg/L	50	4	8%	0.38	0.46	MW-1	1/21/2011	46	92%	0.25	0.25
Diesel Range Hydrocarbons	mg/L	54	2	4%	0.18	0.18	MW-1	1/21/2011 4/26/2011	52	96%	0.1	0.1
Heavy Oil Range Hydrocarbons	mg/L	54	3	6%	0.2	0.53	MW-1	1/21/2011	51	94%	0.2	0.2
Semivolatile Organic Compounds												
Pentachlorophenol	µg/L	54	10	19%	0.29	1.4	MW-5	1/21/2011 4/28/2011	44	81%	0.25	0.25
Carcinogenic Polycyclic Aromatic Hydrocarbons												
Benzo(a)anthracene	µg/L	54	2	4%	0.0058	0.017	MW-1	1/21/2011	52	96%	0.01	0.01
Benzo(a)pyrene	µg/L	54	3	6%	0.0057	0.021	MW-1	1/21/2011	51	94%	0.01	0.01
Benzofluoranthenes (total)	µg/L	54	2	4%	0.012	0.031	MW-1	1/21/2011	52	96%	0.01	0.01
Chrysene	µg/L	54	4	7%	0.008	0.026	MW-1	1/21/2011	50	93%	0.01	0.01
Dibenzo(a,h)anthracene	µg/L	54	0	0%	--	--	--	--	54	100%	0.01	0.01
Indeno(1,2,3-cd)pyrene	µg/L	54	1	2%	0.012	0.012	MW-1	1/21/2011	53	98%	0.01	0.01
Summed cPAH TEQ[2,3]	µg/L	54	4	7%	0.0013	0.027	MW-1	1/21/2011	50	93%	0	0
Summed cPAH TEQ with One-half of the Reporting Limit[2,4]	µg/L	54	4	7%	0.0078	0.028	MW-1	1/21/2011	50	93%	0.0071	0.0071
Volatile Organic Compounds												
1,2-Dichloroethane	µg/L	54	6	11%	0.026	0.07	MW-5	8/13/2010	48	89%	0.02	0.02
Benzene	µg/L	54	0	0%	--	--	--	--	54	100%	0.2	1
cis-1,2-Dichloroethene	µg/L	54	6	11%	0.028	0.26	MW-1	1/21/2011	48	89%	0.02	0.02
Ethylbenzene	µg/L	54	5	9%	1.1	3.1	MW-1	1/21/2011	49	91%	0.2	1
Tetrachloroethene	µg/L	54	4	7%	0.024	0.035	MW-13	8/12/2010	50	93%	0.02	0.02
Toluene	µg/L	54	0	0%	--	--	--	--	54	100%	0.2	1
trans-1,2-Dichloroethene	µg/L	54	5	9%	0.041	0.11	MW-1	8/13/2010	49	91%	0.02	0.02
Trichloroethene	µg/L	54	5	9%	0.12	0.17	MW-1	8/13/2010	49	91%	0.02	0.02
m,p-Xylene	µg/L	54	4	7%	1.8	5.6	MW-1	1/21/2011	50	93%	0.4	1
o-Xylene	µg/L	54	2	4%	8.6	9.2	MW-1	1/21/2011	52	96%	0.2	1
Dioxins/Furans												
2,3,7,8-TCDD	pg/L	44	2	5%	2.27	3.34	MW-1	1/21/2011	42	95%	0.55	4.54
1,2,3,7,8-PeCDD	pg/L	44	4	9%	1.5	9.29	MW-1	1/21/2011	40	91%	1.07	4.96
1,2,3,4,7,8-HxCDD	pg/L	44	4	9%	2.91	5.19	MW-1	1/21/2011	40	91%	0.92	5.61
1,2,3,6,7,8-HxCDD	pg/L	44	5	11%	15.9	46.6	MW-1	1/21/2011	39	89%	1.16	6.15
1,2,3,7,8,9-HxCDD	pg/L	44	5	11%	6.43	20.6	MW-1	1/21/2011	39	89%	1.02	5.6
1,2,3,4,6,7,8-HpCDD	pg/L	44	17	39%	2.62	920	MW-1	1/21/2011	27	61%	1.49	8.01
Total OCDD	pg/L	44	25	57%	6.65	16,200	MW-1	1/21/2011	19	43%	2.34	14.4
2,3,7,8-TCDF	pg/L	44	0	0%	--	--	--	--	44	100%	0.48	3.1
1,2,3,7,8-PeCDF	pg/L	44	4	9%	11.8	14.6	MW-1	4/29/2011	40	91%	0.77	3.39
2,3,4,7,8-PeCDF	pg/L	44	3	7%	2.5	4.51	MW-1	1/21/2011	41	93%	0.83	4.02
1,2,3,4,7,8-HxCDF	pg/L	44	4	9%	2.58	5.06	MW-1	1/21/2011	40	91%	0.77	4.23

Table 6.3
Frequency of Detections for Lora Lake Apartments 2010 to 2011 Groundwater Analytical Results

Analyte	Unit	Number of Results	Number of Detects	% Detect	Minimum Detected Value	Maximum Detected Value	Location of Maximum Detect	Date of Maximum Detect	Number of Non-detects	% Non-detect	Minimum Non-detect Value[1]	Maximum Non-detect Value[1]
Dioxins/Furans (continued)												
1,2,3,6,7,8-HxCDF	pg/L	44	3	7%	4.42	6.06	MW-1	4/29/2011	41	93%	0.75	9.83
2,3,4,6,7,8-HxCDF	pg/L	44	5	11%	6.34	17.4	MW-1	1/21/2011	39	89%	0.76	4.74
1,2,3,7,8,9-HxCDF	pg/L	44	2	5%	2.04	2.11	MW-1	4/29/2011	42	95%	0.65	5.13
1,2,3,4,6,7,8-HpCDF	pg/L	44	8	18%	3.5	126	MW-1	1/21/2011	36	82%	0.74	5.92
1,2,3,4,7,8,9-HpCDF	pg/L	44	5	11%	4.16	11.7	MW-1	1/21/2011	39	89%	0.94	9.24
Total OCDF	pg/L	44	8	18%	10.6	384	MW-1	1/21/2011	36	82%	2.06	14.3
Summed Dioxin/Furan TEQ[5,6]	pg/L	44	25	57%	0.002	37.6	MW-1	1/21/2011	19	43%	--	--
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[5,7]	pg/L	44	25	57%	1.6	38.3	MW-1	1/21/2011	19	43%	1.43	6.38

Notes:
-- Indicates not applicable or not available.
1 If all results were detected, the minimum and maximum reporting limits are shown.
2 Calculation of cPAH TEQ concentrations was performed using the California Environmental Protection Agency 2005 Toxic Equivancy Factors as presented in Table 708-2 of WAC 173-340-900 (WSDOE 2007).
3 Calculated using detected cPAH concentrations.
4 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.
5 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).
6 Calculated using detected dioxin/furan concentrations.
7 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:
cPAH Carcinogenic polycyclic aromatic hydrocarbon
OCDD Octachlorodibenzo-p-dioxin
OCDF Octachlorodibenzofuran
TEQ Toxic equivalency quotient
WAC Washington Administrative Code
WSDOE Washington State Department of Ecology

Table 6.4
Soil, Groundwater, and Surface Sediment Site Contaminants of Concern Cleanup Levels

Media	Contaminant of Concern	Pathway	Cleanup Level Source/Reference[1]	Cleanup Level Value	Unit	Area of Site Where Cleanup Level Applies
Soil	**Metals**					
	Arsenic	Human health—direct contact and protection of groundwater, adjusted for natural background for soil	MTCA Method A—Unrestricted Land Use	20	mg/kg	LL Apartments Parcel and LL Parcel
		Human health—direct contact (ingestion only)	MTCA Method C—Standard, Carcinogen—Industrial Land Use	88	mg/kg	DMCA
	Lead	Human health—direct contact, prevention of unacceptable blood lead levels	MTCA Method A—Unrestricted Land Use	250	mg/kg	LL Apartments Parcel and LL Parcel
		Human health—direct contact (ingestion only)	MTCA Method A— Industrial Land Use	1,000	mg/kg	DMCA
	Total Petroleum Hydrocarbons					
	Gasoline Range Hydrocarbons	Human health—protection of groundwater for non-carcinogenic effects during drinking water use	MTCA Method A—Unrestricted Land Use	100[2]	mg/kg	Site-wide
	Diesel Range Hydrocarbons	Prevention of accumulation of free product in groundwater	MTCA Method A—Unrestricted Land Use	2,000	mg/kg	Site-wide
	Heavy Oil Range Hydrocarbons	Prevention of accumulation of free product in groundwater	MTCA Method A—Unrestricted Land Use	2,000	mg/kg	Site-wide
	Semivolatile Organic Compounds					
	Pentachlorophenol	Human health—direct contact (ingestion only)	MTCA Method B—Standard, Carcinogen	2,500	µg/kg	LL Apartments Parcel and LL Parcel
			MTCA Method C—Standard, Carcinogen—Industrial Land Use	330,000	µg/kg	DMCA
	cPAHs TEQ	Human health—direct contact (ingestion only)	MTCA Method B—Standard, Carcinogen	137	µg/kg	LL Apartments Parcel and LL Parcel
			MTCA Method C—Standard, Carcinogen—Industrial Land Use	18,000	µg/kg	DMCA
	Volatile Organic Compounds					
	Ethylbenzene	Human health—direct contact (ingestion only)	MTCA Method B—Standard, Non-carcinogen	8,000	mg/kg	LL Apartments Parcel and LL Parcel
			MTCA Method C—Standard, Carcinogen—Industrial Land Use	350,000	mg/kg	DMCA
	Toluene	Human health—direct contact (ingestion only)	MTCA Method B—Standard, Non-carcinogen	6,400	mg/kg	LL Apartments Parcel and LL Parcel
			MTCA Method C—Standard, Carcinogen—Industrial Land Use	280,000	mg/kg	DMCA
	Dioxins/Furans					
	Dioxins/Furans TEQ	Human health—direct contact (ingestion only)	MTCA Method B—Standard, Carcinogen	13	pg/g	LL Apartments Parcel
		Human health—direct contact (ingestion only)	MTCA Method C—Standard, Carcinogen—Industrial Land Use	1,700	pg/g	DMCA
		Washington State natural background	*Natural Background for Dioxins/Furans in Washington Soils Technical Memorandum* (WSDOE 2010)[3]	5.2	pg/g	LL Parcel
Groundwater	**Metals**					
	Arsenic	Washington State background	MTCA Method A	5	µg/L	Site-wide
	Total Petroleum Hydrocarbons					
	Gasoline Range Hydrocarbons	Human health—protection of groundwater for non-carcinogenic effects during drinking water use	MTCA Method A—Unrestricted Land Use	1000[2]	µg/L	Site-wide
	Diesel Range Hydrocarbons		MTCA Method A—Unrestricted Land Use	500	µg/L	Site-wide
	Heavy Oil Range Hydrocarbons		MTCA Method A—Unrestricted Land Use	500	µg/L	Site-wide
	Semivolatile Organic Compounds					
	Pentachlorophenol	Human health—drinking water beneficial use	State and Federal MCL	1	µg/L	Site-wide
	cPAHs TEQ	Human health—drinking water beneficial use	MTCA Method B—Standard, Carcinogen	0.12	µg/L	Site-wide
	Dioxins/Furans					
	Dioxin/Furan TEQ	Human health—drinking water beneficial use	MTCA Method B—Adjusted, Carcinogen[4]	6.7	pg/L	Site-wide

Table 6.4
Soil, Groundwater, and Surface Sediment Site Contaminants of Concern Cleanup Levels

	Contaminant of Concern	Pathway	Cleanup Level Source/Reference[1]	Cleanup Level Value		Unit	Area of Site Where Cleanup Level Applies
Surface Sediment[5]	**Metals**			**SCO**	**CSL**		
	Arsenic	Protection of benthic aquatic organisms	Sediment Management Standards—Freshwater Chemical Criteria	14	120	mg/kg	Lora Lake and Miller Creek
		Human health--fish consumption	Sediment Management Standards—Human Health Criteria	*11*	*11*	mg/kg	Lora Lake and Miller Creek
	Lead	Protection of benthic aquatic organisms	Sediment Management Standards—Freshwater Chemical Criteria	360	>1,300	mg/kg	Lora Lake and Miller Creek
		Human health--fish consumption	Sediment Management Standards—Human Health Criteria	*21*	*21*	mg/kg	Lora Lake and Miller Creek
	Semivolatile Organic Compounds						
	Pentachlorophenol	Protection of benthic aquatic organisms	Sediment Management Standards—Freshwater Chemical Criteria	1,200	*>1,200*	µg/kg	Lora Lake and Miller Creek
		Human health--fish consumption	Sediment Management Standards—Human Health Criteria	*160*	1,600	µg/kg	Lora Lake and Miller Creek
	cPAHs TEQ	Protection of benthic aquatic organisms	Sediment Management Standards—Freshwater Chemical Criteria[6]	17,000	30,000	µg/kg	Lora Lake and Miller Creek
		Human health--fish consumption	Sediment Management Standards—Human Health Criteria	*440*	*4,400*	µg/kg	Lora Lake and Miller Creek
	Dioxins/Furans						
		Human health--fish consumption	Sediment Management Standards—Human Health Criteria	5	5	pg/g	Lora Lake and Miller Creek

Notes:

1 The most stringent applicable cleanup levels for the complete human health pathways are identified for the Lora Lake Apartments Site.

2 Gasoline range hydrocarbons cleanup levels for soil and groundwater are based on the higher cleanup level as testing indicated that benzene was not present.

3 As presented in the WSDOE 2010 technical memorandum the Washington State natural background concentration of 5.2 pg/g TEQ is calculated as the lower of the 90th percentile and 4 X 50 percentile (per WAC 173-340-709). Refer to Appendix M of the LL Apartments Site Remedial Investigation/Feasibility Study for more details.

4 Adjusted dioxin/furan groundwater cleanup level is calculated using adjusted MTCA Method B per MTCA Equation 720-2 (with a risk level of 10^5).

5 Surface sediment standards protective of both benthic and human health exposure pathways have been presented for informational purposes. The lesser of these two values (italicized) will be applied as the sediment cleanup level value for all contaminants of concern. The derivation of the human health criteria is discussed in a technical memorandum submitted to WSDOE in December 2014 (Floyd|Snider 2014).

6 A total PAHs SCO is available, but no SCO is available for cPAH TEQ. The total PAHs SCO is applied in lieu of a cPAH SCO.

Abbreviations:

cPAH Carcinogenic polycyclic aromatic hydrocarbon
CSL Cleanup Screening Level
DMCA Dredged Material Containment Area
EIC Ecological Indicator Soil Concentration
MCL Maximum Contaminant Level
MTCA Model Toxics Control Act
NA Not available
PAH Polycyclic aromatic hydrocarbon
SCO Sediment Cleanup Objective
TEE Terrestrial Ecological Evaluation
TEQ Toxic equivalency quotient
WAC Washington Administrative Code
WSDOE Washington State Department of Ecology

Table 6.5
Biological Criteria for Freshwater Sediment[1]

Toxicity Test	CSL failure	SCO failure
Hyalella azteca 10-day mortality	T–C > 25% and T versus C SD ($p \leq 0.05$)	T–C > 15% and T versus C SD ($p \leq 0.05$)
Chironomus dilutus 20-day mortality	T–C > 25% and T versus C SD ($p \leq 0.05$)	T–C > 15% and T versus C SD ($p \leq 0.05$)
Chironomus dilutus 20-day growth	T/C > 0.4 and T versus C SD ($p \leq 0.05$)	T/C > 0.25 and T versus C SD ($p \leq 0.05$)

Note:

1 Interpretive criteria and performance standards are based on the Sediment Management Standards Freshwater Biological Criteria (WAC 173-204)) with the modification of comparison of test results to the negative control rather than reference results due to lack of freshwater reference areas.

Abbreviations:

C Control
CSL Cleanup Screening Level
p Significance level
SCO Sediment Cleanup Objective
SD Statistically significant difference
T Test sample

Table 7.1
Physical-chemical Properties of Contaminants of Concern

Contaminant of Concern	CAS Number	Boiling Point (°C)	Melting Point (°C)	Specific Gravity	Form at 20°C	Vapor Pressure at 25°C (atm)	Solubility at 20°C (mg/L)	Henry's Law Constant at 25°C (atm-m^3/mol)	Partitioning Coeffiecient Organic Carbon to Water (K_{oc}) (cm^3/g)	Mobility in Water
Metals										
Arsenic	7440-38-2	614 [1]	817 [1]	5.778 [1]	Solid	9.87E-6 at 280°C [1]	Insoluble [1]	0 [2]	NA	High
Lead	7439-92-1	1740 [3]	327 [3]	11.34 [3]	Solid	0.0023 at 1000°C [1]	Insoluble [1]	0 [2]	NA	Low
Total Petroleum Hydrocarbons										
TPH—Gasoline Range	8006-61-9	32 to 210 [4]	-90.5 to -95.4 [4]	0.70 to 0.80 [4]	Liquid	0.40 to 0.90 at 20°C [5]	Insoluble [6]	4.80E-04 to 3.3E-04 at 20°C [7]	1.35E+02 to 7.41E+04 [7]	High
TPH—Diesel Range	68476-34-6	282 to 338 [7]	18 [7]	0.87 to 0.95 [7]	Liquid	0.0028 to 0.03473 at 21°C [7]	Insoluble [7]	5.90E-05 to 7.40E-05 at 20°C [7]	2.00E+03 to 1.15E+07 [7]	Moderate
TPH—Heavy Oil Range[5]	68476-31-3	101 to 588 [7]	-29 to -9 [7]	1 [7]	Liquid	0.0028 to 0.035 at 21°C [7]	5 [7]	5.90E-05 to 7.40E-05 at 20°C [7]	1.00E+3 to 5.01E+6 [7]	Low
Semivolatile Organic Compounds										
Pentachlorophenol	87-86-5	309 [6]	190 [6]	1.978 [6]	Solid	1.30E-07 [6]	14 [6]	3.40E-06 [6]	590 to 5000 [2, 32]	Low
Carcinogenic Polycyclic Aromatic Hydrocarbons										
Benzo(a)pyrene	50-32-8	310 to 312 at 0.013 atm [4]	179 [9]	1.351 [10]	Solid	7.22E-12 (extrapolated value) [11]	1.62E-03 [12]	4.57E-07 [13]	1.02E+06 [14]	Low
Benzo(a)anthracene	56-55-3	437.6 [15]	160 [16]	1.25 [17]	Solid	6.58E-12 [18]	9.40E-03 [19]	3.35E-06 [14]	3.98E+05 [14]	Low
Benzo(b)fluoranthene	205-99-2	716 [20]	168 [21]	NA	Solid	6.58E-10 [22]	0.0015 [20]	1.11E-04 [20]	1.23E+06 [14]	Low
Benzo(k)fluoranthene	207-08-9	480 [21]	217 [21]	NA	Solid	1.28E-12 [23]	8.00E-04 [24]	5.84E-07 [13]	1.23E+06 [14]	Low
Chrysene	218-01-9	448 [21]	258.2 [21]	1.274 [16]	Solid	8.20E-12 [25]	0.0063 [20]	9.44E-05 [20]	3.98E+05 [14]	Low
Dibenzo(a,h)anthracene	53-70-3	524 [26]	269.5 [21]	1.282 [5]	Solid	1.26E-12 [27]	0.0005 [5]	7.30E-08 [28]	3.80E+06 [14]	Low
Indeno(1,2,3-cd)pyrene	193-39-5	536 [26]	163.6 [5]	NA	Solid	1.00E-10 [29]	6.20E-02 [30]	3.48E-07 [13]	3.47E+06 [14]	Low
Volatile Organic Compounds										
Ethylbenzene	100-41-4	136.19 [1]	-94.975 [1]	0.867 [1]	Liquid	.00921 at 20°C [1]	152 [1]	7.9E-3 to 8.43E-3 [1]	166 to 251 [1]	High
Toluene	108-88-3	110.6 [1]	-95 [1]	0.8669 [1]	Liquid	0.03737 [1]	534.8 at 25°C [1]	5.94E-03 [1]	37 to 178 [1]	High
Dioxins/Furans										
Dioxins/Furans[31]	1746-01-6 (2378-TCDD); 3268-87-9 (OCDD)	446 to 510 [1]	240 to 332 [1]	1.827 [1]	Solid	1.09E-18 to 4.47E-8 [1]	2.27E-9 to 3.2E-4 at 25°C [1]	1.31E-6 to 1.01E-4 [1]	1.0E+06 to 2.4E+07 [33]	Very low

Notes:

1 From ASTDR CDC Toxicity Profiles website: http://www.atsdr.cdc.gov/toxprofiles/index.asp,toxicity profiles also available on CD.
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Table 7.1
Physical-chemical Properties of Contaminants of Concern

Notes (continued):

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29 Handbook of RCRA Groundwater Monitoring Consituents - Chemical Physical Properties, EPAA530-R-92-022.
30 Sims RC, Overcash MR; Res Rev 88: 1-68 (1983).
31 Where a single value is provided, value is based on 2,3,7,8-TCDD. Where a range is provided, range includes 2,3,7,8-TCDD through OCDD.
32 USEPA Region Screen Level Chemical Specific Analytes Supporting Table (June 2011).
33 USEPA 2003, Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds National Academy Sciences (NAS) Review Draft, Part I: Estimating Exposure to Dioxin-Like Compounds, vol 3: Site-Specific Assessment Procedures.

Abbreviations:

NA Not available
NIOSH The National Institute for Occupational Safety and Health
OCDD Octachlorodibenzo-p-dioxin
USEPA U.S. Environmental Protection Agency
2,3,7,8-TCDD 2,3,7,8-Tetrachlorodibenzo-p-Dioxin

Table 7.2
Lora Lake Apartments Parcel Soil Exceedances

		Location	DP-3[1]	LL-01			LL-07	LL-08			LL-10		LL-11	LL-12	HA-2
		Sample ID	DP-3-1.5	LL01-0-0.5	LL01-1.5-2	DUP02-040308	LL07-1.5-2	LL08-1.5-2	LL08-2-4	DUP01-040308	LL10-0-0.5	LL10-1.5-2	LL11-0-0.5	LL12-0-0.5	LLA-HA2-0-0.5-041811
		Sample Date	6/8/2009	04/03/2008	04/03/2008	04/03/2008	04/03/2008	04/03/2008	04/03/2008	04/03/2008	04/03/2008	04/03/2008	04/03/2008	04/03/2008	04/18/2011
		Sample Depth	1.5 feet	0–0.5 foot	1.5–2 feet	1.5–2 feet	1.5–2 feet	1.5–2 feet	2–4 feet	2–4 feet	0–0.5 foot	1.5–2 feet	0–0.5 foot	0–0.5 foot	0–0.5 foot
Analyte	**Unit**	**CUL**													
Metals															
Arsenic	mg/kg	20	NA	4.39 J	3.17 J	2.83 J	7.11	2.93	5.47 J	5.32 J	11.1	3.28 J	3.76 J	6.3	NA
Lead	mg/kg	250	NA	41.6	**265** J	91.6	30 J	18.4 J	106 J	108 J	67.6 J	57	21.3	74.9 J	NA
Total Petroleum Hydrocarbons															
Gasoline Range[2]	mg/kg	100	NA	2.4 J	5.7 U	5.7 U	6.1 U	5.6 U	5.4 J	2.6 J	6.3 U	17 JN	6.1 U	6.2 U	NA
Diesel Range[2]	mg/kg	2,000	NA	22 J	22 J	13 J	16 J	NA	160 JN	100 JN	12 J	37 JN	4.3 J	23 J	NA
Heavy Oil Range	mg/kg	2,000	NA	170 JN	97 J	69 J	120 J	NA	610 J	400 J	94 J	230 J	53 J	110 J	NA
Summed Diesel and Heavy Oil Ranges with One-half of the Reporting Limit	mg/kg	2,000	NA	192 J	119 J	82 J	136 J	NA	770 J	500 J	106 J	267 J	57.3 J	133 J	NA
Semivolatile Organic Compounds															
Pentachlorophenol	µg/kg	2,500	NA	110	370	720 J	58 U	53 J	340 J	250 J	42 J	1900	310	150	NA
Summed cPAH TEQ[3,4]	µg/kg	137	NA	13 J	1 J	1.5 J	1.1 J	32 J	120 J	**160** J	77 J	0 U	0.76 J	18 J	NA
Summed cPAH TEQ with One-half of the Reporting Limit[3,5]	µg/kg	137	0.013	13 J	4.4 J	4.5 J	4.3 J	32 J	120 J	**160** J	77 J	42 U	4.2 J	18 J	NA
Volatile Organic Compounds															
Ethylbenzene	µg/kg	8,000,000	NA	6.4 U	5.2 U	5.6 U	0.34 J	4.8 U	4.7 U	0.31 J	6.6 U	6 U	6.9 U	0.46 J	NA
Toluene	µg/kg	6,400,000	NA	1.8 J	0.46 J	0.65 J	2.6 J	4.8 U	0.38 J	2.3 J	0.98 J	1.1 J	0.86 J	3.1 J	NA
Dioxins/Furans															
Summed Dioxin/Furan TEQ[6,7]	pg/g	13	--	**493 J**	**1,590 J**	**1,810 J**	**33.8 JN**	**43.7 J**	**650 J**	**504 J**	**155 J**	**2,600 J**	**56.9 J**	**234 JN**	**107 J**
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[6,8]	pg/g	13	**56**	**493 J**	**1,590 J**	**1,810 J**	**33.8 JN**	**43.7 J**	**650 J**	**504 J**	**155 J**	**2,600 J**	**57 J**	**234 JN**	**107 J**

Notes:

-- Not available.
Bold Indicates exceedance of CUL.
1 The results of the off-site soil sampling conducted as part of the Former Sunnydale Substation Phase II Environmental Site Assessment (Pinnacle GeoSciences 2009) have been included in order to delineate cPAH and dioxin/furan contamination beyond the property boundary. For that reason, only cPAH and dioxin/furan results are presented here and on Figures 4.6 and 4.9. The Phase II Environmental Site Assessment data are included in Appendix D.
2 The MTCA Method A CULs for both diesel range and heavy oil range TPH are based on prevention of accumulation of free product in groundwater. Therefore, the summed diesel and heavy oil concentrations are also presented and compared to the single CUL of 2,000 mg/kg.
3 Calculation of cPAH TEQ concentrations was performed using the California Environmental Protection Agency 2005 Toxic Equivancy Factors as presented in Table 708-2 of WAC 173-340-900 (WSDOE 2007).
4 Calculated using detected cPAH concentrations.
5 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.
6 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).
7 Calculated using detected dioxin/furan concentrations.
8 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:

cPAH Carcinogenic polycyclic aromatic hydrocarbon
CUL Cleanup level
MTCA Model Toxics Control Act
NA Not analyzed
TEQ Toxic equivalency quotient
TPH Total petroleum hydrocarbons
WAC Washington Administrative Code
WSDOE Washington State Department of Ecology

Qualifiers:

J Estimated value
JN Estimated due to tentative identification
U Not detected
UJ Not detected, estimated detection limit

Table 7.2
Lora Lake Apartments Parcel Soil Exceedances

		Location	HA-3	LLP-02	LLP-04	MW-01	MW-02	MW-04			MW-05				MW-12
		Sample ID	LLA-HA3-0-0.5-041811	LLP-2-6.5	LLP-4-14.5	LLP4-MW-1-14	MW02-0-0.5	MW04-0-0.5	MW04-1.5-2	MW04-9-10.5	MW05-0-0.5	MW05-1.5-2	MW05-6.5-8	MW05-11.5-13	MW12-0-0.5-080210
		Sample Date	04/18/2011	07/24/2007	07/25/2007	10/25/2007	03/18/2008	03/17/2008	03/17/2008	03/17/2008	03/17/2008	03/17/2008	03/17/2008	03/17/2008	08/02/2010
		Sample Depth	0–0.5 foot	6.5–7 feet	14.5–15.5 feet	14–15 feet	0–0.5 foot	0–0.5 foot	1.5–2 feet	9–10.5 feet	0–0.5 foot	1.5–2 feet	6.5–8 feet	11.5–13 feet	0–0.5 foot
Analyte	**Unit**	**CUL**													
Metals															
Arsenic	mg/kg	20	NA	11 U	11 U	NA	11.2	10.1	2.6	2.6	10.2	3.6	3.1	8.7	NA
Lead	mg/kg	250	NA	NA	47	NA	53.7	**370**	12.3	10.3	**294**	18.2	78.8	121	NA
Total Petroleum Hydrocarbons															
Gasoline Range[2]	mg/kg	100	NA	NA	**1,900 J**	**1,000 J**	6.4 U	6 U	5.4 U	5.3 U	5.9 U	5.8 U	5.9 U	14 JN	NA
Diesel Range[2]	mg/kg	2,000	NA	1,300	**6,000**	**8,900 J**	30 U	96 JN	2.1 J	1.5 J	90 JN	2.7 J	19 J	1,100 J	NA
Heavy Oil Range	mg/kg	2,000	NA	**9,800**	**17,000**	**12,000 JN**	190 JN	480 J	110 U	110 U	480 J	110 U	120 U	810 J	NA
Summed Diesel and Heavy Oil Ranges with One-half of the Reporting Limit	mg/kg	2,000	NA	**11,100**	**23,000**	**20,900 J**	205 J	576 J	57.1 J	56.5 J	570 J	57.7 J	79 J	1,910	NA
Semivolatile Organic Compounds															
Pentachlorophenol	µg/kg	2,500	NA	NA	**3,700 U**	**2,900 UJ**	57 J	**15,000**	57 J	130	**2,700**	53 J	120	2,000 U	NA
Summed cPAH TEQ[3,4]	µg/kg	137	NA	NA	**760**	**870 J**	18 J	**150 J**	2.3 J	5.2 J	**240 J**	0.033 J	6 J	4.1 J	NA
Summed cPAH TEQ with One-half of the Reporting Limit[3,5]	µg/kg	137	NA	NA	**760**	**880 J**	18 J	**150 J**	3.8 J	5.7 J	**240 J**	7.5 J	6.5 J	**140 J**	NA
Volatile Organic Compounds															
Ethylbenzene	µg/kg	8,000,000	NA	NA	1400	NA	6.6 U	5.9 U	4.9 U	2.8 U	6.7 U	5.6 U	5.6 U	5.2 U	NA
Toluene	µg/kg	6,400,000	NA	NA	620	NA	0.6 J	0.34 J	0.33 J	2.8 U	1.5 J	0.52 J	0.64 J	0.99 J	NA
Dioxins/Furans															
Summed Dioxin/Furan TEQ[6,7]	pg/g	13	**17.7 J**	NA	NA	**302 J**	**30.2 JN**	**2,570 JN**	**31.1 J**	**126 JN**	**3,100 JN**	**24 JN**	**572 JN**	**59.6 J**	**23.3 J**
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[6,8]	pg/g	13	**17.7 J**	NA	NA	**302 J**	**30.2 JN**	**2,570 JN**	**31.2 J**	**126 JN**	**3,100 JN**	**24 JN**	**572 JN**	**59.7 J**	**23.6 J**

Notes:

-- Not available.
Bold Indicates exceedance of CUL.
1 The results of the off-site soil sampling conducted as part of the Former Sunnydale Substation Phase II Environmental Site Assessment (Pinnacle GeoSciences 2009) have been included in order to delineate cPAH and dioxin/furan contamination beyond the property boundary. For that reason, only cPAH and dioxin/furan results are presented here and on Figures 4.6 and 4.9. The Phase II Environmental Site Assessment data are included in Appendix D.
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4 Calculated using detected cPAH concentrations.
5 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.
6 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).
7 Calculated using detected dioxin/furan concentrations.
8 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:

cPAH Carcinogenic polycyclic aromatic hydrocarbon
CUL Cleanup level
MTCA Model Toxics Control Act
NA Not analyzed
TEQ Toxic equivalency quotient
TPH Total petroleum hydrocarbons
WAC Washington Administrative Code
WSDOE Washington State Department of Ecology

Qualifiers:

J Estimated value
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Table 7.2
Lora Lake Apartments Parcel Soil Exceedances

Location			MW-12		MW-13		PSB-02	PSB-03	PSB-04	PSB-05	PSB-06			PSB-09A	PSB-10
Sample ID			MW12-1.5-2-080210	MW12-2-4-080210	MW13-0-0.5-080210	MW13-1.5-2-080210	PSB02-1.5-2-072910	PSB03-0-0.5-072910	PSB04-0-0.5-072810	PSB05-1.5-2-072810	PSB06-0-0.5-072810	PSB06-1.5-2-072810	PSB06-1.5-2-072810-D	PSB09A-0-0.5-073010	PSB10-0-0.5-073010
Sample Date			08/02/2010	08/02/2010	08/02/2010	08/02/2010	07/29/2010	07/29/2010	07/28/2010	07/28/2010	07/28/2010	07/28/2010	07/28/2010	07/30/2010	07/30/2010
Sample Depth			1.5–2 feet	2–4 feet	0–0.5 foot	1.5–2 feet	1.5–2 feet	0–0.5 foot	0–0.5 foot	1.5–2 feet	0–0.5 foot	1.5–2 feet	1.5–2 feet	0–0.5 foot	0–0.5 foot
Analyte	**Unit**	**CUL**													
Metals															
Arsenic	mg/kg	20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	8	5 U
Lead	mg/kg	250	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	46	43
Total Petroleum Hydrocarbons															
Gasoline Range[2]	mg/kg	100	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	8.7	3.1 U
Diesel Range[2]	mg/kg	2,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.2 U	24
Heavy Oil Range	mg/kg	2,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	16	310
Summed Diesel and Heavy Oil Ranges with One-half of the Reporting Limit	mg/kg	2,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	18.6	334
Semivolatile Organic Compounds															
Pentachlorophenol	µg/kg	2,500	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	38 J	53 J
Summed cPAH TEQ[3,4]	µg/kg	137	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0 U	5 J
Summed cPAH TEQ with One-half of the Reporting Limit[3,5]	µg/kg	137	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	24 U	67 J
Volatile Organic Compounds															
Ethylbenzene	µg/kg	8,000,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	9.8 U	7.8 U
Toluene	µg/kg	6,400,000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	9.8 U	7.8 U
Dioxins/Furans															
Summed Dioxin/Furan TEQ[6,7]	pg/g	13	**15.2 J**	**14.7 J**	**26.1 J**	**24.8 J**	**21.5 J**	**58.4 J**	**194 J**	12.8 J	**96.3 J**	**702 J**	**580 J**	11.5 J	**473 J**
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[6,8]	pg/g	13	**15.7 J**	**14.7 J**	**26.2 J**	**24.8 J**	**21.5 J**	**58.7 J**	**194 J**	12.8 J	**96.3 J**	**702 J**	**580 J**	11.6 J	**473 J**

Notes:

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Bold Indicates exceedance of CUL.
1 The results of the off-site soil sampling conducted as part of the Former Sunnydale Substation Phase II Environmental Site Assessment (Pinnacle GeoSciences 2009) have been included in order to delineate cPAH and dioxin/furan contamination beyond the property boundary. For that reason, only cPAH and dioxin/furan results are presented here and on Figures 4.6 and 4.9. The Phase II Environmental Site Assessment data are included in Appendix D.
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4 Calculated using detected cPAH concentrations.
5 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.
6 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).
7 Calculated using detected dioxin/furan concentrations.
8 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:

cPAH Carcinogenic polycyclic aromatic hydrocarbon
CUL Cleanup level
MTCA Model Toxics Control Act
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TEQ Toxic equivalency quotient
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WAC Washington Administrative Code
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Table 7.2
Lora Lake Apartments Parcel Soil Exceedances

		Location	PSB-10				PSB-11								PSB-12
		Sample ID	PSB10-1.5-2-073010	PSB10-2-4-073010	PSB10-4-6-073010	PSB10-8.5-10-073010	PSB11-0-0.5-073010	PSB11-1.5-2-073010	PSB11-2-4-073010	PSB11-2-4-073010-D	PSB11-4-6-073010	PSB11-7.5-9.5-073010	PSB11-11-13-073010	PSB11-14-16-073010	PSB12-1.5-2-072810
		Sample Date	07/30/2010	07/30/2010	07/30/2010	07/30/2010	07/30/2010	07/30/2010	07/30/2010	07/30/2010	07/30/2010	07/30/2010	07/30/2010	07/30/2010	07/28/2010
		Sample Depth	1.5–2 feet	2–4 feet	4–6 feet	8.5–10 feet	0–0.5 foot	1.5–2 feet	2–4 feet	2–4 feet	4–6 feet	7.5–9.5 feet	11–13 feet	14–16 feet	1.5–2 feet
Analyte	**Unit**	**CUL**													
Metals															
Arsenic	mg/kg	20	5 U	5 U	5 U	7	5 U	5 U	7	6	5 U	NA	5 U	6 U	5 U
Lead	mg/kg	250	35	36	33	29	12 J	**304 J**	**1,680 J**	**2,880 J**	131 J	NA	162 J	45 J	9
Total Petroleum Hydrocarbons															
Gasoline Range[2]	mg/kg	100	3.6 U	3.1 U	3.1 U	3.5 U	3.3 U	**150**	10	17	8.2	NA	3.5 U	26	3.5 U
Diesel Range[2]	mg/kg	2,000	5.4 U	6.5	12	5.6 U	32	400	440	430	41	NA	98	130	5.1 U
Heavy Oil Range	mg/kg	2,000	21	42	120	27	370	1,600	**2,700**	**2,700**	170	NA	510	450	12
Summed Diesel and Heavy Oil Ranges with One-half of the Reporting Limit	mg/kg	2,000	23.7	48.5	132	29.8	402	2,000	**3,140**	**3,130**	211	NA	608	580	14.6
Semivolatile Organic Compounds															
Pentachlorophenol	µg/kg	2,500	210	280	450	28	12 J	2,400 J	1,100 J	1,300	210	NA	210	160	27
Summed cPAH TEQ[3,4]	µg/kg	137	0 U	14 J	1.4 J	0 U	0.52 J	130 J	0 U	100 J	21 J	NA	50 J	47	0 U
Summed cPAH TEQ with One-half of the Reporting Limit[3,5]	µg/kg	137	14 U	16 J	14 J	13 U	42 J	**150 J**	**270 U**	**140 J**	23 J	NA	59 J	49	14 U
Volatile Organic Compounds															
Ethylbenzene	µg/kg	8,000,000	8.9 U	7.7 U	7.8 U	8.8 U	8.2 U	8.9 U	9.6 U	9.4 U	8.9 U	NA	8.6 U	9.3 U	8.8 U
Toluene	µg/kg	6,400,000	8.9 U	7.7 U	7.8 U	8.8 U	8.2 U	8.9 U	9.6 U	9.4 U	8.9 U	NA	8.6 U	9.3 U	8.8 U
Dioxins/Furans															
Summed Dioxin/Furan TEQ[6,7]	pg/g	13	**402 J**	**803 J**	**388 J**	**108 J**	**59.5 J**	**21200**	**10,300 J**	**11,700 J**	**2,490 J**	**2,140 J**	**1,800 J**	**2,050 J**	12.9 J
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[6,8]	pg/g	13	**402 J**	**803 J**	**388 J**	**108 J**	**59.5 J**	**21200**	**10,300 J**	**11,700 J**	**2,490 J**	**2,140 J**	**1,800 J**	**2,050 J**	**13.2 J**

Notes:

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4 Calculated using detected cPAH concentrations.
5 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.
6 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).
7 Calculated using detected dioxin/furan concentrations.
8 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:

cPAH Carcinogenic polycyclic aromatic hydrocarbon
CUL Cleanup level
MTCA Model Toxics Control Act
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Table 7.2
Lora Lake Apartments Parcel Soil Exceedances

Location			PSB-12				PSB-13				PSB-14				
Sample ID			PSB12-2-4-072810	PSB12-4-6-072810	PSB12-8-10-072810	PSB12-14-17-072810	PSB13-0-0.5-072910	PSB13-1.5-2-072910	PSB13-2-4-072910	PSB13-4-6-072910	PSB14-0-0.5-072810	PSB14-1.5-2-072810	PSB14-2-4-072810	PSB14-4-7-072810	PSB14-7-9-072810
Sample Date			07/28/2010	07/28/2010	07/28/2010	07/28/2010	07/29/2010	07/29/2010	07/29/2010	07/29/2010	07/28/2010	07/28/2010	07/28/2010	07/28/2010	07/28/2010
Sample Depth			2–4 feet	4–6 feet	8–10 feet	14–17 feet	0–0.5 foot	1.5–2 feet	2–4 feet	4–6 feet	0–0.5 foot	1.5–2 feet	2–4 feet	4–7 feet	7–9 feet
Analyte	**Unit**	**CUL**													
Metals															
Arsenic	mg/kg	20	5 U	5 U	5 U	5 U	11	5 U	5 U	10 U	5 U	5 U	5 U	NA	5 U
Lead	mg/kg	250	30	47	4	3	60	29	18	23	17	3	11	NA	16
Total Petroleum Hydrocarbons															
Gasoline Range[2]	mg/kg	100	2.9 U	3.6 U	4.8 U	2.6 U	3.7 U	3.2 U	6.4 U	3.2 U	2.9 U	3.2 U	3.4 U	NA	4.2 U
Diesel Range[2]	mg/kg	2,000	6	10	5.2 U	5.1 U	5.3 U	5.4	54	5.6 U	13	5.4 U	5.4 U	NA	9
Heavy Oil Range	mg/kg	2,000	50	110	10 U	42	32	53	930	15	180	11 U	11 U	NA	120
Summed Diesel and Heavy Oil Ranges with One-half of the Reporting Limit	mg/kg	2,000	56	120	7.6 U	44.6	34.7	58.4	984	17.8	193	8.2 U	8.2 U	NA	129
Semivolatile Organic Compounds															
Pentachlorophenol	µg/kg	2,500	14	16	6.2 U	61	6.6 U	18	6.5 UJ	11	8.5 J	11	9	NA	9.4 J
Summed cPAH TEQ[3,4]	µg/kg	137	0 U	0.099 J	0 U	0 U	0 U	0 UJ	0 UJ	0 U	0.1 J	0 UJ	0 U	NA	0 UJ
Summed cPAH TEQ with One-half of the Reporting Limit[3,5]	µg/kg	137	14 U	14 J	13 U	13 U	53 U	14 UJ	13 UJ	14 U	13 J	14 UJ	13 U	NA	13 UJ
Volatile Organic Compounds															
Ethylbenzene	µg/kg	8,000,000	7.3 U	9.1 U	12 U	6.4 U	9.1 U	8.1 U	16 U	8 U	7.2 U	8 U	8.4 U	NA	11 U
Toluene	µg/kg	6,400,000	7.3 U	9.1 U	12 U	6.4 U	9.1 U	8.1 U	16 U	8 U	7.2 U	8 U	8.4 U	NA	11 U
Dioxins/Furans															
Summed Dioxin/Furan TEQ[6,7]	pg/g	13	**16.2 J**	**24.5 J**	**13.3 J**	**73.5 J**	**16.6 J**	**187 J**	**52.1 J**	**50.5 J**	**132 J**	**38.4 J**	**41.7 J**	**87.4 J**	**81.3 J**
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[6,8]	pg/g	13	**16.5 J**	**24.5 J**	**13.6 J**	**74.1 J**	**16.6 J**	**187 J**	**52.5 J**	**50.5 J**	**132 J**	**38.4 J**	**41.7 J**	**87.4 J**	**81.3 J**

Notes:

-- Not available.

Bold Indicates exceedance of CUL.

1 The results of the off-site soil sampling conducted as part of the Former Sunnydale Substation Phase II Environmental Site Assessment (Pinnacle GeoSciences 2009) have been included in order to delineate cPAH and dioxin/furan contamination beyond the property boundary. For that reason, only cPAH and dioxin/furan results are presented here and on Figures 4.6 and 4.9. The Phase II Environmental Site Assessment data are included in Appendix D.

2 The MTCA Method A CULs for both diesel range and heavy oil range TPH are based on prevention of accumulation of free product in groundwater. Therefore, the summed diesel and heavy oil concentrations are also presented and compared to the single CUL of 2,000 mg/kg.

3 Calculation of cPAH TEQ concentrations was performed using the California Environmental Protection Agency 2005 Toxic Equivancy Factors as presented in Table 708-2 of WAC 173-340-900 (WSDOE 2007).

4 Calculated using detected cPAH concentrations.

5 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.

6 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).

7 Calculated using detected dioxin/furan concentrations.

8 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:

cPAH Carcinogenic polycyclic aromatic hydrocarbon
CUL Cleanup level
MTCA Model Toxics Control Act
NA Not analyzed
TEQ Toxic equivalency quotient
TPH Total petroleum hydrocarbons
WAC Washington Administrative Code
WSDOE Washington State Department of Ecology

Qualifiers:

J Estimated value
JN Estimated due to tentative identification
U Not detected
UJ Not detected, estimated detection limit

Table 7.2
Lora Lake Apartments Parcel Soil Exceedances

		Location	PSB-14	PSB-15					PSB-16				PSB-18	PSB-19		PSB-20
		Sample ID	**PSB14-12-14-072810**	**PSB15-0-0.5-073010**	**PSB15-1.5-2-073010**	**PSB15-2-4-073010**	**PSB15-4-6-073010**	**PSB15-13-15-073010**	**PSB16-0-0.5-082510**	**PSB16-1-2-082510**	**PSB16-2-4-082510**	**PSB16-4-6-082510**	**PSB18-0-0.5-082610**	**PSB19-0-1-082510**	**PSB19-1-2-082510**	**PSB20-0-0.5-082510**
		Sample Date	**07/28/2010**	**07/30/2010**	**07/30/2010**	**07/30/2010**	**07/30/2010**	**07/30/2010**	**08/25/2010**	**08/25/2010**	**08/25/2010**	**08/25/2010**	**08/26/2010**	**08/25/2010**	**08/25/2010**	**08/25/2010**
		Sample Depth	**12–14 feet**	**0–0.5 foot**	**1.5–2 feet**	**2–4 feet**	**4–6 feet**	**13–15 feet**	**0–0.5 foot**	**1–2 feet**	**2–4 feet**	**4–6 feet**	**0–0.5 foot**	**0–1 feet**	**1–2 feet**	**0–0.5 foot**
Analyte	**Unit**	**CUL**														
Metals																
Arsenic	mg/kg	20	6 U	8	5 U	5 U	5 U	6 U	10	5 U	5 U	5 U	7	5	5 U	9
Lead	mg/kg	250	2 U	245 J	21 J	34 J	43 J	165 J	79	21	14	13	78	62	27	32
Total Petroleum Hydrocarbons																
Gasoline Range[2]	mg/kg	100	3.4 U	4 U	3.5 U	5.5	3.2 U	3.9 U	20 J	2.9 UJ	3 UJ	3.3 J	3.7 U	3.4 U	2.9 U	3.6 U
Diesel Range[2]	mg/kg	2,000	5.4 U	20	5.3 U	5.2 U	5.1 U	24	7.5	110	5.2 U	6.3	9.3	5 U	5.2 U	22
Heavy Oil Range	mg/kg	2,000	11 U	120	10 U	12	17	230	65	890	15	30	72	44	17	210
Summed Diesel and Heavy Oil Ranges with One-half of the Reporting Limit	mg/kg	2,000	8.2 U	140	7.7 U	14.6	19.6	254	72.5	1,000	17.6	36.3	81.3	46.5	19.6	232
Semivolatile Organic Compounds																
Pentachlorophenol	µg/kg	2,500	11	480	6.7 UJ	14 J	63	21	95	6.5 UJ	11 J	19	100	220	21	12
Summed cPAH TEQ[3,4]	µg/kg	137	0 U	120 J	0 U	0 U	0 U	0 UJ	20 J	11 J	0 U	0 U	71 J	9.5 J	22 J	**350**
Summed cPAH TEQ with One-half of the Reporting Limit[3,5]	µg/kg	137	13 U	120 J	14 U	13 U	13 U	42 UJ	22 J	100 J	14 U	14 U	71 J	45 J	24 J	**350**
Volatile Organic Compounds																
Ethylbenzene	µg/kg	8,000,000	8.5 U	9.9 U	8.7 U	7.7 U	8 U	9.7 U	0.7 U	0.5 U	0.6 U	0.6 U	9.4 U	8.5 U	7.2 U	9.1 U
Toluene	µg/kg	6,400,000	8.5 U	9.9 U	8.7 U	7.7 U	8 U	9.7 U	3.9	0.5 U	0.6 U	0.6 U	9.4 U	8.5 U	7.2 U	9.1 U
Dioxins/Furans																
Summed Dioxin/Furan TEQ[6,7]	pg/g	13	**31.1 J**	**2,260**	11.9 J	**51.9 J**	**328 J**	**134 J**	**205 J**	**13.2 J**	**16.5 J**	**33.3 J**	**209 J**	**135 J**	**16.1 J**	**31 J**
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[6,8]	pg/g	13	**31.1 J**	**2,260**	12.1 J	**52.4 J**	**328 J**	**134 J**	**205 J**	**13.2 J**	**16.6 J**	**33.3 J**	**209 J**	**135 J**	**16.1 J**	**31 J**

Notes:
- -- Not available.
- **Bold** Indicates exceedance of CUL.
- 1 The results of the off-site soil sampling conducted as part of the Former Sunnydale Substation Phase II Environmental Site Assessment (Pinnacle GeoSciences 2009) have been included in order to delineate cPAH and dioxin/furan contamination beyond the property boundary. For that reason, only cPAH and dioxin/furan results are presented here and on Figures 4.6 and 4.9. The Phase II Environmental Site Assessment data are included in Appendix D.
- 2 The MTCA Method A CULs for both diesel range and heavy oil range TPH are based on prevention of accumulation of free product in groundwater. Therefore, the summed diesel and heavy oil concentrations are also presented and compared to the single CUL of 2,000 mg/kg.
- 3 Calculation of cPAH TEQ concentrations was performed using the California Environmental Protection Agency 2005 Toxic Equivalency Factors as presented in Table 708-2 of WAC 173-340-900 (WSDOE 2007).
- 4 Calculated using detected cPAH concentrations.
- 5 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.
- 6 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).
- 7 Calculated using detected dioxin/furan concentrations.
- 8 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:
- cPAH Carcinogenic polycyclic aromatic hydrocarbon
- CUL Cleanup level
- MTCA Model Toxics Control Act
- NA Not analyzed
- TEQ Toxic equivalency quotient
- TPH Total petroleum hydrocarbons
- WAC Washington Administrative Code
- WSDOE Washington State Department of Ecology

Qualifiers:
- J Estimated value
- JN Estimated due to tentative identification
- U Not detected
- UJ Not detected, estimated detection limit

Table 7.2
Lora Lake Apartments Parcel Soil Exceedances

		Location	PSB-20	PSB-21		PSB-24	PSB-27		SSB-02	
		Sample ID	PSB20-2-4-082510	PSB21-0-0.5-082510	PSB21-2-4-082510	PSB24-0-0.5-072910	PSB27-0-0.5-082610	PSB27-1.5-2-082610	SSB02-0-0.5-080310	SSB02-1-1.5-080310
		Sample Date	08/25/2010	08/25/2010	08/25/2010	07/29/2010	08/26/2010	08/26/2010	08/03/2010	08/03/2010
		Sample Depth	2–4 feet	0–0.5 foot	2–4 feet	0–0.5 foot	0–0.5 foot	1.5–2 feet	0–0.5 foot	1.5–2 feet
Analyte	**Unit**	**CUL**								
Metals										
Arsenic	mg/kg	20	5 U	8	6	9	5 U	5 U	NA	NA
Lead	mg/kg	250	3	45	26	32	39 J	152 J	NA	NA
Total Petroleum Hydrocarbons										
Gasoline Range[2]	mg/kg	100	**440 U**	4.3 U	3.1 U	NA	NA	NA	NA	NA
Diesel Range[2]	mg/kg	2,000	5.2 U	5.2 U	5.4 U	5.2 U	NA	NA	NA	NA
Heavy Oil Range	mg/kg	2,000	10 U	19	34	18	NA	NA	NA	NA
Summed Diesel and Heavy Oil Ranges with One-half of the Reporting Limit	mg/kg	2,000	7.6 U	21.6	36.7	20.6	NA	NA	NA	NA
Semivolatile Organic Compounds										
Pentachlorophenol	µg/kg	2,500	6.5 U	13	14	14	NA	NA	NA	NA
Summed cPAH TEQ[3,4]	µg/kg	137	0 U	0.11 J	0 U	1.2 J	NA	NA	NA	NA
Summed cPAH TEQ with One-half of the Reporting Limit[3,5]	µg/kg	137	14 U	14 J	41 U	14 J	NA	NA	NA	NA
Volatile Organic Compounds										
Ethylbenzene	µg/kg	8,000,000	1,100 U	11 U	7.7 U	NA	NA	NA	NA	NA
Toluene	µg/kg	6,400,000	1,100 U	74	7.7 U	NA	NA	NA	NA	NA
Dioxins/Furans										
Summed Dioxin/Furan TEQ[6,7]	pg/g	13	2.52 J	**18.5 J**	11.2 J	**16.5 J**	**282 J**	**1,650 J**	11.5 J	**15.2 J**
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[6,8]	pg/g	13	2.63 J	**18.5 J**	11.2 J	**16.6 J**	**282 J**	**1,650 J**	11.5 J	**15.2 J**

Notes:
-- Not available.
Bold Indicates exceedance of CUL.
1 The results of the off-site soil sampling conducted as part of the Former Sunnydale Substation Phase II Environmental Site Assessment (Pinnacle GeoSciences 2009) have been included in order to delineate cPAH and dioxin/furan contamination beyond the property boundary. For that reason, only cPAH and dioxin/furan results are presented here and on Figures 4.6 and 4.9. The Phase II Environmental Site Assessment data are included in Appendix D.
2 The MTCA Method A CULs for both diesel range and heavy oil range TPH are based on prevention of accumulation of free product in groundwater. Therefore, the summed diesel and heavy oil concentrations are also presented and compared to the single CUL of 2,000 mg/kg.
3 Calculation of cPAH TEQ concentrations was performed using the California Environmental Protection Agency 2005 Toxic Equivancy Factors as presented in Table 708-2 of WAC 173-340-900 (WSDOE 2007).
4 Calculated using detected cPAH concentrations.
5 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.
6 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).
7 Calculated using detected dioxin/furan concentrations.
8 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:
cPAH Carcinogenic polycyclic aromatic hydrocarbon
CUL Cleanup level
MTCA Model Toxics Control Act
NA Not analyzed
TEQ Toxic equivalency quotient
TPH Total petroleum hydrocarbons
WAC Washington Administrative Code
WSDOE Washington State Department of Ecology

Qualifiers:
J Estimated value
JN Estimated due to tentative identification
U Not detected
UJ Not detected, estimated detection limit

Table 7.3
Lora Lake Apartments Parcel Groundwater Exceedances

		Location	MW-01					MW-05		MW-13
		Sample ID	MW01-081310	MW01-012111	MW01-012111-D	MW01-042911	MW01-042911-D	MW05-012111	MW05-042811	MW13-081210
		Sample Date	08/13/2010	01/21/2011	01/21/2011	04/29/2011	04/29/2011	01/21/2011	4/28/2011	08/12/2010
Analyte	**Unit**	**CUL**								
Metals										
Arsenic	µg/L	5	**5.6**	**11.7**	**11.9**	**14.2**	**13.4**	**5.4**	4.6	0.3
Total Petroleum Hydrocarbons										
Gasoline Range Hydrocarbons[1]	mg/L	1	0.25 U	0.46	0.46	0.38	0.4	0.25 U	0.25 U	0.25 U
Diesel Range Hydrocarbons	mg/L	0.5	0.1 U	0.1 U	0.18	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Heavy Oil Range Hydrocarbons	mg/L	0.5	0.2 U	0.25	**0.53**	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Semivolatile Organic Compounds										
Pentachlorophenol	µg/L	1	0.25 U	0.76	0.68	0.41	0.42	**1.4**	**1.4**	0.25 U
Summed cPAH TEQ[2,3]	µg/L	0.12	0 U	0.027	0.0013	0.0058 J	0.0093 J	0 U	0 U	0 U
Summed cPAH TEQ with One-half of the Reporting Limit[2,4]	µg/L	0.12	0.0071 U	0.028	0.0078	0.0078 J	0.011 J	0.0071 U	0.0071 U	0.0071 U
Dioxins/Furans										
Summed Dioxin/Furan TEQ[5,6]	pg/L	6.7	**16.1 J**	**37.6 J**	**30.8 J**	**24.1 J**	**11.2 J**	0.377 J	0.325 J	0 UJ
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[5,7]	pg/L	6.7	**18.8 J**	**38.3 J**	**34.8 J**	**24.2 J**	**11.9 J**	3.01 J	2.38 J	6.38 UJ

Notes:

Bold Indicates exceedance of CUL.
1 Gasoline range TPH CUL for groundwater is based on the higher CUL because testing indicated that benzene was not present.
2 Calculation of cPAH TEQ concentrations was performed using the California Environmental Protection Agency 2005 Toxic Equivancy Factors as presented in Table 708-2 of WAC 173-340-900 (WSDOE 2007).
3 Calculated using detected cPAH concentrations.
4 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.
5 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).
6 Calculated using detected dioxin/furan concentrations.
7 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:

cPAH Carcinogenic polycyclic aromatic hydrocarbon
CUL Cleanup level
TEQ Toxic equivalency quotient
WSDOE Washington State Department of Ecology

Qualifiers:

J Estimated value
U Not detected
UJ Not detected, estimated detection limit

Table 7.4
Lora Lake Parcel Surface Sediment Exceedances

			Location	**LL–SED1**		**LL–SED2**	**LL–SED3**	**LL–SED4**	**LL–SED5**	**MC–SED1**	**MC–SED2**	**MC–SED3**
			Sample ID	**LL–SED1–0–15–032911**	**LL–SED1–0–15–032911–D**	**LL–SED2–0–15–032911**	**LL–SED3–0–15–032911**	**LL–SED4–0–15–032911**	**LL–SED5–0–15–032911**	**MC–SED1–0–10–032911**	**MC–SED2–0–10–032911**	**MC–SED3–0–10–032911**
			Sample Date	**03/29/2011**	**03/29/2011**	**03/29/2011**	**03/29/2011**	**03/29/2011**	**03/29/2011**	**03/29/2011**	**03/29/2011**	**03/29/2011**
			Sample Depth	**0–15 cm**	**0–15 cm**	**0–15 cm**	**0–15 cm**	**0–15 cm**	**0–15 cm**	**0–10 cm**	**0–10 cm**	**0–10 cm**
Analyte	**Unit**	**SCO**	**CSL**									
Metals												
Arsenic	mg/kg	11	11	**20**	**20**	**50**	**70**	**40**	7	8	6 U	6 U
Lead	mg/kg	21	21	**319**	**281**	**390**	**361**	**492**	**48**	12	11	4
Semivolatile Organic Compounds												
Pentachlorophenol	µg/kg	160	1,200	50 J	20 U	**330 U**	24 U	25 U	33	7.5 U	7.3 U	6.5 U
Summed cPAH TEQ[1,2]	µg/kg	440	4,400	180	170	120	62	43	48	0 UJ	0 U	0 U
Summed cPAH TEQ with One-half of the Reporting Limit[1,3]	µg/kg	440	4,400	180	170	120	62	43	48	3.2 UJ	3.5 U	3.5 U
Dioxins/Furans												
Summed Dioxin/Furan TEQ[4,5]	pg/g	5	5	**193 J**	**187 J**	**217**	**152 J**	**149**	**7.41 J**	0.109 J	0.0383 J	0.0121 J
Summed Dioxin/Furan TEQ with One–half of the Detection Limit[4,6]	pg/g	5	5	**193 J**	**187 J**	**217**	**152 J**	**149**	**7.55 J**	0.442 J	0.435 J	0.327 J

Notes:

Bold Indicates exceedance of SQS.
NA Not available.
1 Calculation of cPAH TEQ concentrations was performed using the California Environmental Protection Agency 2005 Toxic Equivancy Factors as presented in Table 708–2 of WAC 173–340–900 (WSDOE 2007).
2 Calculated using detected cPAH concentrations.
3 Calculated using detected cPAH concentrations plus one–half the reporting limit for cPAHs that were not detected.
4 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006).
5 Calculated using detected dioxin/furan concentrations.
6 Calculated using detected dioxin/furan concentrations plus one–half the detection limit for dioxins/furans that were not detected.

Abbreviations:

cPAH Carcinogenic polycyclic aromatic hydrocarbon
CSL Cleanup Screening Level
SCO Sediment Cleanup Objective
TEQ Toxic equivalency quotient
WAC Washington Administrative Code
WSDOE Washington State Department of Ecology

Qualifiers:

J Estimated value
U Not detected
UJ Not detected, estimated detection limit

Table 7.5
Lora Lake Parcel Soil Exceedances

		Location	LL-SB2	LL-SB4	LL-SB5	LL-SB5	LL-SB5	LL-SB6	LL-SB6
		Sample ID	LL-SB2-0-0.5-041911	LL-SB4-0-0.5-	LL-SB5-0-0.5-041811	LL-SB5-1.5-2-041811	LL-SB5-2-4-041811	LL-SB6-0-0.5-041811	LL-SB6-1.5-2-041811
		Sample Date	04/19/2011	4/19/2011	04/18/2011	04/18/2011	04/18/2011	04/18/2011	04/18/2011
		Sample Depth	0–0.5 foot	0–0.5 foot	0–0.5 foot	1.5–2 feet	2–4 feet	0–0.5 foot	1.5–2 feet
Analyte	**Unit**	**CUL**							
Metals									
Arsenic	mg/kg	20	13	13	12	12	10	9	10
Lead	mg/kg	250	58	26	64	14	14	17	13
Total Petroleum Hydrocarbons									
Gasoline Range[1]	mg/kg	100	5.8 U	7.2 U	9.5 U	5.8 U	6.9 U	7.2 U	6.5 U
Diesel Range[1]	mg/kg	2,000	5.7 U	6.1	13 U	5.7 U	6.1 U	6 U	5.7 U
Heavy Oil Range	mg/kg	2,000	17	17	150	22	17	49	11 U
Summed Diesel and Heavy Oil Ranges with One-half of the Reporting Limit	mg/kg	2,000	20			25	20	52	11 U
Semivolatile Organic Compounds									
Pentachlorophenol	µg/kg	2,500	6.8 U	7.5 U	8.7 U	7 U	7.6 U	24	7.1 U
Summed cPAH TEQ[2,3]	µg/kg	137	1.4	17	25 J	7	0.06	13	0 U
Summed cPAH TEQ with One-half of the Reporting Limit[2,4]	µg/kg	137	4.4	17	26 J	7.7	3.4	13	3.2 U
Volatile Organic Compounds									
Ethylbenzene	µg/kg	8,000,000	29 U	36 U	47 U	29 U	35 U	36 U	32 U
Toluene	µg/kg	6,400,000	29 U	36 U	47 U	29 U	35 U	36 U	32 U
Dioxins/Furans									
Summed Dioxin/Furan TEQ[5,6]	pg/g	5.2	**13.2 J**	**5.59 J**	**8.76 J**	**10.8 J**	**22.7 J**	**40.4 J**	**7.57 J**
Summed Dioxin/Furan TEQ with One-half of the Detection Limit[5,7]	pg/g	5.2	**13.2 J**	**5.59 J**	**8.76 J**	**10.8 J**	**22.7 J**	**40.4 J**	**7.57 J**

Notes:

Bold Indicates exceedance of CUL.

1 The MTCA Method A CULs for both diesel range and heavy oil range TPH are based on prevention of accumulation of free product in groundwater. Therefore, the summed diesel and heavy oil concentrations are also presented and compared tc the single CUL of 2,000 mg/kg.

2 Calculation of cPAH TEQ concentrations was performed using the California Environmental Protection Agency 2005 Toxic Equivancy Factors as presented in Table 708-2 of WAC 173-340-900 (WSDOE 2007).

3 Calculated using detected cPAH concentrations.

4 Calculated using detected cPAH concentrations plus one-half the reporting limit for cPAHs that were not detected.

5 World Health Organization 2005 Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (Van den Berg et al. 2006)

6 Calculated using detected dioxin/furan concentrations.

7 Calculated using detected dioxin/furan concentrations plus one-half the detection limit for dioxins/furans that were not detected.

Abbreviations:

cPAH Carcinogenic polycyclic aromatic hydrocarbon
CUL Cleanup level
MTCA Model Toxics Control Act
TEQ Toxic equivalency quotient
TPH Total petroleum hydrocarbons
WAC Washington Administrative Code
WSDOE Washington State Department of Ecology

Qualifiers:

J Estimated value
U Not detected

Qualifiers:

J Estimated value
U Not detected

Table 9.1
Potential Location-specific ARARs for the Lora Lake Apartments Parcel

Standard, Requirement, or Limitation	Description	Applicability
Adjacent to Airport		
Federal Aviation Administration Runway Protection Zone—Extended Object Free Area (FAA 2008. AC 150/5300, Airport Design. Revised 19 June)	The Extended Object Free Area must be kept clear of objects including structures, equipment, and terrain, except for those objects necessary for air navigation or aircraft ground-maneuvering purposes.	Not applicable as no portion of the LL Apartments Parcel lies within the Extended Object Free Area.
Federal Aviation Administration Runway Protection Zone—Controlled Activity Area (FAA 2008. AC 150/5300, Airport Design. Revised 19 June)	The Controlled Activity Area is the zone outside of and adjacent to the Extended Object Free Area in which land use is restricted by the FAA and excludes the construction of residences and public gathering spaces such as shopping centers, offices, or hospitals.	Applicable to future development of the Lora Lake Apartments Parcel; may not be applicable during construction activities.
Shoreline, Wetlands, and other Critical Areas		
Washington Shoreline Management Act (RCW 90.58; WAC 173-14)	The Washington Shoreline Management Act, authorized under the federal Coastal Zone Management Act, establishes requirements for substantial development occurring within the waters of Washington State or within 200 feet of a shoreline.	Not applicable, as the LL Apartments Parcel is more than 200 feet from the Lora Lake shoreline.
City of Burien—Shoreline Master Program (BMC Title 20)	Implements the requirements imposed on the City of Burien by the Washington Shoreline Management Act (RCW 90.58) and ensures that development under the program will not cause a net loss of ecological functions.	Not applicable as the portions of the property residing in the City of Burien are outside of the zone managed by this plan.
City of Burien—Critical Areas Regulations (BMC Chapter 19.40)	This chapter establishes regulations pertaining to the development within or adjacent to critical areas, which include areas that provide a variety of biological and physical functions that benefit the City of Burien and its residents, including water quality protection, fish and wildlife habitat, food chain support, etc.	Not applicable; areas of the LL Apartments Parcel regulated by City of Burien are not within a critical area.
Executive Order 11990, Protection of Wetlands (40 CFR 6, Appendix A)	Executive Order 11990 Section 7 requires measures to minimize the destruction, loss, or degradation of wetlands. Requires no net loss of remaining wetlands.	Not applicable; areas of the LL Apartments Parcel to be remediated are not within designated wetlands.
Shoreline, Wetlands, and other Critical Areas (continued)		
Flood Plain Management 40 CFR 6, Appendix A: 10 CFR 1022 and FEMA requirements	In 100-year flood plains, actions must be taken to reduce the risk of flood loss, minimize the impact of floods on human safety, and restore and preserve the natural beneficial values of flood plains.	Not applicable; the LL Apartments Parcel is not located within a designated floodplain.
Washington Floodplain Management Plan RCW 68.16; WAC 173-158	An advisory standard pertaining to wetlands management that suggests local governments, with technical assistance from WSDOE, institute a program that can identify and map critical wetland areas located within base floodplains.	

Table 9.1
Potential Location-specific ARARs for the Lora Lake Apartments Parcel

Standard, Requirement, or Limitation	Description	Applicability
Tribal and Cultural Protections		
Native American Graves Protection and Repatriation Act (25 USC 3001 through 3113; 43 CFR Part 10) Washington's Indian Graves and Records Law (RCW 27.44)	These statutes prohibit the destruction or removal of Native American cultural items and require written notification of inadvertent discovery to the appropriate agencies and Native American tribe. These programs are applicable to the remedial action if cultural items are found. The activities must cease in the area of the discovery; a reasonable effort must be made to protect the items discovered; and notice must be provided.	Because of the LL Apartments Parcel's commercial/industrial and development history, Native American protections are likely not an issue; however, the National Historic Preservation Act is applicable.
Archaeological Resources Protection Act (16 USC 470aa et seq.; 43 CFR part 7)	This program sets forth requirements that are triggered when archaeological resources are discovered. These requirements only apply if archaeological items are discovered during implementation of the selected remedy.	
National Historic Preservation Act (16 USC 470 et seq.; 36 CFR parts 60, 63, and 800)	This program sets forth a national policy of historic preservation and provides a process that must be followed to ensure that impacts of actions on archaeological, historic, and other cultural resources are protected.	

Abbreviations:
AC Advisory Circular
ARAR Applicable or Relevant and Appropriate Requirement
BMC Burien Municipal Code
CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
CFR Code of Federal Regulations
DMCA 1982 Dredged Material Containment Area
ESA Endangered Species Act
FAA Federal Aviation Administration
FEMA Federal Emergency Management Agency
HPA Hydraulic Projects Approval
MSA Magnuson-Stevens Act
MTCA Model Toxics Control Act
RCW Revised Code of Washington
RI/FS Remedial Investigation/Feasibility Study
SEPA State Environmental Policy Act
Site Lora Lake Apartments Site
SMC SeaTac Municipal Code
USC United States Code
WAC Washington Administrative Code
WRIA Water Resource Inventory Area
WSDOE Washington State Department of Ecology

Table 9.2
Potential Action-specific ARARs for the Lora Lake Apartments Parcel

Standard, Requirement, or Limitation	Description	Applicability
Evaluate Environmental Impacts		
State Environmental Policy Act (RCW 43.21C, WAC 197-11)	Establishes the state's policy for protection and preservation of the natural environment.	Applicable; implemented during design and permitting phase. Coordination with federal agencies may be necessary to ensure the SEPA process will to meet NEPA requirements. SEPA and MTCA are integrated processes per WAC 197-11-250 through 197-11-268.
Upland Disposal of Soils		
Resource Conservation and Recovery Act (42 USC 6921-6949a; 40 CFR Part 268, Subtitles C and D)	Establishes requirements for the identification, handling, and disposal of hazardous and non-hazardous waste.	Applicable only if waste is generated from selected alternative.
Dangerous Waste Regulations (RCW 70.105; WAC 173-303)	Establishes regulations that are the state equivalent of RCRA requirements for determining whether a solid waste is a state dangerous waste. This regulation also provides requirements for the management of dangerous wastes.	Applicable only if waste is generated from selected alternative.
Solid Waste Disposal Act (42 USC Sec. 325103259, 6901-6991; 40 CFR 257,258) Federal Land Disposal Requirements (40 CFR part 268)	Protects health and the environment and promotes conservation of valuable material and energy resources.	Applicable only if waste is generated from selected alternative.
Minimum Functional Standards for Solid Waste Handling (WAC 173-304)	Sets minimum functional standards for the proper handling of all solid waste materials originating from residences, commercial, agricultural, and industrial operations as well as other sources.	Applicable only if waste is generated from selected alternative.
Solid Waste Handling Standards (WAC 173-350)	Establishes minimum standards for handling and disposal of solid waste. Solid waste includes wastes that are likely to be generated as a result of site remediation, including contaminated soils, construction and demolition wastes, and garbage.	Applicable only if waste is generated from selected alternative.
Construction Grading		
City of Burien—Construction Codes for Grading (adopted from the State Building Code WAC 51-50/International Building Code)	The provisions of the grading chapter (Appendix J, International Building Code) apply to grading, excavation and earthwork construction, including fills and embankments. No grading should be performed without obtaining a permit from the City of Burien.	Substantive requirements are applicable. MTCA remedial actions are exempt from the procedural requirements of this law but must comply with the substantive requirements.
City of SeaTac—Construction Codes for Grading (SMC Chapter 13.190)	This chapter is intended to regulate clearing and removal of vegetation, excavation, and grading and earthwork construction including cuts and fills, gravel pits, dumping, and quarrying and mining operations within City of SeaTac in order to protect public health, safety, and welfare.	Applicable only if earthwork (soil consolidation) is conducted at the DMCA or within the City of Seatac Right-of-Way as part of the selected alternative. MTCA remedial actions are exempt from the procedural requirements of this law but must comply with the substantive requirements. Also applicable to site improvement activities conducted by the Port at the DMCA simultaneous, but not included in the selected alternative. These actions would not be exempt from the procedural or substantive requirements of this law.

Table 9.2
Potential Action-specific ARARs for the Lora Lake Apartments Parcel

Standard, Requirement, or Limitation	Description	Applicability
Wastewater/Stormwater Discharge		
Washington Water Pollution Control Law RCW 90.48; WAC 173-216, WAC 173-220 National Pollution Discharge Elimination System (CWA Part 402)	Washington State has been delegated authority to issue NPDES permits. CWA Section 301, 302, and 303 require states to adopt water quality standards and implement a NPDES permitting process. The Washington Water Pollution Control Law and regulations address this requirement.	State version of CWA NPDES. Substantive requirements are applicable. MTCA remedial actions are exempt from the procedural requirements of this law but must comply with the substantive requirements. Any construction or regrading activity will require compliance with NPDES.
King County Industrial Waste Program	The King County Industrial Waste Program monitors discharge of liquid waste to the wastewater (sanitary sewer) system. Any discharges during construction to the wastewater system must be approved by King County prior to discharge. The King County Industrial Waste Program monitors volume and water quality of liquid waste discharged to the system.	Applicable to any wastewater (dewatering water, stormwater, etc.) discharged to the sanitary sewer system during remedy implementation.
Worker Safety		
Health and Safety for Hazardous Waste Operations and Emergency Response (WAC 296-62; and Health and Safety 29 CFR 1901.120)	The HAZWOPER regulates health and safety operations for hazardous waste sites. The health and safety regulations describe federal requirements for health and safety training for workers at hazardous waste sites.	Any cleanup work will require compliance with OSHA and WISHA
Occupational Safety and Health Act (29 USC 653, 655, 657) Occupational Safety and Health Standards (29 CFR 1910)	Employee health and safety regulations for construction activities and general construction standards as well as regulations for fire protection, materials handling, hazardous materials, personal protective equipment, and general environmental controls. Hazardous waste site work requires employees to be trained prior to participation in site activities, medical monitoring, monitoring to protect employees from excessive exposure to hazardous substances, and decontamination of personnel and equipment.	Any cleanup work will require compliance with OSHA and WISHA.
Washington Industrial Safety and Health Act (RCW 49.17) Washington Industrial Safety and Health Regulations (WAC 296-62, WAC 296-155)	Adopts the OSHA standards that govern the conditions of employment in all work places. The regulations encourage efforts to reduce safety and health hazards in the work place and set standards for safe work practices for dangerous areas such as trenches, excavations, and hazardous waste sites.	Any cleanup work will require compliance with OSHA and WISHA.
Air Quality Controls		
Federal, State, and Local Air Quality Protection Programs State Implementation of Ambient Air Quality Standards NWAPA Ambient and Emission Standards Regional Standards for Fugitive Dust Emissions Toxic Air Pollutants	Regulations promulgated under the federal Clean Air Act (42 USC 7401) and the Washington State Clean Air Act (RCW 70.94) governs the release of airborne contaminants from point and non-point sources. Local air pollution control authorities such as the PSCAA have also set forth regulations for implementing these air quality requirements. These requirements may be applicable to the Site for the purposes of dust control should the selected remedial alternatives require excavation activities. Both PSCAA (under Regulation III) and WAC 173-460 establish ambient source impact levels for arsenic.	The selected alternative will require compliance with air quality regulations and BMPs for dust control.

Table 9.2
Potential Action-specific ARARs for the Lora Lake Apartments Parcel

Standard, Requirement, or Limitation	Description	Applicability
Miscellaneous		
Noise Control Act of 1974 (RCW 70.107, WAC 173-60)	Establishes maximum noise levels.	The selective alternative will need to comply with local and state noise pollution requirements. Construction and other activities will need to be limited to normal working hours.
National Electrical Code (NFPA 70) and the Seattle Electric Code Supplement for Class 1 Division 2 Environments.	Establishes restrictions and guidelines for temporary and/or permanent electrical installations.	Compliance required should the selected alternative require temporary electrical power.

Abbreviations:

ARAR	Applicable or Relevant Appropriate Requirement
BMP	Best management practice
CFR	Code of Federal Regulations
CWA	Clean Water Act
HAZWOPER	Health and Safety for Hazardous Waste Operations and Emergency Management
MTCA	Model Toxics Control Act
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NWAPA	Northwest Air Pollution Authority
OSHA	Occupational Safety and Health Act
PSCAA	Puget Sound Clean Air Authority
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
SEPA	State Environmental Policy Act
Site	Lora Lake Apartments Site
USC	United States Code
WAC	Washington Administrative Code
WDFW	Washington State Department of Fish and Wildlife
WISHA	Washington Industrial Safety and Health Act

Table 9.3
Potential Chemical-specific ARARs for the Lora Lake Apartments Parcel

Standard, Requirement, or Limitation	Description	Applicability
Groundwater Requirements		
Model Toxics Control Act (WAC 173-340)	Establishes Washington State administrative processes and standards to identify, investigate, and clean up facilities where hazardous substances are located.	Site is regulated under MTCA and must meet MTCA standards. Cleanup levels must consider beneficial use of groundwater, which is impact to surface water.
Drinking Water Standards—State MCLs (WAC 246-290-310)	Establishes standards for contaminant levels in drinking water for water system purveyors.	Highest potential future beneficial use at the Site is drinking water, therefore applicable.
Water Quality Standards for Groundwaters of the State of Washington (WAC 173-200)	Implements the Water Pollution Control Act and the Water Resources Act of 1971 (90.54 RCW).	Not applicable to sites undergoing cleanup actions under MTCA (per WAC 173-200-010(3)(c)).
National Recommended Water Quality Standards 40 CFR 131 Washington State Maximum Contaminant Levels (WAC 246-290-310)	These water quality standards define the water quality goals of the water body by designating the use or uses to be made of the water and by setting criteria necessary to protect the uses. States adopt water quality standards from 40 CFR 131 to protect public health or welfare, enhance the quality of water, and serve the purposes of the CWA. Washington State water quality standards (MCLs) are presented in WAC.	Applicable.
Soil Requirements		
Model Toxics Control Act (WAC 173-340)	Establishes Washington State administrative processes and standards to identify, investigate, and clean up facilities where hazardous substances are located.	Site is regulated under MTCA and must meet MTCA standards.

Abbreviations:
- AET Apparent Effects Threshold
- ARAR Applicable, Relevant, and Appropriate Requirement
- CFR Code of Federal Regulations
- CWA Clean Water Act
- MCL Maximum Contaminant Level
- MTCA Model Toxics Control Act
- NTR National Toxics Rule
- RCW Revised Code of Washington
- RI/FS Remedial Investigation/Feasibility Study
- Site Lora Lake Apartments Site
- SMS Sediment Management Standards
- SQV Sediment quality values
- USC United States Code
- WAC Washington Administrative Code
- WSDOE Washington State Department of Ecology

Table 12.1
Preliminary Screening of Technologies for the Lora Lake Apartments Parcel

Remedial Technology	Applicable Media	COCs Addressed	General Technology Benefits	General Technology Constraints	Consideration of Site Physical Conditions and RAOs	Technology Retained for or Rejected from Further Evaluation
No Action	• Soil • Groundwater	• Applicable to all site soil and groundwater COCs with concentrations greater than cleanup levels.	• No cost to implement. • No long-term monitoring cost. • Does not cause substantial impacts to site operations.	• Does not reduce or remove chemical concentrations. • Does not protect human health and the environment. • Does not meet cleanup goals in a reasonable restoration time frame. • Technology does not have proven success at sites with similar conditions.	• Not impacted by physical conditions at the Site. • Does not contribute to achievement of RAOs.	The No Action technology does not address any of the site COCs or achieve RAOs. **No Action is Rejected** from further evaluation for the following: o Remediation of soil o Remediation of groundwater
Institutional Controls	• Soil • Groundwater	• Applicable to all site soil and groundwater COCs with concentrations greater than cleanup levels.	• Low cost to implement. • Protective of direct contact pathway through controls. • Technology does have proven success at sites with similar conditions.	• Does not reduce or remove chemical concentrations. • Limits future site operations through restrictive covenants or administrative measures.	• Can be implemented in conjunction with site development plans for building or paving. • Not limited by site physical conditions. • Contributes to achievement of RAOs when used in combination with other technologies.	ICs are applicable to all COCs and all media, achieve RAOs when used in combination with other technologies, and can be implemented given site conditions. The technology of **Institutional Controls is Retained** for further evaluation for the following: o Remediation of soil o Remediation of groundwater
Surface Capping	• Soil	• Applicable to all site soil COCs with concentrations greater than cleanup levels.	• Contains contaminated soil below the ground surface and provides barrier from contact pathways. • Technology does have proven success at sites with similar conditions.	• Chemicals remain in place and are not removed or destroyed. • Surface cap maintenance required in perpetuity.	• Can be implemented in conjunction with site development plans for building or paving. • Not limited by site physical conditions. • Contributes to achievement of RAOs when used in combination with other technologies.	Surface capping is applicable to all COCs in soil, achieve RAOs when used in combination with other technologies, and can be implemented given site conditions. **Surface Capping is Retained** for further evaluation for: o Remediation of soil
Solidification and Stabilization	• Soil	• Applicable to lead, PCP, dioxins/ furans. • Not applicable for remediation of TPHs or cPAHs.	• Technology reduces the mobility of soil contamination through physical or chemical immobilization. • Toxicity of individual COCs may be reduced through chemical reaction processes (stabilization only). • Controls contaminant migration and/or leaching to groundwater.	• Requires long-term groundwater compliance testing to ensure the immobilization of contaminants. • Feasibility of implementation decreases with depth below ground surface. • Chemicals remain in place and are immobilized, but not removed (solidification). • Technology does not have proven success at sites with similar conditions.	• Could be difficult to implement due to the large footprint of contamination. • May impact future site redevelopment at the LL Apartments Parcel. • Contributes to achievement of RAOs when used in combination with other technologies.	Due to limited applicability to soil COCs, feasibility concerns given the extent of contamination, unproven success at similar sites, and restrictions on future site uses, **Solidification and Stabilization is Rejected** from further evaluation for: o Remediation of soil

Table 12.1
Preliminary Screening of Technologies for the Lora Lake Apartments Parcel

Remedial Technology	Applicable Media	COCs Addressed	General Technology Benefits	General Technology Constraints	Consideration of Site Physical Conditions and RAOs	Technology Retained for or Rejected from Further Evaluation
In-situ Vitrification	• Soil	• Applicable to all site soil COCs with concentrations greater than cleanup levels.	• Completely immobilizes inorganic contaminants and destroys organic contaminants by high temperatures. • Effective to depths up to 20 feet. • Resulting glass/vitreous mass prevents contamination from leaching to groundwater.	• Requires heating the ground to very high temperatures and a high cost. • Resulting glass/vitreous mass would affect site groundwater flow. • Does not treat deep contamination. • Vaporized contamination requires capture and treatment. • Technology does not have proven success at sites with similar conditions.	• Technology would not address deep contamination in primary source area. • Would be difficult to implement due to the large site footprint. • May impact future site redevelopment at the LL Apartments Parcel. • Contributes to achievement of RAOs when used in combination with other technologies.	Due to implementability concerns given site conditions such as contaminant depth and footprint, unproven use at sites with similar conditions, and restrictions on future site use, **In-situ Vitrification is Rejected** from further evaluation for the following: o Remediation of soil
Source Removal by Excavation and Landfill Disposal	• Soil • Groundwater	• Applicable to all site soil and groundwater COCs with concentrations greater than cleanup levels.	• Results in immediate removal of chemicals from the Site, reducing mass in a short time frame. • Effectively removes all COCs in excavation area. • Removal of soil contamination in areas of impacted groundwater removes the ongoing source of contaminants to groundwater. • Does not require long-term monitoring and maintenance. • Technology does have proven success at sites with similar conditions.	• Can be expensive to implement because of landfill disposal costs. • Technology is limited by contaminant depth. • May require shoring for stability if open cuts cannot be made. • Dewatering may be required for excavations extending below the groundwater table, which generates liquid waste streams that would require treatment and disposal.	• Technology would not be inhibited by site operations or conditions. • Contributes to achievement of RAOs when used in combination with other technologies.	Source removal addresses all COCs, is implementable given site conditions, and achieves RAOs when combined with other remedial technologies, therefore, **Source Removal by Excavation is Retained** for further evaluation for the following: o Remediation of soil o Remediation of groundwater
Soil Vapor Extraction	• Soil	• Applicable to TPH contamination. • Not applicable to lead, PCP, dioxins/furans, or cPAHs.	• Can be implemented with limited disturbance to surface activities. • System can be easily turned on and off to optimize performance and cost.	• Limited to treatment of vadose zone soil and volatile contaminants. • Relatively expensive to install and maintain. • Does not address groundwater contamination for site COCs. • Technology does not have proven success at sites with similar conditions.	• Does not address contamination in the saturated zone. • Does not contribute to achievement of RAOs when used in combination with other remedial technologies.	Because Soil Vapor Extraction is limited in applicability to vadose zone volatile contamination, **Soil Vapor Extraction is Rejected** from further evaluation for the following: o Remediation of soil

Table 12.1
Preliminary Screening of Technologies for the Lora Lake Apartments Parcel

Remedial Technology	Applicable Media	COCs Addressed	General Technology Benefits	General Technology Constraints	Consideration of Site Physical Conditions and RAOs	Technology Retained for or Rejected from Further Evaluation
Chemical Oxidation	• Soil • Groundwater	• Applicable to arsenic, lead, TPH, PCP, and cPAH contamination. • Not applicable to dioxin/furan contamination.	• Technology reduces contaminant concentrations and mass in place. • Low cost associated with implementation (i.e., no landfill disposal fees).	• Effectiveness limited by subsurface conditions and site heterogeneity as injected solutions can follow preferential pathways. • Requires multiple rounds of injection. • Contaminant rebound may be observed when source concentrations and volume are elevated and insufficient source treatment has occurred. • Technology does not have proven success at sites with similar conditions.	• Technology does not cause significant impacts to site activities because the Site is vacant, but would be more challenging under developed site conditions. • Does not contribute to achievement of RAOs when used in combination with other remedial technologies.	Because applicability of Chemical Oxidation is limited to COCs in the source area, and has not been proven for use at sites with similar conditions, **Chemical Oxidation is Rejected** from further evaluation for the following: o Remediation of soil o Remediation of groundwater
Soil Flushing	• Soil	• Applicable to lead contamination. • Not applicable to TPH, PCP, cPAH, or dioxin/furan contamination.	• Can be implemented with minimal disturbance to surface activities.	• Requires injection of large volumes of water and surfactant to release soil contamination into groundwater. • High risk associated with capturing all downgradient groundwater/surfactant to insure chemicals are not mobilized, then transported downgradient. • Technology is expensive to implement due to requirement for groundwater capture and treatment of water. • Technology does not have proven success at sites with similar conditions.	• High risk associated with the ability to capture groundwater downgradient of the LL Apartments Parcel. • Contributes to achievement of RAOs when used in combination with other technologies.	The Soil Flushing technology has not been proven effective at sites with similar conditions, and has high risk associated with implementation, therefore, **Soil Flushing is Rejected** from further evaluation for the following: o Remediation of soil.
Soil Mixing by Auger	• Soil	• Applicable to lead, TPH, and PCP contamination. • Not applicable to dioxin/furan or cPAH contamination.	• Technology promotes in-situ destruction of contaminant mass by addition of zero-valent iron (ZVI) or oxidants directly to contaminated soil brought up by augers. • Can reach deep soil contamination.	• Technology requires disturbance of the entire treated area subsurface, and inhibits other construction activities. • Technology results in generation of excess contaminated soil that must be disposed of in a landfill facility. • Wedges of contaminated material may be left in place between auger locations, depending on the degree of overlap of locations. • Technology does not have proven success at sites with similar conditions.	• Vacant site would allow technology to be easily implemented, but may interfere with future development, or implementation of additional remedial actions. • Depth footprint of contamination would result in significant volumes of contaminated soil that would require landfill disposal. • Does not contribute to achievement of RAOs when used in combination with other remedial technologies.	The Soil Mixing by Auger technology has not been proven effective at sites with similar conditions, and does not address the majority of contamination at the Site, therefore, **Soil Mixing by Auger is Rejected** from further evaluation for the following: o Remediation of soil

Table 12.1
Preliminary Screening of Technologies for the Lora Lake Apartments Parcel

Remedial Technology	Applicable Media	COCs Addressed	General Technology Benefits	General Technology Constraints	Consideration of Site Physical Conditions and RAOs	Technology Retained for or Rejected from Further Evaluation
Thermal Treatment	• Soil • Groundwater	• Applicable to TPH contamination. • Not applicable to arsenic, lead, PCP, cPAH, or dioxin/furan contamination.	• Can be implemented in a short time frame. • Can be implemented at greater depths than other technologies. • Treats both soil and groundwater contamination simultaneously. • No long-term maintenance required.	• High cost associated with implementation. • Requires large loads of on-site power. • Requires substantial surface infrastructure for operation. • Technology does not have proven success at sites with similar conditions.	• Technology not limited by site physical conditions, and can be implemented in coordination with future use conditions. • Contributes to achievement of RAOs when used in combination with other technologies.	Since Thermal Treatment is only applicable to TPH contamination, and does not treat any of the other site COCs, **Thermal Treatment is Rejected** from further evaluation for the following: o Remediation of soil o Remediation of groundwater
Monitored Natural Attenuation	• Groundwater	• Applicable to TPH, contamination. • Not applicable to arsenic, PCP, or dioxin/furan contamination.	• Low cost associated with implementation. • Does not cause impacts to site operations. • Technology does have proven success at sites with similar conditions.	• Long-term monitoring required in perpetuity. • Does not control chemical migration.	• Is not limited by site physical conditions, and can be implemented under any future use conditions. • Does not contribute to achievement of RAOs when used in combination with other remedial technologies.	The majority of current groundwater contaminants at the Site do not naturally degrade , therefore, **Monitored Natural Attenuation is Rejected** for further evaluation for the following: o Remediation of groundwater
Permeable Reactive Barrier Wall	• Groundwater	• Applicable to arsenic, PCP, and TPH contamination. • Not applicable to dioxin/furan contamination.	• Passively treats contaminated groundwater as it passes through the reactive barrier area. • Can be straightforward to implement, except at significant depths. • Is relatively feasible to implement at shallow depths and does not cause significant disruption to site operations.	• A PRB wall can become "clogged" by migration of fines in groundwater and can be costly to maintain. • Depending on the concentrations in groundwater, the PRB wall may require replacement once the reaction capacity of the material in the wall is reached or the wall pores become clogged. • Technology does not have proven success at sites with similar conditions (dioxin/furan contamination).	• Limited applicability given the physical conditions at the Site: site COCs are generally not mobile, and groundwater contamination is limited to the Central and Eastern Source Areas. • Does not contribute to achievement of RAOs when used in combination with other remedial technologies.	PRB does not have proven success at sites with similar conditions, and has limited applicability given physical conditions, therefore, a **Permeable Reactive Barrier Wall is Rejected** from further evaluation for the following: o Remediation of groundwater

Table 12.1
Preliminary Screening of Technologies for the Lora Lake Apartments Parcel

Remedial Technology	Applicable Media	COCs Addressed	General Technology Benefits	General Technology Constraints	Consideration of Site Physical Conditions and RAOs	Technology Retained for or Rejected from Further Evaluation
Low Permeability Barrier Wall	• Groundwater	• Applicable to all site groundwater COCs.	• Attains RAOs by containing soil and groundwater contaminants, and restricting continued migration of contaminated groundwater.	• Is relatively costly to implement. • May impact future site operations, or require relocation of existing utilities. • Requires hydraulic control (pumping) inside the barrier wall to maintain an inward gradient of groundwater in perpetuity. • Does not address contamination that has already migrated past the point of treatment. • Technology does not have proven success at sites with similar conditions (dioxin/furan contamination).	• Site geology indicates the presence of a confining layer (silt unit) below the fill and recessional outwash deposits that would assist in wall construction. • Limited applicability given the physical conditions at the Site: site COCs are generally not mobile, and groundwater contamination is limited to the Central and Eastern Source Areas. • Does not contribute to achievement of RAOs when used in combination with other remedial technologies.	Low Permeability Barrier Wall does not have proven success at sites with similar conditions, and has limited applicability given physical conditions, therefore, the technology of a **Low Permeability Barrier Wall is Rejected** from further evaluation for the following: o Remediation of groundwater
Pump and Treat	• Groundwater	• Applicable to arsenic, PCP, and TPH contamination. • Not applicable to dioxin/furan contamination.	• Removes dissolved-phase chemicals from groundwater. • Typically causes minimal impact to site operations.	• Does not treat soil source contamination. • High groundwater pumping rates may be required resulting in high volumes of groundwater for treatment and disposal. • Significant cost associated with treatment and discharge of treated waste stream. • Long-term operation and maintenance required for extraction system in perpetuity. • Technology does not have proven success at sites with similar conditions (dioxin/furan contamination).	• Permeable subsurface conditions would likely result in excessive water volumes requiring treatment and disposal in perpetuity. • Dioxin/furan contamination in groundwater is likely resulting from solids, and is not dissolved-phase contamination. Pump and Treat may not result in removal of dioxin/furan contamination. • Could be implemented with current and expected future site use. • Does not contribute to achievement of RAOs when used in combination with other remedial technologies.	Pump and Treat is not expected to remediate site groundwater COCs, because the dioxin/furan contamination is associated with solids content rather than dissolved phase contamination. The physical conditions also result in high volumes of water generation in perpetuity, which makes Pump and Treat infeasible for groundwater treatment, therefore, **Pump and Treat is Rejected** from further evaluation for: o Remediation of groundwater

Abbreviations

BMP	Best management practice
COC	Contaminant of concern
cPAH	Carcinogenic polycyclic aromatic hydrocarbon
IC	Institutional Control
LL	Lora Lake
MNA	Monitored natural attenuation
O&M	Operations and maintenance
PCP	Pentachlorophenol
PRB	Permeable reactive barrier
RAO	Remedial Action Objective
SVE	Soil vapor extraction
TPH	Total petroleum hydrocarbons

Table 12.2
Remedial Alternative Components for the Lora Lake Apartments Parcel

	Lora Lake Apartments Parcel Cleanup Areas			Groundwater
	Cleanup Area A	Cleanup Area B	Cleanup Area C	
Alternative 1	Capping and Institutional Controls[1]	Capping and Institutional Controls[1]	Capping and Institutional Controls[1]	Compliance Monitoring and Institutional Controls
Alternative 2	Excavation[3] (off-site disposal)	Capping and Institutional Controls[1,2]	Capping and Institutional Controls[1,2]	Compliance Monitoring and Institutional Controls
Alternative 3	Excavation[3] (off-site disposal)	Excavation[3] (off-site disposal)	Capping and Institutional Controls[1,2]	Compliance Monitoring and Institutional Controls
Alternative 4	Excavation[3] (off-site disposal)	Excavation[3] (off-site disposal)	On-site Consolidation to Minimize Extent of Institutional Controls[1]	Compliance Monitoring and Institutional Controls
Alternative 5	Excavation[3] (off-site disposal)[1]	Excavation[3] (off-site disposal)[1]	Excavation[3] (off-site disposal)[1]	Compliance Monitoring and Institutional Controls

Notes:
1 All Alternatives include storm drain system improvements or abandonment.
2 All capping alternatives include institutional controls for long term cap maintenance.
3 The extent of excavation areas within the Lora Lake Apartments Parcel Cleanup Areas are based on the extent of dioxin/furan contamination, which is the driver contaminant of concern for soil remediation.

Table 12.3
Remedial Alternatives—Source Removal Details[1,2]

	Alternative 1	Alternative 2	Alternatives 3/4[3]	Alternative 5
Pentachlorophenol				
Mass of PCP Removed (kg)	0	4.9	4.9	4.9
Percent of LL Apartments Parcel PCP Mass Removed	0%	100%	100%	100%
Volume (CY) of PCP Contaminated Soil Removed	-	480	480	480
Total Volume (CY) of Soil Removed[4]	-	8,600	19,000	49,000
Carcinogenic Polycyclic Aromatic Hydrocarbons				
Mass of cPAHs Removed (kg)	0	0.79	0.82	0.88
Percent of LL Apartments Parcel cPAHs Mass Removed	0%	89%	94%	100%
Volume (CY) of cPAH Contaminated Soil Removed	-	1,200	1,400	1,800
Total Volume (CY) of Soil Removed[4]	-	8,600	19,000	49,000
Dioxins/Furans				
Mass of Dioxins/Furans Removed (kg)	0	0.027	0.030	0.031
Percent of LL Apartments Parcel Dioxin/Furan Mass Removed	0%	88%	96%	100%
Volume (CY) of Dioxin/Furan Contaminated Soil Removed	-	8,400	14,000	39,000
Total Volume (CY) of Soil Removed[4]	-	8,600	19,000	49,000

Notes:

1 All values have been rounded to two significant figures. Percentages presented in this table are a result of calculations completed prior to rounding.

2 Soil volume calculations conducted prior to revision of the dioxins/furans cleanup level. Modification to the cleanup level is not expected to have a measureable effect on analysis results, and volumes were not recalculated.

3 Excavated contaminant mass for off-site disposal and soil volumes for Alternatives 3 and 4 are identical. With Alternative 3 the residual contaminant mass will remain in place and with Alternative 4 the residual contaminant mass will be consolidated on-site.

4 The total volume of soil removed is the actual volume of soil that would be excavated for each alternative to ensure the contamination is removed. This volume includes overburden.

Abbreviations:

cPAH Carcinogenic polycyclic aromatic hydrocarbon
LL Lora Lake
PCP Pentachlorophenol
CY Cubic yards

Table 13.1
Lora Lake Apartments Parcel Alternatives Evaluation[1]

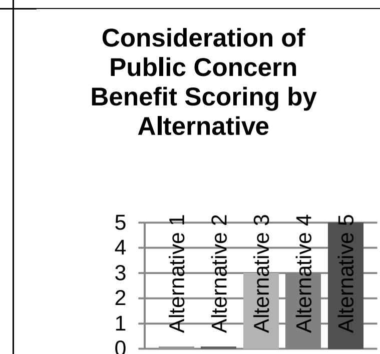
Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative Benefit Scoring
Alternative Description	Alternative 1 involves capping of the LL Apartments Parcel Cleanup Areas to address direct worker contact pathways. LL Apartments Parcel groundwater would be monitored and managed via ICs. This alternative includes stormwater source control through storm drain system improvements and/or abandonment/replacement.	Alternative 2 removes dioxin/furan contamination for off-site disposal through excavation of the Cleanup Area A to 1000 pptr. Approximately 88% of the dioxin/furan soil contamination mass would be removed; 12% would be left on-site. This alternative also consists of capping the LL Apartments Parcel Cleanup Areas A, B and C where contamination would remain at concentrations greater than 13 pptr. This alternative addresses exposure routes through source removal and pathway control. Groundwater monitoring for compliance following remedy completion is included, following groundwater treatment by source removal. This alternative includes stormwater source control through storm drain system improvements and/or abandonment/replacement.	Alternative 3 includes removal of LL Apartments Parcel dioxin/furan contamination through excavation and off-site disposal of Cleanup Area A and B to 100 pptr. Approximately 96% of the dioxin/furan contamination soil mass would be removed; 4% would remain on-site. This alternative would include capping Cleanup Areas A, B, and C where concentrations would remain at concentrations greater than 13 pptr. The alternative addresses exposure routes through source removal and pathway control. Groundwater monitoring for compliance is included, following groundwater treatment by source removal. This alternative includes stormwater source control through storm drain system improvements and/or abandonment/replacement.	Alternative 4 includes removal of LL Apartments Parcel dioxin/furan contamination through excavation and off-site disposal of Cleanup Areas A and B to 100 pptr. This alternative also consists of consolidation of the remaining soil with dioxin/furan concentrations between 13 and 100 pptr on a secured Port-owned area of the Site to minimize ICs. Approximately 96% of the dioxin/furan contamination soil mass would be disposed of off-site and 4% would be consolidated on site. As needed, capping and/or ICs would be applied to the consolidation area to manage exposure routes through pathway control. Groundwater monitoring for compliance is included, following groundwater treatment by source removal. This alternative includes stormwater source control through storm drain system improvements and/or abandonment/replacement.	Alternative 5 consists of excavation of 100% of LL Apartments Parcel soil contaminants by excavation and off-site disposal. This alternative includes stormwater source control through storm drain system improvements and/or abandonment/replacement.	
Consideration of Public Concerns • Whether the community has concerns • Degree to which the alternative addresses those concerns	Public comments received indicate the commenting public is not in favor of remedial actions that leave high concentrations of COCs on-site. Alternative 1 would not address public concerns.	Public comments received indicate the commenting public is not in favor of remedial actions that leave high concentrations of COCs on-site. Alternative 2 would not be expected to address public concerns.	Public concerns with on-site containment of low-concentration contaminated material will be addressed by WSDOE in the CAP, and final remedy selection. Public comments received did not result in revision of the proposed Alternative 3.	Public concerns with on-site containment of low-concentration contaminated material will be addressed by WSDOE in the CAP, and final remedy selection. Public comments received do not result in revision of the proposed Alternative 4.	Public comments indicated the preference for Alternative 5; however, the cost to benefit of this alternative remains disproportionate. Public comments received did not result in revision of the proposed Alternative 5.	

Table 13.1
Lora Lake Apartments Parcel Alternatives Evaluation[1]

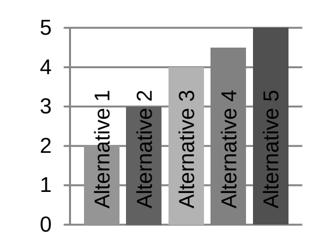
Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative Benefit Scoring
Overall Protectiveness • Degree to which existing risks are reduced • Time required to reduce risks and attain cleanup standards • On- and off-site risks resulting from alternative implementation • Improvement in overall environmental quality	• Risks would be reduced through control of the exposure pathway via capping at the LL Apartments Parcel. Stormwater system upgrades and/or abandonment would reduce the risk of contaminant infiltration to the stormwater system. • There would be an immediate reduction of risk through pathway control; however, maintenance of the cap and ICs would be required in perpetuity to maintain risk reduction. The time frame required for achievement of groundwater cleanup levels would also be indefinite, as the soil source is not removed or reduced. • No on or off-site risks result from implementation of this alternative; however, the existing risk to the public from areas of contamination outside the Site fencing would not be addressed with this alternative. • There is a slight improvement in overall environmental quality resulting from implementation of this alternative through stormwater system improvements, and exposure pathway control with capping and ICs.	• Risks would be reduced through contaminant mass removal and capping. Approximately 88% of the dioxin/furan soil contamination mass would be removed; 12% would be left on-site following excavation of Cleanup Area A, which provides a moderate reduction of existing risk. The remainder of the Site would be capped, also providing reduction of risk of residual contamination through pathway control. Stormwater system upgrades and/or abandonment would reduce the risk of contaminant infiltration to the stormwater system. • There is an immediate reduction of risk through source removal and pathway control; however, contamination would remain on-site greater than cleanup levels between 13 and 1000 pptr, requiring cap maintenance and ICs in perpetuity. Groundwater compliance with cleanup levels is expected to occur more rapidly than Alternative 1, due to soil source removal. • No on or off-site risks result from implementation of this alternative. In addition, existing risks are reduced through source removal and capping of areas in the LL Apartments Parcel where future development will occur. • This alternative provides a moderate degree of improvement in overall environmental quality for the Site through the removal of 88% of the Site dioxin/furan contaminant mass in soil, improvement of the stormwater drainage system, and the control of direct contact pathways through capping.	• Risks would be reduced through contaminant mass removal and capping. Approximately 96% of the dioxin/furan contamination soil mass would be removed and 4% would remain on-site following excavation of Cleanup Areas A and B, which would provide a moderate to high reduction of risk. The remainder of the Site would be capped, also providing reduction of risk of residual contamination through pathway control. Stormwater system upgrades and/or abandonment would reduce the risk of contaminant infiltration to the stormwater system. • There is an immediate reduction of risk through source removal and pathway control; however, contamination would remain on-site greater than cleanup levels between 13 and 100 pptr, requiring cap maintenance and ICs in perpetuity. Groundwater compliance with cleanup levels is expected to occur more rapidly than Alternative 2 due to additional soil source removal. • No on or off-site risks result from implementation of this alternative. In addition, existing risks are reduced through source removal and capping of areas in the LL Apartments Parcel where future development will occur. • This alternative provides a moderate to high degree of improvement in overall environmental quality for the Site through the removal of 96% of the Site dioxin/furan contaminant mass in soil, improvement of the stormwater drainage system, and the control of direct contact pathways through capping.	• Risks would be reduced through contaminant mass removal and consolidation. Approximately 96% of the dioxin/furan contamination soil mass would be removed; 4% would remain on-site following excavation of Cleanup Areas A and B. The remainder of the LL Apartments Parcel contamination would be consolidated on a secure Port-owned area of the Site to further minimize risk, and minimize ICs. The consolidated material would be capped, if necessary, providing reduction of risk through pathway control. Together, the contamination excavation and consolidation on a future Port-owned area of the Site provides a moderate to high degree of reduction of risk. Stormwater system upgrades and/or abandonment would reduce the risk of contaminant infiltration to the stormwater system. • There is an immediate reduction of risk through source removal and pathway control; however, contamination would remain on a Port-owned area of the Site greater than the LL Apartments Parcel cleanup levels, in a consolidated location. If the contaminated soil is consolidated off of the LL Apartments Parcel at the DMCA, cleanup levels are achieved at the LL Apartments Parcel immediately following implementation. If the remaining contaminated soil is consolidated on the LL Apartments Parcel, ICs would be required in perpetuity. Groundwater compliance with cleanup levels is expected to occur rapidly due to soil source removal. • No on or off-site risks result from implementation of this alternative. In addition, existing risks are reduced through source removal and consolidation. • This alternative provides a high degree of improvement in overall environmental quality for the Site through the removal contaminant mass in soil, improvement of the stormwater drainage system, and the control of direct contact pathways through consolidation.	• This alternative provides for removal of all accessible contaminant mass in soil and groundwater at the LL Apartments Parcel. Stormwater system upgrades and/or abandonment would reduce the risk of contaminant infiltration to the stormwater system. • The time required to reduce risk and achieve cleanup levels is short and includes the period of remedy implementation, and groundwater recovery. • There are no on- or off-site risks resulting from implementation of this alternative. • This alternative provides a high degree of improvement in overall environmental quality for the Site through the removal of all accessible contaminant mass in soil groundwater.	**Overall Protectiveness Benefit Scoring by Alternative** 

Table 13.1
Lora Lake Apartments Parcel Alternatives Evaluation[1]

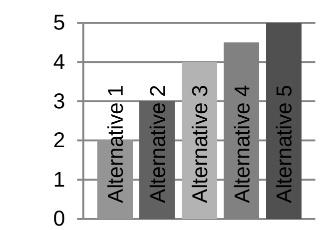
Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative Benefit Scoring
Permanence • Degree of reduction of contaminant toxicity, mobility, and volume • Adequacy of destruction of hazardous substances • Reduction or elimination of substance release, and source of release • Degree of irreversibility of waste treatment processes • Volume and characteristics of generated treatment residuals	• This alternative provides no reduction of contaminant toxicity or volume. It provides some reduction of mobility through capping, but does not eliminate the release of contaminated soil particles to groundwater. • With this alternative, all contaminants in soil remain in place; and little to no destruction of hazardous substances occurs. • Primary release mechanisms of contamination have been removed, as historical operations are responsible for contaminant release, and are no longer active at the Site. Improvements to the stormwater system would eliminate any potential releases to the stormwater system from contaminated soil or groundwater. • Waste treatment processes include capping, which is not irreversible. • There are no treatment residuals associated with implementation of this technology.	• This alternative provides a moderate degree of reduction in contaminant toxicity, mobility, and volume as 88% of the LL Apartments Parcel dioxin/furan contaminant mass would be removed via excavation for off-site disposal. • The destruction of hazardous substances associated with this alternative is accomplished through removal, which is both adequate and irreversible. • All primary release mechanisms of contamination have been removed, as historical operations responsible for contaminant release are no longer active at the Site. Improvements to the stormwater system would eliminate any potential for releases to the stormwater system from contaminated soil or groundwater. This alternative greatly reduces the release of contaminated soil particles to groundwater through soil source excavation in the saturated zone. • The waste treatment processes associated with this alternative include excavation and capping. Excavation is irreversible. Capping is a reversible technology, unless maintained. • There are no treatment residuals associated with implementation of this technology.	• This alternative provides a high degree of reduction in contaminant toxicity, mobility, and volume as 96% of the LL Apartments Parcel dioxin/furan contaminant mass would be removed via excavation for off-site disposal. Additional reduction in mobility would be accomplished through capping. • The destruction of hazardous substances associated with this alternative is accomplished through removal, which is both adequate and irreversible. • All primary release mechanisms of contamination have been removed, as historical operations responsible for contaminant release are no longer active at the Site. Improvements to the stormwater system would eliminate any potential for releases to the stormwater system from contaminated soil or groundwater. This alternative greatly reduces the release of contaminated soil particles to groundwater through soil source excavation in the saturated zone. • The waste treatment processes associated with this alternative include excavation and capping. Excavation is irreversible. Capping is a reversible technology, unless maintained. • There are no treatment residuals associated with implementation of this technology.	• This alternative provides a high degree of reduction in contaminant toxicity, mobility, and volume as 96% of the LL Apartments Parcel dioxin/furan contaminant mass would be removed via excavation for off-site disposal. The remaining contaminant mass would be consolidated on a secure Port-owned area of the Site to minimize the ICs required. • The destruction of hazardous substances associated with this alternative is accomplished through removal, which is both adequate and irreversible. • All primary release mechanisms of contamination have been removed, as historical operations responsible for contaminant release are no longer active at the Site. Improvements to the stormwater system would eliminate any potential for releases to the stormwater system from contaminated soil or groundwater. This alternative greatly reduces the release of contaminated soil particles to groundwater through soil source excavation in the saturated zone. • The waste treatment processes associated with this alternative include excavation and capping. Excavation is irreversible. Capping is a reversible technology, unless maintained. • There are no treatment residuals associated with implementation of this technology.	• Of the proposed Alternatives, Alternative 5 provides the highest degree of reduction in contaminant toxicity, mobility, and volume. With this alternative, all accessible LL Apartments Parcel contaminant mass in soil would be removed via excavation and off-site disposal. • The destruction of hazardous substances associated with this alternative is accomplished through removal, which is both adequate and irreversible. • All primary release mechanisms of contamination have been removed, as historical operations responsible for contaminant release are no longer active at the Site. All secondary release mechanisms are removed with this alternative, as contaminants greater than cleanup levels are removed from the Site. • The waste treatment processes that would be used for the full removal alternative are permanent and irreversible. • There are no treatment residuals associated with implementation of this technology.	**Permanence Benefit Scoring by Alternative** 

Table 13.1
Lora Lake Apartments Parcel Alternatives Evaluation[1]

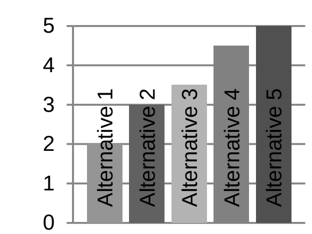
Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative Benefit Scoring
Effectiveness over the Long-term • Degree of certainty of alternative success • Reliability while contaminants remain on-site greater than cleanup levels • Magnitude of residual risk • Effectiveness of controls implemented to manage residual risk	• This alternative provides a moderate degree of certainty of success. Capping and ICs are common technologies that would control exposure pathways, but require maintenance in perpetuity. • This alternative is reliable as long as the cap is properly maintained and ICs are followed. • Residual risk is high, as all contamination remains on-site. • Risks are controlled through the enforcement of institution controls which are considered to be effective at managing risk.	• This alternative provides a high degree of certainty of success. Both excavation and capping are common technologies that would either remove contaminants or manage pathways; however, soil caps require maintenance and ICs in perpetuity. • Excavation is a reliable technology with measurable success for similar excavation and disposal projects. Capping is a reliable technology as long as the cap is properly maintained. • The magnitude of residual risk associated with this alternative is low, as the highest concentrations of dioxins/furans on-site, and 88% of the dioxin/furan mass would be removed, removing the potential source to groundwater contamination, and reducing the potential for impact to the stormwater system through system improvements. Some residual risk remains because not all contaminants are removed from the Site. • Residual risks are controlled through the enforcement of ICs which are considered to be effective at managing risk.	• This alternative provides a very high degree of certainty of success. Both excavation and capping are common technologies that would either remove contaminants or block pathways; however, caps require maintenance and ICs in perpetuity. • Excavation is a reliable technology with measurable success for similar excavation and disposal projects. Capping is a reliable technology as long as the cap is properly maintained. • The magnitude of residual risk associated with this alternative is low, as nearly all site contamination would be removed, including 96% of dioxin/furan contaminant mass, and all remaining contamination would be capped. This source removal reduces the source of contaminants to groundwater, and the stormwater system improvements would eliminate potential inputs to the stormwater system. Some residual risk remains because not all contaminants are removed from the Site. • Residual risks are controlled through the enforcement of ICs which are considered to be effective at managing risk.	• This alternative provides a high degree of certainty of success. Excavation is a common technology that would remove contaminants. Consolidation of soil provides a high degree of certainty for success in managing the residual contamination because it will be on a secure Port-owned area of the Site. • Excavation is a reliable technology with measurable success for similar excavation and disposal projects. If capping of the consolidated area is needed, capping is a reliable technology as long as the cap is properly maintained. • The magnitude of residual risk associated with this alternative is low, as nearly all site contamination would be removed, including 96% of dioxin/furan contaminant mass, and all remaining contamination would be consolidated on a Port-owned area of the Site to minimize capping and ICs. This source removal reduces the source of contaminants to groundwater, and the stormwater system improvements would eliminate potential inputs to the stormwater system. Some residual risk remains because not all contaminants are removed from the Site. • Residual risks are controlled through the enforcement of ICs which are considered to be effective at managing risk.	• This alternative provides the highest degree of certainty of success. Excavation is a common technology that would effectively remove contaminants from the LL Apartments Parcel. • The full removal alternative is reliable with measurable success for similar excavation and disposal projects. • The magnitude of residual risk associated with this alternative is low because none of the contaminant mass would remain on-site. • No controls would be required to manage residual risk from excavation.	**Long-term Effectiveness Benefit Scoring by Alternative** 

Table 13.1
Lora Lake Apartments Parcel Alternatives Evaluation[1]

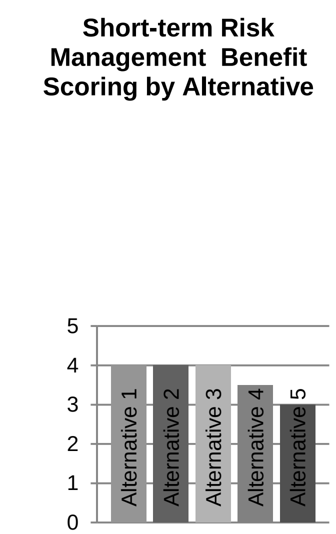
Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative Benefit Scoring
Short-term Risk Management • Risk to human health and the environment associated with alternative construction • The effectiveness of controls in place to manage short-term risks	With Alternative 1, no contaminated soil is removed from the LL Apartments Parcel. • There is low short-term risk to human health and the environment during implementation because activities are limited to capping, which does not require substantial materials handling. • Site activities would require appropriate PPE, BMPs, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk.	With Alternative 2, approximately 8,800 cubic yards of contaminated soil are removed from the LL Apartments Parcel. • This alternative has a low to moderate short-term risk associated with worker direct-contact during excavation and capping activities. There is also a low risk for public exposure with this alternative as contaminated soil would be removed and transported from the Site for disposal over public roadways; however, the excavated soil would be managed by licensed professionals. Approximately 400–500 truck trips would be required to dispose the soil off-site. • Site activities would require appropriate PPE, BMPs, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk.	With Alternative 3, approximately 19,000 cubic yards of contaminated soil are removed from the LL Apartments Parcel. • This alternative has a low to moderate short-term risk associated with worker direct-contact during excavation and capping activities. There is also a low but increased risk for public exposure with this alternative as a greater volume of contaminated soil would be removed and transported from the Site for disposal over public roadways; however, the excavated soil would be managed by licensed professionals. Approximately 1,000 truck trips would be required to dispose the soil off-site. • Site activities would require appropriate PPE, BMPs, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk.	With Alternative 4, approximately 19,000 cubic yards of contaminated soil are removed from the LL Apartments Parcel. Up to an additional 30,000 cubic yards would be handled and consolidated. • This alternative has a moderate short-term risk associated with worker direct-contact during excavation and handling, disposal, and consolidation of contaminated soil and groundwater. There is also a low but increased risk for public exposure with this alternative as a greater volume of contaminated soil would be removed and transported from the Site for disposal over public roadways; however, the excavated soil would be managed by licensed professionals. Approximately 1,000 truck trips would be required to dispose the soil off-site. • Site activities would require appropriate PPE, BMPs, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk.	With Alternative 5, approximately 49,000 cubic yards of contaminated soil are removed from the LL Apartments Parcel. • This alternative has a moderate to high degree of short-term risk associated with increased volume of handling, management and disposal of contaminated materials. It would generate a potential direct-contact risk to workers during excavation, handling, and disposal of contaminated soil, and groundwater. There is a greater risk for public exposure with this alternative, as material is being removed from the Site for disposal; however, the removed materials would be managed properly by licensed professionals. Approximately 2,500 truck trips would be required to dispose the soil off-site. • Site activities would require appropriate PPE, BMPs, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk.	

Table 13.1
Lora Lake Apartments Parcel Alternatives Evaluation[1]

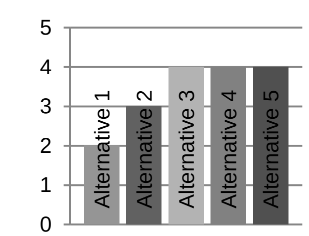
Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative Benefit Scoring
Technical and Administrative Implementability Ability of alternative to be implemented considering: • Technical possibility • Availability of off-site facilities, services, and materials • Administrative and regulatory requirements • Schedule, size, and complexity of construction • Monitoring requirements • Site access for construction, operations, and monitoring • Integration with existing site operations or other current and potential future remedial action	• This alternative is technically possible to implement and involves common technologies. • All necessary off-site facilities, materials, and services are available within the region. • This alternative would not comply with all administrative and regulatory requirements. This alternative does not adequately reduce risk to human health and the environment, or meet site RAOs. • This alternative is moderate in scale. This alternative would be managed and constructed by specialty professionals familiar with the type of work, and this alternative can easily be implemented in a single construction season. • Monitoring requirements include soil cap and groundwater monitoring in perpetuity for all of Cleanup Area A. • This alternative is assumed to be implemented in combination with site redevelopment, and site access would not be impeded; however leaving contamination on-site complicates site redevelopment and creates health and safety requirements and site restrictions that are not part of typical site redevelopment. Future site access would be required for groundwater monitoring, soil cap monitoring and maintenance. • This alternative can be integrated with both existing and proposed future site uses.	• This alternative is technically possible to implement and involves common technologies. • All necessary off-site facilities, materials, and services are available within the region. • This alternative complies with all applicable administrative and regulatory requirements. • This alternative is anticipated to achieve compliance with regulatory requirements in a short time frame. This alternative is moderate in scale. This alternative would be managed and constructed by specialty professionals familiar with the type of work, and this alternative can easily be implemented in a single construction season. • Groundwater compliance and cap monitoring would be required following implementation. • This alternative is assumed to be implemented in combination with site redevelopment, and site access would not be impeded; however, leaving anticipated levels of contamination on-site moderately complicates site redevelopment and creates health and safety requirements and site restrictions that are not part of typical site redevelopment. This alternative would require future site access for groundwater compliance monitoring and soil cap maintenance that can easily be coordinated with existing and planned future site uses. • This alternative is expected to be constructed in coordination with future development on the Site, and would be easily integrated with existing and future site uses.	• This alternative is technically possible to implement and involves common technologies. • All necessary off-site facilities, materials, and services are available within the region. • This alternative complies with all applicable administrative and regulatory requirements. • This alternative is anticipated to achieve compliance with regulatory requirements in a short time frame. This alternative is moderate in scale. This alternative would be managed and constructed by specialty professionals familiar with the type of work, and this alternative can easily be implemented in a single construction season. • Groundwater compliance and cap monitoring would be required following implementation. • This alternative is assumed to be implemented in combination with site redevelopment, and site access would not be impeded; however, leaving anticipated levels of contamination on-site moderately complicates site redevelopment and creates health and safety requirements and site restrictions that are not part of typical site redevelopment. This alternative would require future site access for groundwater compliance monitoring and soil cap maintenance which can easily be coordinated with existing and planned future site uses. • This alternative is expected to be constructed in coordination with future development on the Site, and would be easily integrated with existing and future site uses.	• This alternative is technically possible to implement and involves common technologies. • All necessary off-site facilities, materials, and services are available within the region. • This alternative complies with all applicable administrative and regulatory requirements. • This alternative is anticipated to achieve compliance with regulatory requirements in a short time frame. This alternative is large in scale. This alternative would be managed and constructed by specialty professionals familiar with the type of work, and this alternative can easily be implemented in a single construction season. • Groundwater compliance and cap monitoring would be required following implementation if contaminated soil is consolidated on the LL Apartments Parcel. If the contaminated soil is consolidated on the DMCA, only short-term groundwater compliance testing would be required. • This alternative is assumed to be implemented in combination with site redevelopment, and site access would not be impeded. Following completion, no soil contamination, or ICs will be in place on the LL Apartments Parcel property to be redeveloped by others, reducing the administrative complexity of long-term management of ICs. This alternative would require future site access for groundwater compliance monitoring and soil cap maintenance but the extent is reduced from that of the other alternatives. This alternative can easily be coordinated with existing and planned future site uses. • This alternative is expected to be constructed in coordination with future development on the Site, and would be easily integrated with existing and future site uses.	• This alternative is technically possible to implement and involves common technologies. • All necessary off-site facilities, materials, and services are available within the region. • This alternative meets all administrative and regulatory requirements. • This alternative is anticipated to achieve compliance with cleanup levels within a short time frame. The alternative is large in scale. This alternative would be managed and constructed by specialty professionals familiar with the type of work. The volume of soil to be transported for off-site disposal with this alternative is more than double the other alternatives, lowering the implementability of this alternative. • No long-term monitoring is required with this alternative, but short-term groundwater compliance testing would likely be completed. • This alternative is assumed to be implemented in combination with site redevelopment, and site access would not be impeded. Future site access for monitoring or additional remedial actions will not be required. • This alternative can be integrated with both existing and proposed future site uses.	**Technical and Administrative Implementability Benefit Scoring by Alternative** 

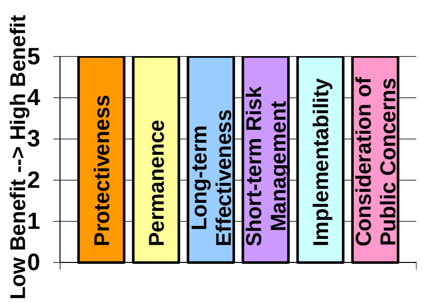
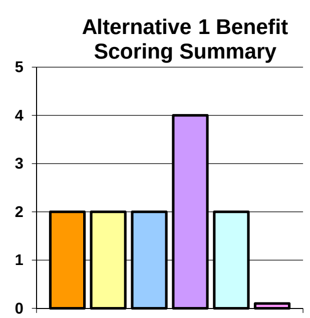
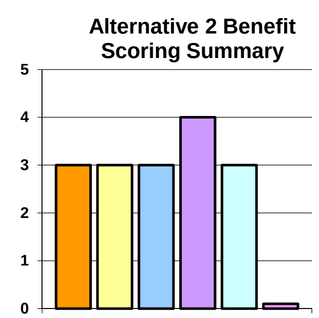
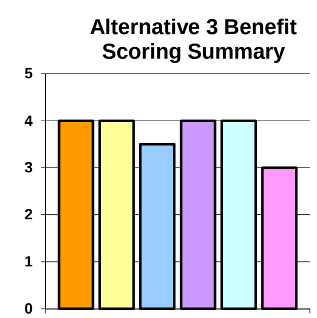
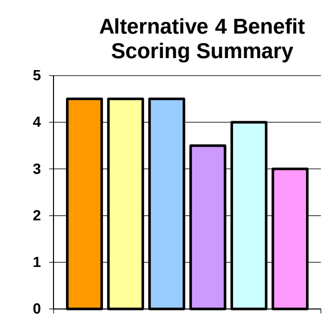
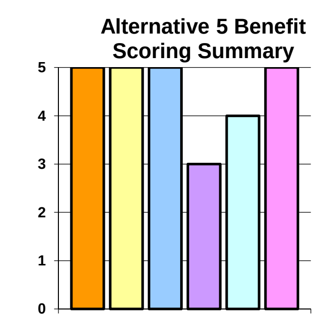
Table 13.1
Lora Lake Apartments Parcel Alternatives Evaluation[1]

Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative Benefit Scoring
Cost • Cost of construction • Long-term monitoring, operations, and maintenance costs • Agency oversight costs	• Construction Cost = 2.2 M • Long-term Monitoring, Operations and Maintenance Cost = 1 M • Agency Oversight Cost = 0.1 M • Total Alternative Cost[2] = 4.7M	• Construction Cost = 4.0 M • Long-term Monitoring, Operations and Maintenance Cost = 0.3 M • Agency Oversight Cost = 0.02 M • Total Alternative Cost[2] = 6.1 M	• Construction Cost = 4.9 M • Long-term Monitoring, Operations and Maintenance Cost = 0.3 M • Agency Oversight Cost = 0.02 M • Total Alternative Cost[2] = 7.1 M	• Construction Cost = 5.4 M • Long-term Monitoring, Operations and Maintenance Cost = .25 M • Agency Oversight Cost = 0.02 M • Total Alternative Cost[2] = 7.7 M	• Construction Cost = 7.2 M • Long-term Monitoring, Operations and Maintenance Cost = 0.25 M • Agency Oversight Cost = 0.01 M • Total Alternative Cost[2] = 9.2 M	

Notes:
1 This alternatives evaluation table compares each of the alternatives to the MTCA criteria in 173-340-360(3). Because the alternatives are similar to each other, the alternative evaluation descriptions are often the identical or similar.
2 Total Alternative Cost includes contingencies, permitting, and oversight costs not listed in this table. Refer to Appendix O for cost detail.

Abbreviations:
BMP Best management practice
CAP Cleanup Action Plan
DMCA Dredged Material Containment Area
IC Institutional control
LL Lora Lake
M Million
MTCA Model Toxics Control Act
Port Port of Seattle
PPE Personal protective equipment
pptr Parts per trillion
RAO Remedial Action Objective
WSDOE Washington State Department of Ecology

Table 13.2
Lora Lake Apartments Parcel Disproportionate Cost Analysis Summary

Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Alternative Description	Alternative 1 involves capping of the LL Apartments Parcel Cleanup Areas to address direct worker contact pathways. LL Apartments Parcel groundwater would be monitored and managed via institutional controls. This alternative includes stormwater source control through storm drain system improvements or abandonment and replacement.	Alternative 2 removes dioxin/furan contamination for off-site disposal through excavation of Cleanup Area A to 1000 pptr. Approximately 88% of the dioxin/furan soil contamination mass would be removed with 12% left on-site. This alternative also consists of capping Cleanup Areas A, B, and C where contamination would remain at concentrations greater than 13 pptr. This alternative addresses exposure routes through source removal and pathway control. Groundwater monitoring for compliance following remedy completion is included, following groundwater treatment by source removal. This alternative includes stormwater source control through storm drain system improvements or abandonment and replacement.	Alternative 3 includes removal of LL Apartments Parcel dioxin/furan contamination through excavation and off-site disposal of Cleanup Areas A and B to 100 pptr. Approximately 96% of the dioxin/furan contamination soil mass would be removed with 4% remaining on-site. This alternative would include capping Cleanup Areas A, B, and C where dioxins/furans would remain at concentrations greater than 13 pptr. The alternative addresses exposure routes through source removal and pathway control. Groundwater monitoring for compliance is included, following groundwater treatment by source removal. This alternative includes stormwater source control through storm drain system improvements or abandonment and replacement.	Alternative 4 includes removal of 96% of LL Apartments Parcel dioxin/furan contamination through excavation and off-site disposal of Cleanup Areas A and B to 100 pptr. Approximately 4% of the dioxin/furan contamination would remain on-site. This material, consisting of the remaining dioxin/furan contamination between 13 and 100 pptr, would be consolidated in a secure future Port-owned area of the site to minimize institutional controls. As needed, capping and/or institutional controls would be applied to the consolidation area, which addresses exposure routes through pathway control. Groundwater monitoring for compliance is included, following groundwater treatment by source removal. This alternative includes stormwater source control through storm drain system improvements or abandonment and replacement.	Alternative 5 consists of excavation of 100% of LL Apartments Parcel soil contaminants by excavation and off-site disposal. This alternative includes stormwater source control through storm drain system improvements or abandonment and replacement.
Cost per Unit Benefit Ratio[1]	**0.39**	**0.38**	**0.31 [2]**	**0.32**	**0.34**
KEY 					
Compliance with MTCA Threshold Requirements	Yes	Yes	Yes	Yes	Yes
Estimated Alternative Cost[3]	$4.7 M	$6.1 M	$7.1 M	$7.7 M	$9.2 M
Restoration Time Frame (to achieve remediation goals)	Following Construction	Following Construction	Following Construction	Following Construction	Following Construction
Benefit Scoring					
Overall Protectiveness	2	3	4	4.5	5
Permanence	2	3	4	4.5	5
Long-term Effectiveness	2	3	3.5	4.5	5
Short-term Risk Management[4]	4	4	4	3.5	3
Implementability	2	3	4	4	4
Consideration of Public Concerns	0	0	3	3	5
Total Benefit Score	**12**	**16**	**22.5**	**24**	**27**

Notes:
1. Cost per Unit Benefit Ratio calculated by dividing the total alternative cost (in millions) by the alternative Total Benefit Score. Lower value indicates the most benefit for the associated cost.
2. With the lowest Cost per Unit Benefit Ratio score, Alternative 3 provides the greatest degree of benefit for the associated cost of all the alternatives, making it the preferred remedial alternative.
3. Specific cost estimate information is provided in Appendix O.
4. Higher scores equate to a higher level of relative benefit. Fewer short-term risks result in a higher score.

Abbreviations:
- LL Lora Lake
- M Million
- MTCA Model Toxics Control Act
- pptr Parts per trillion

Table 15.1
Potential Location-specific ARARs for the Lora Lake Parcel

Standard, Requirement, or Limitation	Description	Applicability
Adjacent to Airport		
Federal Aviation Administration Runway Protection Zone-Extended Object Free Area (FAA 2008. AC 150/5300, Airport Design. Revised 19 June)	The FAA RPZ-Extended Object Free Area must be kept clear of objects including structures, equipment, and terrain, except for those objects necessary for air navigation or aircraft ground-maneuvering purposes.	Applicable to future development of LL Parcel, and may be applicable during construction activities if activities generate dust. Activities will be completed in daytime hours only to avoid using misleading landing lights or lights that may create glare or attract wildlife. Consultation with FAA likely required.
Federal Aviation Administration Runway Protection Zone-Controlled Activity Area (FAA 2008. AC 150/5300, Airport Design. Revised 19 June)	The FAA RPZ-Controlled Activity Area is the zone outside of and adjacent to the FAA RPZ-Extended Object Free Area in which land use is restricted by the FAA and excludes the construction of residences and public gathering spaces such as shopping centers, offices, or hospitals.	Not applicable to the LL Parcel because mitigation area restrictive covenants require that the parcel will be maintained as a wetland mitigation area indefinitely.
Miller Creek/Lora Lake/Vacca Farm Wetland and Flood Plain Zone Mitigation Area		
Washington State Department of Ecology Order #1996-4-0235 (Amendment 2) U.S. Army Corps of Engineers Section 404 Permit #1996-4-0235	Mitigation associated with the STIA Master Plan Update improvements, including the construction of the 3rd Runway, are required by the USACE and WSDOE. The Natural Resource Mitigation Plan describes the mitigation actions including site-specific objectives, functions, and implementation requirements for impacts to wetlands and streams.	Applicable if changes to the LL Parcel wetland mitigation area are proposed.
Wildlife Hazard Management Plan Seattle-Tacoma International Airport (Unabridged Section 26 of the Airport Certification Manual for SEA) (CFR Title 14 FAR part 139.337(e)	The WHMP identifies monitoring, documenting, and reporting plans for wildlife hazards within the airfield and describes mitigation and control procedures. The WHMP also describes habitat management and procedures for dispersing and controlling wildlife.	Applicable if changes to the LL Parcel wetland mitigation area are proposed.
Shoreline, Wetlands, and other Critical Areas		
Washington Shoreline Management Act (RCW 90.58; WAC 173-14)	The Washington Shoreline Management Act, authorized under the federal Coastal Zone Management Act, establishes requirements for substantial development occurring within the waters of Washington State or within 200 feet of a shoreline.	Substantive requirements are applicable to actions conducted in Lora Lake, or within 200 feet of the shore. MTCA remedial actions are exempt from the procedural requirements of this law but must comply with the substantive requirements.
City of SeaTac—Shoreline Master Program (City of SeaTac Ordinance Number 10-1002)	Implements the requirements imposed on the City of SeaTac by the Washington Shoreline Management Act (RCW 90.58) and ensures that development under the program will not cause a net loss of ecological functions.	Substantive requirements are applicable. MTCA remedial actions are exempt from the procedural requirements of this law but must comply with the substantive requirements.
City of SeaTac—Environmentally Sensitive Areas Regulations (SMC Chapter 15.30)	The purpose of this chapter is to implement the goals and policies of the Washington State Environmental Policy Act, Chapter 43.21C RCW, and the SeaTac Comprehensive Plan, which call for protection of the natural environment and the public health.	Substantive requirements are applicable. MTCA remedial actions are exempt from the procedural requirements of this law but must comply with the substantive requirements.
Executive Order 11990, Protection of Wetlands (40 CFR 6, Appendix A)	Section 7 of Executive Order 11990 requires measures to minimize the destruction, loss, or degradation of wetlands. Requires no net loss of remaining wetlands.	Applicable if alternatives impact wetlands.

Table 15.1
Potential Location-specific ARARs for the Lora Lake Parcel

Standard, Requirement, or Limitation	Description	Applicability
Shoreline, Wetlands, and other Critical Areas (continued)		
Flood Plain Management 40 CFR 6, Appendix A: 10 CFR 1022 and FEMA requirements	In 100-year flood plains, actions must be taken to reduce the risk of flood loss, minimize the impact of floods on human safety, and restore and preserve the natural beneficial values of flood plains.	Areas of the LL Parcel are located within a designated flood plain, therefore flood plain requirements are applicable.
Washington Flood Plain Management Plan RCW 68.16; WAC 173-158	An advisory standard pertaining to wetlands management that suggests local governments, with technical assistance from WSDOE, institute a program that can identify and map critical wetland areas located within base flood plains.	
In-water		
Washington Department of Fish and Wildlife Regulations Regarding Construction Projects in State Waters (RCW 77.55; WAC 220-100 (SEPA) and WAC 220-110 (HPA))	Regulates habitat protection for fish and wildlife for construction projects in state waters. Requires SEPA review and Hydraulic Project Approval permits. Although cleanup actions under MTCA and CERCLA are exempt from procedural requirements, the substantive requirements must still be met.	Substantive requirements are applicable. MTCA remedial actions are exempt from the procedural requirements of this law, but must comply with the substantive requirements.
Washington State Hydraulic Projects Approval (RCW 77.55, WAC 220-110)	This statute and its implementing regulations apply to any work conducted within the designated shoreline that changes the natural flow or bed of the water body (and therefore has the potential to affect fish habitat). The requirements include bank protections and prohibited work times based on life stages of endangered or threatened fish species.	
Washington State Instream Resources Protection Program—Green-Duwamish River Basin, WRIA 9 (WAC 173-509)	This chapter establishes rules to retain perennial streams, rivers, and lakes in the Green-Duwamish River drainage basin with instream flows and levels necessary for preservation and protection of wildlife; fish; scenic, aesthetic, and other environmental values; recreational and navigational values; and preservation of water quality.	The LL Parcel is located within the Green-Duwamish River Basin, therefore the rules are applicable.
Protection of Habitat		
Endangered Species Act (16 USC 1531 et seq.; 50 CFR Part 200; 50 CFR Part 402)	Section 7 of ESA requires that federal agencies consult with Natural Resources Trustees if listed threatened or endangered species are present in or near the project area before making any decisions that may affect these species.	Miller Creek is not critical habitat for any Washington Department of Fish and Wildlife- or National Marine Fisheries Service-listed species. Requirements may be applicable for non-listed species, depending on selected alternative.
Washington Department of Fish and Wildlife Regulations Regarding Salmon and Steelhead Recovery and Management (RCW 77.85 and 110; WAC 220-47 and 48)	Regulates habitat protection for fish and wildlife habitat management and mitigation policies.	
Fish and Wildlife Coordination Act 40 CFR 6.302; 16 USC 661-666	Requires consultation when activities modify any stream or other water body adequate for protection of fish and wildlife resources.	

Table 15.1
Potential Location-specific ARARs for the Lora Lake Parcel

Standard, Requirement, or Limitation	Description	Applicability
Protection of Habitat (continued)		
Magnuson-Stevens Act (16 USC § 1801 et seq.)	The MSA governs marine fisheries management in the United States. The MSA mandates the identification of essential fish habitat for federally-managed species and development of measures to conserve and enhance the habitat necessary for the fish life cycles.	Not applicable. Miller Creek is not identified as critical habitat for any listed species.
Tribal and Cultural Protections		
Native American Graves Protection and Repatriation Act (25 USC 3001 through 3113; 43 CFR Part 10) Washington's Indian Graves and Records Law (RCW 27.44)	These statutes prohibit the destruction or removal of Native American cultural items and require written notification of inadvertent discovery to the appropriate agencies and Native American tribe. These programs are applicable to the remedial action if cultural items are found. The activities must cease in the area of the discovery, a reasonable effort must be made to protect the items discovered, and notice must be provided.	Because of the development history of the LL Parcel, Native American protections are likely not an issue; however, the National Historic Preservation Act is applicable.
Archaeological Resources Protection Act (16 USC 470aa et seq.; 43 CFR part 7)	This program sets forth requirements that are triggered when archaeological resources are discovered. These requirements only apply if archaeological items are discovered during implementation of the selected remedy.	
National Historic Preservation Act (16 USC 470 et seq.; 36 CFR parts 60, 63, and 800)	This program sets forth a national policy of historic preservation and provides a process that must be followed to ensure that impacts of actions on archaeological, historic, and other cultural resources are protected.	

Abbreviations:

AC	Advisory Circular
ARAR	Applicable or Relevant and Appropriate Requirement
BMC	Burien Municipal Code
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
HPA	Hydraulic Projects Approval
LL	Lora Lake
MSA	Magnuson-Stevens Act
MTCA	Model Toxics Control Act
RCW	Revised Code of Washington
RI/FS	Remedial Investigation/Feasibility Study
RPZ	Runway Protection Zone
SEPA	State Environmental Policy Act
SMC	SeaTac Municipal Code
STIA	Seattle-Tacoma International Airport
USACE	U. S. Army Corps of Engineers
USC	United States Code
WAC	Washington Administrative Code
WHMP	Wildlife Hazard Management Plan
WRIA	Water Resource Inventory Area
WSDOE	Washington State Department of Ecology

Table 15.2
Potential Action-specific ARARs for the Lora Lake Parcel

Standard, Requirement, or Limitation	Description	Applicability
Evaluate Environmental Impacts		
State Environmental Policy Act (RCW 43.21C, WAC 197-11)	Establishes the state's policy for protection and preservation of the natural environment.	Applicable, will be implemented during design and permitting phase. Coordination with federal agencies may be necessary to ensure that the SEPA process will meet NEPA requirements. SEPA and MTCA are integrated processes per WAC 197-11-250 through 197-11-268.
In-water Sediment Disposal and Capping		
Clean Water Act—The National Pollutant Discharge Elimination System (40 CFR 122)	In areas that potentially erode or release sediment, controls and BMPs are to be used to control runoff from construction activities. Requires permits for the discharge of pollutants from any point source into waters of the United States.	Any construction or regrading activity with the potential to erode or release sediment will require compliance with NPDES.
Clean Water Act, Dredge or Fill Requirements Section 404 33 USC 1251 et seq. (40 CFR 230, 33 CFR 320, 323, and 325)	Section 404 of the CWA regulates the excavation and/or discharge of dredged or fill material into the waters of the United States.	May be applicable depending on selected alternative.
Washington State Hydraulics Projects Approval (RCW 75.20.10 through 75.20.160, WAC 220-110)	This statute and its implementing regulations apply to any work conducted within the designated shoreline that changes the natural flow or bed of a water body, and therefore has the potential to affect fish habitat. The requirements include bank protections and prohibited work times based on life stages of endangered or threatened fish species. Any work in Lora Lake or Miller Creek will involve consultation with the WDFW to determine appropriate mitigation measures.	Substantive requirements are applicable. MTCA remedial actions are exempt from the procedural requirements of this law but must comply with the substantive requirements.
Upland Disposal of Soils or Dredged Sediments		
Resource Conservation and Recovery Act (42 USC 6921-6949a; 40 CFR Part 268, Subtitles C and D)	Establishes requirements for the identification, handling, and disposal of hazardous and non-hazardous waste.	Only applicable if waste is generated from selected alternative.
Dangerous Waste Regulations (RCW 70.105; WAC 173-303)	Establishes regulations that are the state equivalent of RCRA requirements for determining whether a solid waste is a state dangerous waste. This regulation also provides requirements for the management of dangerous wastes.	Only applicable if waste is generated from selected alternative.
Solid Waste Disposal Act (42 USC Sec. 325103259, 6901-6991; 40 CFR 257,258) Federal Land Disposal Requirements (40 CFR part 268)	Protects health and the environment and promotes conservation of valuable material and energy resources.	Only applicable if waste is generated from selected alternative.
Minimum Functional Standards for Solid Waste Handling (WAC 173-304)	Sets minimum functional standards for the proper handling of all solid waste materials originating from residences, and commercial, agricultural, and industrial operations as well as other sources.	Only applicable if waste is generated from selected alternative.
Solid Waste Handling Standards (WAC 173-350)	Establishes minimum standards for handling and disposal of solid waste. Solid waste includes wastes that are likely to be generated as a result of site remediation (e.g., contaminated soils, construction and demolition wastes, and garbage).	Only applicable if waste is generated from selected alternative.

Table 15.2
Potential Action-specific ARARs for the Lora Lake Parcel

Standard, Requirement, or Limitation	Description	Applicability
Construction Grading		
City of SeaTac—Construction Codes for Grading (SMC Chapter 13.190)	This chapter is intended to regulate clearing and removal of vegetation, excavation, and grading and earthwork construction (e.g., cuts and fills, gravel pits, dumping, and quarrying and mining operations) within City of SeaTac in order to protect public health, safety, and welfare.	Substantive requirements are applicable. MTCA remedial actions are exempt from the procedural requirements of this law but must comply with the substantive requirements.
Wastewater/Stormwater Discharge		
Washington Water Pollution Control Law RCW 90.48; WAC 173-216, WAC 173-220	Washington State has been delegated authority to issue NPDES permits. CWA Section 301, 302, and 303 require states to adopt water quality standards and implement a NPDES permitting process. The Washington Water Pollution Control Law and regulations address this requirement.	State version of CWA NPDES. Any construction or grading activity will require obtaining a NPDES permit.
National Pollutant Discharge Elimination System (CWA Part 402)		
Worker Safety		
Health and Safety for Hazardous Waste Operations and Emergency Response (WAC 296-62; and Health and Safety 29 CFR 1901.120)	The HAZWOPER regulates health and safety operations for hazardous waste sites. The health and safety regulations describe federal requirements for health and safety training for workers at hazardous waste sites.	Any cleanup work will require compliance with OSHA and WISHA.
Occupational Safety and Health Act (29 USC 653, 655, 657) Occupational Safety and Health Standards (29 CFR 1910)	Employee health and safety regulations for construction activities and general construction standards as well as regulations for fire protection, materials handling, hazardous materials, personal protective equipment, and general environmental controls. Hazardous waste site work requires employees to be trained prior to participation in site activities, medical monitoring, monitoring to protect employees from excessive exposure to hazardous substances, and decontamination of personnel and equipment.	Any cleanup work will require compliance with OSHA and WISHA.
Washington Industrial Safety and Health Act (RCW 49.17) Washington Industrial Safety and Health Regulations (WAC 296-62, WAC 296-155)	Adopts the OSHA standards that govern the conditions of employment in all work places. The regulations encourage efforts to reduce safety and health hazards in the work place and set standards for safe work practices for dangerous areas such as trenches, excavations, and hazardous waste sites.	Any cleanup work will require compliance with OSHA and WISHA.
Air Quality Controls		
Federal, State, and Local Air Quality Protection Programs State Implementation of Ambient Air Quality Standards NWAPA Ambient and Emission Standards Regional Standards for Fugitive Dust Emissions Toxic Air Pollutants	Regulations promulgated under the federal Clean Air Act (42 USC 7401) and the Washington State Clean Air Act (RCW 70.94) governs the release of airborne contaminants from point and non-point sources. Local air pollution control authorities such as the PSCAA have also set forth regulations for implementing these air quality requirements. These requirements may be applicable to the Site for the purposes of dust control should the selected remedial alternatives require excavation activities. Both PSCAA (under Regulation III) and WAC 173-460 establish ambient source impact levels for arsenic.	The selected alternative will require compliance with air quality regulations and BMPs for dust control.

Table 15.2
Potential Action-specific ARARs for the Lora Lake Parcel

Standard, Requirement, or Limitation	Description	Applicability
Miscellaneous		
Noise Control Act of 1974 (RCW 70.107, WAC 173-60)	Establishes maximum noise levels.	The selective alternative will need to comply with local and state noise pollution requirements. Construction and other activities will need to be limited to normal working hours.
National Electrical Code (NFPA 70) and the Seattle Electric Code Supplement for Class 1 Division 2 Environments.	Establishes restrictions and guidelines for temporary and/or permanent electrical installations.	Compliance will be required should the selected alternative require temporary electrical power.

Abbreviations:

ARAR	Applicable or Relevant Appropriate Requirement
BMP	Best management practice
CFR	Code of Federal Regulations
CWA	Clean Water Act
HAZWOPER	Health and Safety for Hazardous Waste Operations and Emergency Management
MTCA	Model Toxics Control Act
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NWAPA	Northwest Air Pollution Authority
OSHA	Occupational Safety and Health Act
PSCAA	Puget Sound Clean Air Authority
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
SEPA	State Environmental Policy Act
Site	Lora Lake Apartments Site
USC	United States Code
WAC	Washington Administrative Code
WDFW	Washington State Department of Fish and Wildlife
WISHA	Washington Industrial Safety and Health Act

Table 15.3
Potential Chemical-specific ARARs for the Lora Lake Parcel

Standard, Requirement, or Limitation	Description	Applicability
Sediment Requirements		
Sediment Management Standards (WAC 173-204)	Establishes standards for the quality of surface sediment in Washington State. These standards provide chemical concentration criteria, which identify surface sediment without adverse effects on biological resources and no significant health risk to humans, and biological criteria, which identifies surface sediment without adverse effects on biological resources.	Applicable.
Surface Water Requirements		
Model Toxics Control Act (WAC 173-340)	Establishes Washington State administrative processes and standards to identify, investigate, and clean up facilities where hazardous substances are located.	The Site is regulated under MTCA and must meet MTCA standards.
Water Quality Standards for Surface Waters of the State of Washington (WAC 173-201A)	The Surface Water Standards establish water quality standards for surface waters of the Washington State. Water quality standards require that toxic substances shall not be introduced beyond the mixing zone greater than levels that have the potential to adversely affect characteristic water users, cause acute or chronic toxicity to the most sensitive biota, or adversely affect public health.	Applicable in the evaluation of the leaching potential of Lora Lake and Miller Creek surface sediments.
Clean Water Act (33 USC 1251 et seq.)	Section 401 of the CWA requires the establishment of guidelines and standards to control the direct or indirect discharge of pollutants to the waters of the United States.	
National Toxics Rule (40 CFR 131.36 et seq., RCW 90.48; WAC 173-220)	This rule promulgates for 14 states (including Washington), the chemical-specific, numeric criteria for priority toxic pollutants necessary to bring all states into compliance with the requirements of Section 303(c)(2)(B) of the CWA.	
Soil Requirements		
Model Toxics Control Act (WAC 173-340)	Establishes Washington State administrative processes and standards to identify, investigate, and clean up facilities where hazardous substances are located.	The Site is regulated under MTCA and must meet MTCA standards.

Abbreviations:

AET	Apparent Effects Threshold	RI/FS	Remedial Investigation/Feasibility Study
ARAR	Applicable, Relevant, and Appropriate Requirement	Site	Lora Lake Apartments Site
CFR	Code of Federal Regulations	SMS	Sediment Management Standards
CWA	Clean Water Act	SQV	Sediment quality values
MTCA	Model Toxics Control Act	USC	United States Code
NTR	National Toxics Rule	WAC	Washington Administrative Code
RCW	Revised Code of Washington	WSDOE	Washington State Department of Ecology

Table 18.1
Preliminary Screening of Technologies for the Lora Lake Parcel

Remedial Technology	Applicable Media	COCs Addressed	General Technology Benefits	General Technology Constraints	Consideration of Site Physical Conditions and RAOs	Technology Retained for or Rejected from Further Evaluation
No Action	• Soil • Sediment	• Applicable to all site soil and sediment COCs that exceed cleanup levels.	• No cost to implement. • No long-term monitoring cost. • Does not cause substantial impacts to site operations.	• Does not reduce or remove chemical concentrations. • Does not protect human health and the environment. • Does not meet cleanup goals in a reasonable restoration time frame.	• Not impacted by physical conditions at the Site. • Does not contribute to achievement of RAOs. • Provides a reference for comparison of the benefits of other remedial technologies.	The No Action technology does not address any of the site COCs or achieve RAOs. **No Action is Rejected** from further evaluation for the following: o Remediation of soil o Remediation of sediment
Institutional Controls	• Soil • Sediment	• Applicable to all site soil and sediment COCs that exceed cleanup levels.	• Low cost to implement. • Protective of direct contact pathway through controls.	• Does not reduce or remove chemical concentrations. • Limits future site operations through restrictive covenants or administrative measures.	• Can be implemented in conjunction with site mitigation requirements and land use plans. • Not limited by site physical conditions. • Contributes to achievement of RAOs when used in combination with other technologies.	ICs are applicable to all COCs and all media, achieve RAOs when used in combination with other technologies, and can be implemented given site conditions. The technology of **Institutional Controls is Retained** for further evaluation for the following: o Remediation of soil o Remediation of sediment
Surface Soil Capping	• Soil	• Applicable to all site soil COCs that exceed cleanup levels.	• Contains contaminated soil below the ground surface and provides barrier from contact pathways.	• Chemicals remain in place and are not removed or destroyed. • Surface cap maintenance required in perpetuity.	• Can be implemented in conjunction with site mitigation requirements and land use plans. • Not limited by site physical conditions, but would require coordination with NRMP at the LL Parcel. • Contributes to achievement of RAOs when used in combination with other technologies.	Surface capping is applicable to all COCs in soil, achieves RAOs when used in combination with other technologies, and can be implemented given site conditions. **Surface Capping is Retained** for further evaluation for: o Remediation of soil
Solidification and Stabilization	• Soil	• Applicable to all site soil COCs that exceed cleanup levels.	• Technology reduces the mobility of soil contamination through physical or chemical immobilization. • Toxicity of individual COCs may be reduced through chemical reaction processes (stabilization only). • Controls contaminant migration and/or leaching to groundwater.	• Requires long-term groundwater compliance testing to ensure the immobilization of contaminants. • Feasibility of implementation decreases with depth below ground surface. • Chemicals remain in place and are immobilized, but not removed (solidification). • Technology does not have proven success at sites with similar conditions.	• May restrict future use of the LL Parcel as a wetland habitat mitigation area as solidification/stabilization of surface soils would limit vegetation growth. • Contributes to achievement of RAOs when used in combination with other technologies.	Due to limited applicability to soil COCs, feasibility concerns given the extent of contamination, unproven success at similar sites, and restrictions on future site uses, **Solidification and Stabilization is Rejected** from further evaluation for: o Remediation of soil

Table 18.1
Preliminary Screening of Technologies for the Lora Lake Parcel

Remedial Technology	Applicable Media	COCs Addressed	General Technology Benefits	General Technology Constraints	Consideration of Site Physical Conditions and RAOs	Technology Retained for or Rejected from Further Evaluation
In-situ Vitrification	• Soil	• Applicable to all site soil COCs that exceed cleanup levels.	• Completely immobilizes inorganic contaminants and destroys organic contaminants with high temperatures. • Effective to depths up to 20 feet. • Resulting glass/vitreous mass prevents contamination from leaching to groundwater.	• Requires heating the ground to very high temperatures at a high cost. • Resulting glass/vitreous mass would affect site groundwater flow. • Does not treat deep contamination. • Contaminants vaporized by the process would require capture and treatment. • Technology does not have proven success at sites with similar conditions.	• May restrict future use of the LL Parcel as a wetland habitat mitigation area because plant growth would be limited in remediated areas. • Contributes to achievement of RAOs when used in combination with other technologies.	Due to implementability concerns, because unproven use at sites with similar conditions, and restrictions on future site use, **In-situ Vitrification is Rejected** from further evaluation for the following: o Remediation of soil
Source Removal by Excavation and Landfill Disposal	• Soil	• Applicable to all site soil COCs that exceed cleanup levels.	• Results in immediate removal of chemicals from the Site, reducing contaminant mass in a short time frame. • Effectively removes all COCs in excavation area. • Does not require long-term monitoring and maintenance.	• Can be expensive to implement because of landfill disposal costs.	• Technology would not be inhibited by site operations or conditions. • May require removal/replacement of site infrastructure such as fencing and sidewalks. • Contributes to achievement of RAOs when used in combination with other technologies.	Source removal addresses all COCs, is implementable given site conditions, and achieves RAOs when combined with other remedial technologies; therefore, **Source Removal by Excavation is Retained** for further evaluation for the following: o Remediation of soil
Monitored Natural Recovery	• Sediment	• Applicable to all site sediment COCs that exceed cleanup levels.	• Low implementation cost. • Does not cause impacts to site operations.	• Long-term monitoring required. • Does not actively control chemical containment or attenuation. • Relies on natural sedimentation for dilution or containment of contaminants. • Technology does not have proven success at sites with similar conditions for recalcitrant COCs.	• Natural degradation processes do not occur for dioxin/furan contamination; therefore MNR would be reliant on sedimentation processes for effectiveness. • Does not prevent leaching from subsurface contaminated sediments. • Does not contribute to achievement of RAOs when used in combination with other remedial technologies.	MNR is limited by site conditions, and does not have proven success at sites with similar conditions, therefore, **Monitored Natural Recovery is Rejected** from further evaluation for the following: o Remediation of sediments
Enhanced Natural Recovery	• Sediment	• Applicable to all site sediment COCs that exceed cleanup levels.	• Low implementation cost. • Accelerates the rate of natural recovery of contaminants through placement of a thin sand layer on the existing sediment. • Mixing of the clean sand may reduce COC concentrations in the surface sediments.	• Long-term monitoring required. • COCs remain in place and are not removed or destroyed. • Technology does not have proven success at sites with similar conditions.	• Natural degradation processes do not occur for dioxin/furan contamination; therefore ENR would be reliant on limited material placement and sedimentation processes for effectiveness. • Does not prevent leaching from contaminated sediment into newly deposited sediments. • Does not contribute to achievement of RAOs when used in combination with other remedial technologies.	ENR is limited by site conditions and does not have proven success at sites with similar conditions, therefore, **Enhanced Natural Recovery is Rejected** from further evaluation for the following: o Remediation of sediments

Table 18.1
Preliminary Screening of Technologies for the Lora Lake Parcel

Remedial Technology	Applicable Media	COCs Addressed	General Technology Benefits	General Technology Constraints	Consideration of Site Physical Conditions and RAOs	Technology Retained for or Rejected from Further Evaluation
Sediment Capping	• Sediment	• Applicable to all site sediment COCs that exceed cleanup levels.	• Physically separates contaminants from the overlying water column. • Contains the sediment contamination but also allows for attenuation and diffusion of groundwater through the cap material. • Cap amendments (such as organo-clays or carbon) can increase chemical attenuation. • Thin lift cap placement strengthens the sediment surface and minimizes resuspension.	• Chemicals generally remain in place and are not removed or destroyed. • Cap maintenance may be required in perpetuity. • Caps are constructed in layers and typically some degree of mixing occurs with underlying sediments during cap placement.	• Applicable at the Site given physical conditions, but would likely require alternative material placement methods due to flocculent nature of lake sediments. Conventional clamshell bucket placement methods would not be suitable. Additionally, there is limited access to the lake for the use of a typical mechanical bucket placement methodology. • Resuspension and migration of contaminated sediments during cap placement is possible given the flocculent nature of sediment, and BMPs would be required. • Contributes to achievement of RAOs when used in combination with other technologies. • Thin-lift cap placement has been effective at other sediment sites with similar physical constraints. • Requires coordination with resource agencies regarding any potential mitigation requirements.	Sediment Capping achieves RAOs in combination with other technologies, is not limited by site conditions, and is applicable to all site COCs, therefore, the technology of **Sediment Capping is Retained** for further evaluation for the following: o Remediation of sediments

Table 18.1
Preliminary Screening of Technologies for the Lora Lake Parcel

Remedial Technology	Applicable Media	COCs Addressed	General Technology Benefits	General Technology Constraints	Consideration of Site Physical Conditions and RAOs	Technology Retained for or Rejected from Further Evaluation
Open Water Filling to Rehabilitate the Wetland	• Sediment	• Applicable to all site sediment COCs that exceed cleanup levels.	• Physically separates contaminants from the new fill surface. • Isolates the sediment contamination beneath several feet of fill material. • Allows for groundwater flow through the fill material.	• Chemicals generally remain in place and are not removed or destroyed. • The fill has to be engineered to account for groundwater and stormwater flow.	• Is applicable at the Site given physical conditions, but would likely require an alternative material and placement method for some thickness of initial sand placement due to flocculent nature of Lora Lake sediments. • Resuspension and migration of contaminated sediments during placement of the initial sand layers is possible given the flocculent nature of sediment. • BMPs would be required to prevent turbid water from discharging to Miller Creek. • Contributes to achievement of RAOs. • Rehabilitates the existing open water aquatic habitat to the hydrogeomorphic conditions that existed prior to historical peat mining. • Requires coordination with resource agencies regarding any potential mitigation requirements.	Open Water Filling to Rehabilitate the Wetland is applicable given the site conditions, is an acceptable habitat change according to the resource agencies, and addresses all site COCs, therefore, **Open Water Filling to Rehabilitate the Wetland is Retained** for further evaluation for the following: o Remediation of sediments
Dredging and Landfill Disposal	• Sediment	• Applicable to all site sediment COCs that exceed cleanup levels.	• Permanent removal of contaminated material. • Does not typically require long-term monitoring and maintenance.	• Dredging of soft sediments causes redeposition and redistribution of contaminated sediments. • May require combination with capping technologies when dredging alone does not achieve site cleanup requirements due to dredging residuals. • Can leave residual contamination in the subsurface. • Short-term increase in turbidity that could affect downstream habitat. • Dredged materials must be contained, dewatered and disposed of off-site. Handling requires significant property acreage including likely construction of containment area for dewatering of hydraulic dredge spoils.	• Resuspension and migration of contaminated sediments during dredging is possible given flocculent nature of sediment and BMPs would be required. • Dredging would likely be conducted hydraulically. A large volume of dredge material would require dewatering and treatment, if necessary, prior to disposal. Would require large area for material handling that causes significant temporary habitat impacts. • Requires truck transport through urban areas to dispose of contaminated sediment. • Contributes to achievement of RAOs when used in combination with other technologies. • Requires coordination with resource agencies regarding any potential mitigation requirements.	Dredging achieves RAOs in combination with other technologies, is applicable given site conditions if properly managed, and addresses all site COCs, therefore, **Dredging and Landfill Disposal is Retained** for further evaluation for the following: o Remediation of sediments

Table 18.1
Preliminary Screening of Technologies for the Lora Lake Parcel

Remedial Technology	Applicable Media	COCs Addressed	General Technology Benefits	General Technology Constraints	Consideration of Site Physical Conditions and RAOs	Technology Retained for or Rejected from Further Evaluation
Engineering Controls	• Sediment	• Applicable to all site sediment COCs that exceed cleanup levels.	• Requires little to no in-water work to block pathways and eliminate exposure through pathway control. • Does not cause substantial impacts to site operations.	• Technology does not remove contamination and site COCs would remain in place. • Would likely require long-term monitoring and/or maintenance. • The technology does not control the potential for sediment movement from Lora Lake to Miller Creek.	• Surface water exchange is currently not limited to the outfall between the lake and creek, and reconstruction of berms would be required. • Long-term O&M would be required to maintain the functionality of engineered controls. • Construction within the wetland mitigation area would require permit and approval coordination with stakeholders. • Contributes to achievement of RAOs when used in combination with other technologies; however, risk of sediment migration downstream is not completely eliminated and potential risk remains.	Engineering Controls, in combination with other technologies, address site contamination, and achieve RAOs. Engineering Controls are not limited by site conditions, therefore, the technology of **Engineering Controls is Retained** for further evaluation for the following: o Remediation of sediments

Abbreviations

BMP Best management practice
COC Contaminant of concern
cPAH Carcinogenic polycyclic aromatic hydrocarbon
DMCA Dredged Material Containment Area
ENR Enhanced natural recovery
IC Institutional Control
LL Lora Lake
MNA Monitored natural attenuation
MNR Monitored natural recovery
NRMP Natural Resource Management Plan
O&M Operations and maintenance
PCP Pentachlorophenol
PRB Permeable reactive barrier
RAO Remedial Action Objective
Site Lora Lake Apartments Site
TPH Total petroleum hydrocarbons

Table 18.2
Remedial Alternative Components by Lora Lake Parcel Cleanup Area

	LL Parcel Shallow Soil Cleanup Area	LL Parcel Sediment Cleanup Area
Alternative 1:	Institutional Controls	Engineering Controls (control sediment movement and fish passage to Miller Creek)
Alternative 2:	Soil Capping[1] (with excavation of 1,900 CY for cap placement)	Sediment Capping[1,2]
Alternative 3:	Excavation (to 5.2 pg/g dioxins/furans TEQ, 2,300 CY soil)	Open Water Lake Filling to Rehabilitate the Wetland[3]
Alternative 4:	Excavation (to 5.2 pg/g dioxins/furans TEQ, 2,300 CY soil)	Dredging (approximately 29,000 CY dredge slurry)

Notes:

1 All capping alternatives include institutional controls for long-term cap maintenance.
2 The sediment cap would be placed in thin lifts to approximately 2 feet thick and would be finalized during design.
3 Lake filling would fill the open water footprint of the lake to the existing ground surface to rehabilitate the lake to its natural wetland condition prior to historical peat mining.

Abbreviations:

CY Cubic yards
LL Lora Lake
TEQ Toxicity Equivalent

Table 19.1
Lora Lake Parcel Alternatives Evaluation[1]

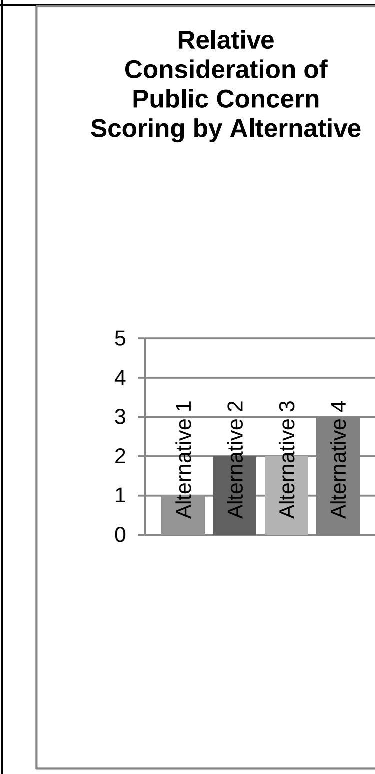
Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Relative Alternative Scoring
Alternative Description	Alternative 1 consists of applying engineering controls at the LL Parcel Sediment Cleanup Area to manage exposure routes by controlling sediment movement and fish passage from Lora Lake to Miller Creek. Institutional Controls (ICs) would be implemented to manage risks at the LL Parcel Shallow Soil Cleanup Area.	Alternative 2 consists of capping the LL Parcel Shallow Soil Cleanup Area and the LL Parcel Sediment Cleanup Area, which addresses exposure routes through pathway control.	Alternative 3 consists of excavation and off-site disposal of soil from the LL Parcel Shallow Soil Cleanup Area to the dioxins/furans TEQ cleanup level of 5.2 pg/g. Alternative 3 also consists of isolating dioxins/furans, arsenic, and lead sediment contamination in the LL Parcel Sediment Cleanup Area through open water filling of Lora Lake to rehabilitate the wetland.	Alternative 4 consists of excavation and off-site disposal of soil from the LL Parcel Shallow Soil Cleanup Area to the dioxins/furans TEQ cleanup level of 5.2 pg/g. Alternative 4 also includes dredging of the LL Parcel Sediment Cleanup Area to remove all current bottom sediments with dioxins/furans, arsenic, and lead contamination and sediment capping to address dredge residuals.	
Consideration of Public Concerns • Whether the community has concerns • Degree to which the alternative addresses those concerns	Public comments received on the Draft RI/FS did not result in a modification to the proposed Alternative 1. Public commenters expressed a preference for removal of contaminated sediments.	Public comments received on the Draft RI/FS did not result in a modification to the proposed Alternative 2. Public commenters expressed a preference for removal of contaminated sediments.	Public comments received on the Draft RI/FS did not result in a modification to the proposed Alternative 3. Public commenters expressed a preference for removal of contaminated sediments.	Public comments received on the Draft RI/FS did not result in a modification to the proposed Alternative 4. Public commenters expressed a preference for removal of contaminated sediments.	

Table 19.1
Lora Lake Parcel Alternatives Evaluation[1]

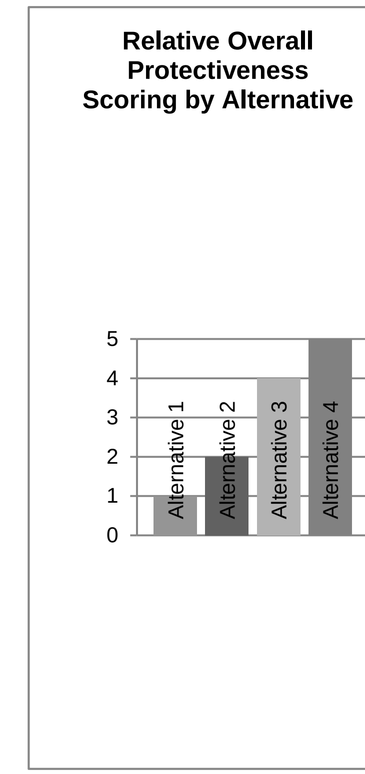
Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Relative Alternative Scoring
Overall Protectiveness • Degree to which existing risks are reduced • Time required to reduce risks and attain cleanup standards • On-site and off-site risks resulting from alternative imple-mentation • Improvement in overall environ-mental quality	• Risks would be reduced through control of the exposure pathway with ICs at the LL Parcel Shallow Soil Cleanup Area. The ICs and runway protection zone restrictions limit most of the LL Parcel Cleanup Areas to Port workers. • Human health risks from downstream fish consumption are reduced due to restriction of fish passage. • ICs would be required in perpetuity to maintain risk reduction. Engineering controls would also have to be maintained in perpetuity. • No on-site or off-site risks result from implementation of this alternative; however, protection of the general public from direct contact between Des Moines Memorial Drive and the site security fence relies on ICs that would likely include signage. No physical barrier would exist. • There is a low improvement in overall environmental quality resulting from implementation of this alternative through ICs and engineering controls. This alternative would not improve the water quality (temperature and dissolved oxygen) of the water leaving Lora Lake and entering Miller Creek without additional mitigation measures.	• Risks would be reduced through contaminant soil and sediment capping, which provides a reduction of risk through pathway control. Excavation of contaminated soil to support capping would also provide a reduction in risk. • There is an immediate reduction of risk through pathway control; however, con-tamination would remain on-site at concentrations greater than cleanup levels, requiring cap maintenance and ICs in perpetuity. • No on-site or off-site risks result from implementation of this alternative. In addition, existing risks are reduced through capping of areas currently located outside of the site security fencing along Des Moines Memorial Drive, where public access is allowed. • This alternative provides a moderate degree of improvement in overall environmental quality for the Site through control of direct contact pathways with capping of the site COC contaminant mass in soil and sediment. This alternative would not improve the water quality (temperature and dissolved oxygen) of the water leaving Lora Lake and entering Miller Creek without additional mitigation measures.	• Risks would be reduced through contaminant mass removal and filling of Lora Lake to rehabilitate the wetland. 2,300 CY of dioxin/furan contaminated soil would be removed from the LL Parcel Shallow Soil Cleanup Area to a TEQ concentration of 5.2 pg/g, providing a high reduction of risk. Filling of Lora Lake to rehabilitate the wetland would also provide a high reduction of risk through pathway control. • There is an immediate reduction of risk through source removal and pathway control. Contamination would remain on-site at concentrations greater than cleanup levels deep beneath the lake fill material, but the depth of the fill that would be placed in the lake is significantly thicker than what was determined as a necessary cap thickness. • No on-site or off-site risks result from implementation of this alternative. In addition, existing risks are reduced through source removal of areas currently located outside of the site security fencing, where public access is allowed. • This alternative provides a high degree of improvement in overall environmental quality for the Site through the removal of dioxin/furan contaminant mass in soil to a TEQ concentration of 5.2 pg/g and the control of direct contact pathways through lake filling to rehabilitate the wetland. The open water filling of Lora Lake to rehabilitate the wetland provides a high degree of improvement in overall environmental quality by replacing a source of warm water/low dissolved oxygen inputs to Miller Creek with a more complex vegetated wetland system.	• This alternative provides a high degree of reduction of risk through the removal of all accessible contaminant mass in soil and sediment on the LL Parcel. 2,300 CY of dioxin/furan contaminated soil and 14,000 CY of contaminated sediment would be removed from the Site for off-site disposal. Following dredging, low levels of dioxins/furans present in underlying native soil could still pose a risk to human health through fish consumption. Additionally, dredging residuals may be present following dredging. For these reasons, dredging would need to be supplemented with a sediment cap. • The time required to reduce risk and achieve cleanup levels is short (within 2 years) and includes the period of remedy implementation. All actions included in this alternative could likely occur over one construction season. • There are no on-site or off-site risks resulting from implementation of this alternative. In addition, existing risks are reduced through source removal of areas currently located outside of the site security fencing, where public access is allowed. • This alternative provides a high degree of improvement in overall environmental quality for the LL Parcel through the removal of all (accessible) contaminant mass in soil and sediments. This alternative would not improve the water quality (temperature and dissolved oxygen) of the water leaving Lora Lake and entering Miller Creek without additional mitigation measures.	

Table 19.1
Lora Lake Parcel Alternatives Evaluation[1]

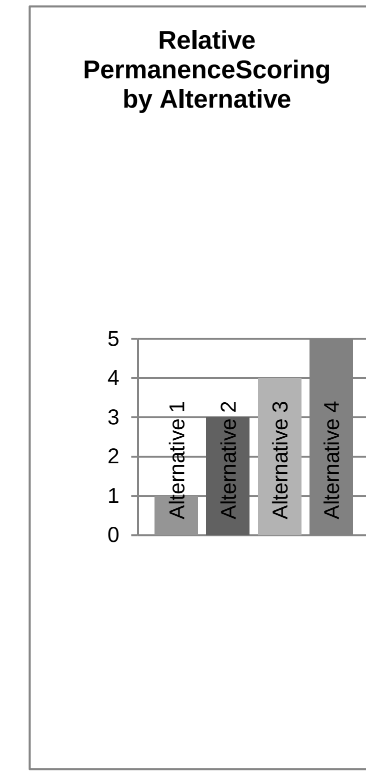
Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Relative Alternative Scoring
Permanence • Degree of reduction of contaminant toxicity, mobility, and volume • Adequacy of destruction of hazardous substances • Reduction or elimination of substance release, and source of release • Degree of irreversibility of waste treatment processes • Volume and characteristics of generated treatment residuals	• This alternative provides no reduction of contaminant toxicity or volume. It provides some reduction of mobility through the engineering controls in Lora Lake. It provides less reduction of contaminant toxicity, mobility, and volume than Alternatives 2 through 4. • With this alternative, all contaminants in soil and sediments remain in place; and little to no destruction of hazardous substances occurs. • Primary release mechanisms of contamination have been removed, since historical operations are responsible for contaminant release and are no longer active at the Site. The secondary source of potential sediment leaching to surface water pathway is not controlled. • Waste treatment processes include low level natural degradation processes. Degradation is irreversible. • There are no treatment residuals associated with implementation of this technology.	• This alternative provides a low reduction of contaminant toxicity and volume compared to the other alternatives through limited excavation of soil to support capping. It provides some reduction of mobility through soil and sediment capping. • With this alternative, some contamination in soil remains in place and little to no destruction of hazardous substances occurs. • All primary release mechanisms of contamination have been removed, as historical operations are responsible for contaminant release, and are no longer active at the Site. This alternative eliminates the secondary source of sediment leaching to surface water through sediment capping. • The waste treatment processes associated with this alternative include capping. Capping is a reversible technology, unless maintained. • There are no treatment residuals associated with implementation of this technology.	• This alternative provides a high degree of reduction in contaminant toxicity, mobility, and volume compared to the other alternatives because the LL Parcel Shallow Soil dioxin/furan contaminant mass would be removed via excavation and the sediment contaminant mass would be isolated by filling of the lake to rehabilitate the wetland. The degree in reduction of contaminant toxicity, mobility, and volume is higher with this alternative than Alternatives 1 and 2. • The destruction of hazardous substances in soil associated with this alternative is accomplished through removal, which is both adequate and irreversible. The sediment contamination would remain isolated in place and little to no destruction of hazardous substances in sediment would occur. • All primary release mechanisms of contamination have been removed, since historical operations are responsible for contaminant release and are no longer active at the Site. This alternative eliminates the secondary source of sediment leaching to surface water by isolating dioxin/furan sediment contamination through open water filling of the lake to rehabilitate the wetland. • The waste treatment processes associated with this alternative include soil excavation, which is irreversible. Due to the depth of the fill, lake filling to rehabilitate the wetland is an irreversible technology. • There are no treatment residuals associated with implementation of this technology.	• This alternative provides a medium to high degree of reduction in contaminant toxicity, mobility, and volume compared to the other alternatives. With this alternative, all of the accessible site contaminant mass would be removed via excavation and dredging; however, contamination is expected to be resuspended and would require the placement of a sediment cap. • The destruction of hazardous substances associated with this alternative is accomplished through removal, which is both adequate and irreversible. With dredging, resuspension and recontamination of the dredge surface is expected because of the flocculent nature of the sediments; thus, capping of the hazardous substances that would remain in place would be required. • All primary release mechanisms of contamination have been removed, since historical operations are responsible for contaminant release and are no longer active at the Site. This alternative eliminates the secondary source of sediment leaching to surface water through dredging. Resuspension of contaminated sediments and recontamination of the dredge surface would require placement of a sand cap to address the sediment to surface water pathway. • The waste treatment processes that would be used for the full removal alternative are permanent and irreversible. • Treatment residuals generated during implementation include geobags filled with contaminated sediment.	

Table 19.1
Lora Lake Parcel Alternatives Evaluation[1]

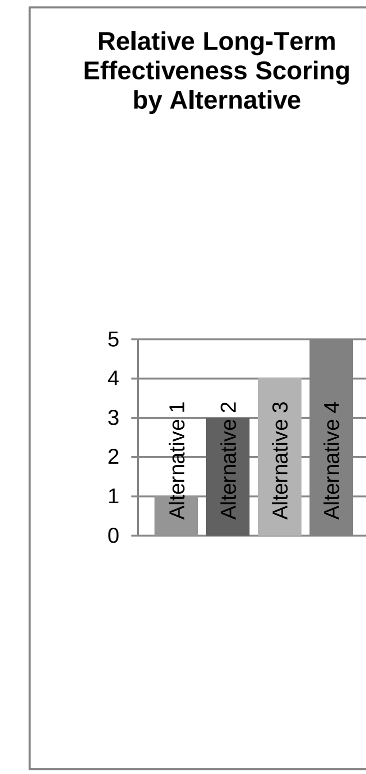
Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Relative Alternative Scoring
Effectiveness over the Long-term • Degree of certainty of alternative success • Reliability while contaminants remain on-site at concentrations greater than cleanup levels • Magnitude of residual risk • Effectiveness of controls implemented to manage residual risk	• This alternative provides a low degree of certainty of success over the long-term compared to the other alternatives. Engineering controls and ICs are common technologies that would control exposure pathways, but are required in perpetuity. Fish exclusion controls would also be required to be controlled in perpetuity in the lake. • This alternative is reliable as long as the ICs are followed. The reliability of the alternative is low for the soil located between Des Moines Memorial Drive and the security fence because the ICs would not effectively control exposure to soil by the general public. • Residual risk is high because all contamination remains on-site. • Risks are controlled through the enforcement of ICs, which are considered to be effective at managing risk.	• This alternative provides a moderate degree of certainty of success compared to the other alternatives. Capping is a common technology that would manage pathways; however, soil and sediment caps require maintenance and ICs in perpetuity. • Capping is a reliable technology as long as the cap is properly maintained. • The magnitude of residual risk associated with this alternative is low, but some residual risk remains because contamination would remain on the Site in perpetuity. • Residual risks are controlled through the enforcement of ICs, which are considered to be effective at managing risk.	• This alternative provides a high degree of certainty of success compared to the other alternatives. Excavation is a common technology that would remove contaminants. Lake filling to rehabilitate the wetland would isolate contaminants below several feet of clean fill, controlling exposure pathways. The depth of the fill that would be placed in the lake is significantly thicker than what was determined as a necessary cap thickness with the numerical cap modeling. • Excavation is a reliable technology with measurable success for similar excavation and disposal projects. Open water filing of Lora Lake to rehabilitate the wetland is a reliable technology as long as the first layers of the fill are placed to minimize resuspension and the fill design has minimal adverse impacts to local hydrology. Additionally, soil and vegetation placed on top of the fill provide further stabilization of the remedy. • The magnitude of residual risk associated with this alternative is low, because all site contamination would be removed or isolated by the thick fill. Very little residual risk would remain on-site from the contaminants isolated by the lake fill. • Residual risks are controlled through the enforcement of ICs, which are considered to be effective at managing risk.	• This alternative provides a moderate degree of certainty of success compared to the other alternatives. The dredge technology is not likely to adequately remove all contaminated sediments without a negative short-term environmental impact and resuspension and recontamination of the dredge surface. Excavation of soil provides a high certainty of success. • Alternative 5 is reliable with measurable success for similar excavation/dredging and disposal projects. Hydraulic dredging is not designed for slopes, which may limit the success of the alternative. • The magnitude of residual risk associated with this alternative is moderate because the contaminant mass would be removed from the Site, but dredge residuals are likely and a cap would be required. • No controls would be required to manage residual risk from excavation and dredging because a cap would be installed to address any dredge residuals. If contamination remains on-site (such as beneath a sediment cap) ICs may be implemented, and are considered effective at managing risk.	

Table 19.1
Lora Lake Parcel Alternatives Evaluation[1]

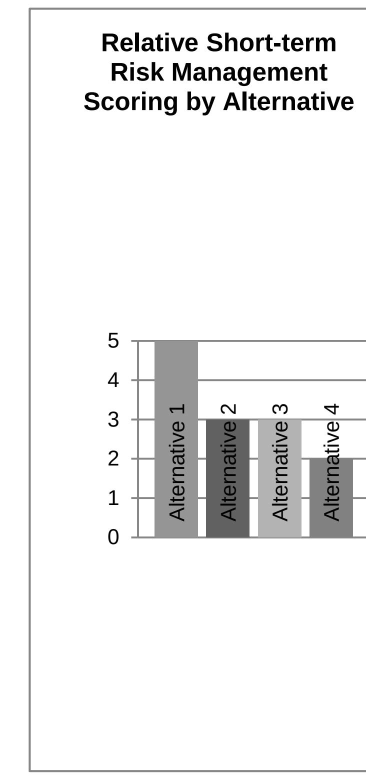
Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Relative Alternative Scoring
Short-term Risk Management • Risk to human health and the environment associated with alternative construction • The effectiveness of controls in place to manage short-term risks	With Alternative 1, no contaminated soil or sediment are removed from the LL Parcel. • There is low short-term risk to human health and the environment during implementation of Alternative 1. Installation of the engineering controls in Lora Lake and implementation of ICs involve very little disturbance of contamination. Common BMPs would be implemented to control sediment migration caused during installation of engineering controls. There is no short-term risk associated with the implementation of ICs. Implementation of this alternative would not negatively impact the habitat functions of the LL Parcel Shallow Soil Cleanup Area. • Installation of engineering controls would require appropriate PPE, BMPs, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk.	With Alternative 2, approximately 1,900 CY of soil would be excavated for placement of the cap. No contaminated sediments are removed from the Site. • This alternative has a moderate short-term risk associated with worker direct contact during excavation and capping activities. There is a slightly greater risk for public exposure with this alternative compared to Alternative 1 because contaminated soil would be removed and transported from the LL Parcel over public roadways for off-site disposal; however, the excavated soil would be managed by licensed professionals. Approximately 100 truck trips would be required to dispose of the soil off-site. There is risk of sediment resuspension and transport downstream during sediment cap placement. Common BMPs would be implemented to minimize turbidity and control sediment migration. The sediment cap would be placed in thin lifts with appropriate construction equipment to minimize resuspension of contamination. A temporary construction access and equipment staging road would be constructed to allow for truck and equipment access to the lake. The road would be removed following alternative construction and is not anticipated to cause risks to human health or the environment. Construction of the road would result in a temporal loss of wetland and buffer functions and would require mitigation. Implementation of this alternative would negatively impact the habitat functions of the LL Parcel Shallow Soil Cleanup Area during cap placement. • Site construction activities would require appropriate PPE, BMPs, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk.	With Alternative 3, approximately 2,300 CY of contaminated soil would be removed from the LL Parcel, while no contaminated sediments are removed from the Site. • This alternative has a moderate short-term risk associated with worker direct contact during excavation and lake-filling activities. There is a slightly greater risk for public exposure with this alternative compared to Alternatives 1 and 2 because contaminated soil would be removed and transported from the LL Parcel over public roadways for off-site disposal; however, the excavated soil would be managed by licensed professionals. Approximately 125 truck trips would be required to dispose of the soil off-site. There is risk of sediment resuspension and transport downstream during placement of the initial fill layers. Common BMPs would be implemented to minimize turbidity and control sediment migration. The initial fill layers would be placed in thin lifts with appropriate construction equipment to minimize resuspension of contamination. A temporary construction access and equipment staging road would be constructed to allow for truck and equipment access to the lake. The road would be removed following alternative construction and is not anticipated to cause risks to human health or the environment. Construction of the road would result in a temporal loss of wetland and buffer functions but would not require mitigation because Alternative 3 is considered self-mitigating by the resource agencies. Implementation of this alternative would have a temporary negative impact on the habitat functions of the LL Parcel Shallow Soil Cleanup Area during excavation. • Site construction activities would require appropriate PPE, BMPs, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk.	With Alternative 4, approximately 2,300 CY of contaminated soil and 14,000 CY of contaminated sediments are removed from the LL Parcel. • This alternative has a moderate to high degree of short-term risk associated with increased volume of handling, management and disposal of contaminated materials. It would generate a potential direct-contact risk to workers during excavation, dredging, handling, and disposal of contaminated soil and sediments. There is a greater risk for public exposure with this alternative than with Alternatives 1, 2, and 3, because material is being removed from the Site for disposal; however, the removed materials would be managed by licensed professionals. Approximately 900 truck trips would be required through urban areas to dispose of the soil and sediment off-site. There is a greater risk for sediment resuspension and transport compared to the other alternatives, including downstream migration during dredging. Common BMPs would be implemented to control sediment migration, but typical BMPs (i.e., silt curtains) may not be effective due to the size of the lake. Substantial land area is necessary for dewatering and re-handling of the dredged material prior to transport. This requires temporary impacts to habitat and risk of release. A temporary construction access and equipment staging road would be constructed to allow for truck and equipment access to the lake. The road would be removed following alternative construction and is not anticipated to cause risks to human health or the environment. Construction of the road would result in a temporal loss of wetland and buffer functions and would require mitigation. Implementation of this alternative would negatively impact the habitat functions of the LL Parcel Shallow Soil Cleanup Area during excavation. • Site construction activities would require appropriate PPE, BMPs, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk.	

Table 19.1
Lora Lake Parcel Alternatives Evaluation[1]

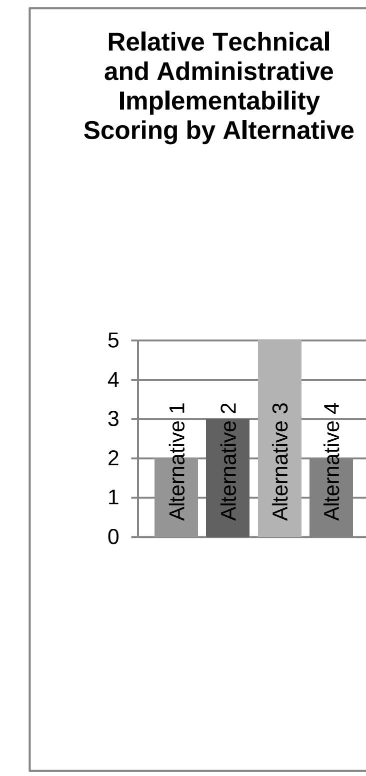
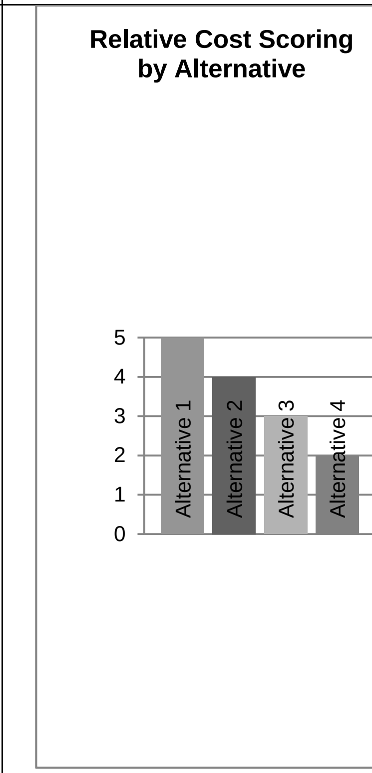
Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Relative Alternative Scoring
Technical and Administrative Implementability Ability of alternative to be implemented considering: • Technical possibility • Availability of off-site facilities, services, and materials • Administrative and regulatory requirements • Schedule, size, and complexity of construction • Monitoring requirements • Site access for construction, operations, and monitoring • Integration with existing site operations or other current and potential future remedial action	• This alternative is technically possible to implement and involves common technologies. • All necessary off-site facilities, materials, and services are available within the region. • This alternative would not comply with all administrative and regulatory requirements, because, for example, blocking fish passage to Lora Lake with engineering controls violates requirements of the NRMP. This alternative does not adequately reduce risk to human health and the environment, or fully meet site RAOs. • This alternative is low in scale. The engineering controls with this alternative would be managed and constructed by specialty professionals familiar with the type of work, and this alternative can easily be implemented in a single construction season. Implementation of ICs does not require construction. • Monitoring requirements include maintenance of the engineering controls and ICs in perpetuity. • Permitted site access would not be impeded by implementation of this alternative. This alternative also includes substantial O&M associated with maintenance of the lake engineering controls; however, site access is not expected to be impeded. • This alternative is not consistent with current and future land uses because the engineering controls would not comply with the NRMP.	• This alternative is technically possible to implement and involves common technologies. • All necessary off-site facilities, materials, and services are available within the region. • This alternative complies with all applicable administrative and regulatory requirements, but based on input from resource agencies it is anticipated that this alternative would require mitigation of approximately 8,000 square feet at an off-site Port mitigation area due to the construction of the construction access road and equipment staging area. The implementation of this alternative would not improve the surface water temperature or dissolved oxygen levels of the water leaving Lora Lake and entering Miller Creek. Therefore, based on input from resource agencies, it is anticipated that temperature mitigation measures may be required following remediation. • This alternative is anticipated to achieve compliance with regulatory requirements in a short timeframe. This alternative is moderate in scale. This alternative would be managed and constructed by specialty professionals familiar with the type of work, and this alternative can easily be implemented in a single construction season. • Cap monitoring would be required following implementation in perpetuity. • Permitted site access would not be impeded by implementation of this alternative. This alternative would require future site access for soil and sediment cap maintenance that can easily be coordinated with existing and planned future site uses because the property is owned by the Port. • This alternative can be integrated with both existing and proposed future site uses. • This alternative complies with MTCA, but it is not preferred by resource agencies because it requires off-site mitigation and doesn't improve the water quality of Miller Creek.	• This alternative is technically possible to implement and involves common technologies. • All necessary off-site facilities, materials, and services are available within the region. • This alternative complies with all applicable administrative and regulatory requirements. Based on input from resource agencies, this alternative is considered self-mitigating, meaning the benefits of rehabilitating the wetland offset the short-term construction impacts and thus, no additional mitigation is anticipated. • This alternative is anticipated to achieve compliance with regulatory requirements in a short time frame. This alternative is large in scale, would be managed and constructed by specialty professionals familiar with the type of work, and can likely be implemented in a single construction season. • Permitted site access would not be impeded by implementation of this alternative. • This alternative can be integrated with both existing and proposed future site uses. • This alternative is preferred by the resource agencies because it rehabilitates the wetland and restores its historical form. It is also viewed as having an ecological benefit on the Miller Creek Relocation Reach by lowering stream temperatures and increasing dissolved oxygen.	• This alternative is technically possible to implement and involves common technologies. • All necessary off-site facilities, materials, and services are available within the region. • This alternative complies with all applicable administrative and regulatory requirements, but based on input from resource agencies it is anticipated that this alternative would require mitigation of approximately 16,500 square feet at an off-site Port mitigation area due to the construction of the construction access road and equipment staging area. The implementation of this alternative would not improve the surface water temperature and dissolved oxygen level issues of the water leaving Lora Lake and entering Miller Creek. Therefore, based on input from resource agencies, it is anticipated that temperature mitigation measures may be required following remediation • This alternative is anticipated to achieve compliance with cleanup levels within a short time frame. The alternative is large in scale and would be managed and constructed by specialty professionals familiar with the type of work. Full removal of accumulated sediments through dredging has technical implementability concerns, and would include disruption of substantial adjacent acreage within the habitat mitigation area. The lake would be hydraulically dredged, requiring an area for containment and dewatering of dredge spoils prior to disposal. Dredging can likely be implemented in a single construction season, although because a sediment cap will be needed due to recontamination of the dredge surface from dredge residuals, an additional construction season may be required. Excavation of contaminated soils can easily be completed in a single construction season. • Because of the risk for dredge residuals, a cap would be required for a clean sediment surface. • Permitted site access would not be impeded by implementation of this alternative. Future site access for monitoring or additional remedial actions will not be required. • This alternative can be integrated with both existing and proposed future site uses. • This alternative complies with MTCA, but it is not preferred by resource agencies because it requires off-site mitigation and doesn't improve the water quality of Miller Creek.	

Table 19.1
Lora Lake Parcel Alternatives Evaluation[1]

Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Relative Alternative Scoring
Cost • Cost of construction • Long-term monitoring, operations, and maintenance costs • Agency oversight costs	• Construction Cost = $0.001 M • Long-term Monitoring, Operations, and Maintenance Cost = $0.05 M • Agency Oversight Cost = $0.11 M • Wetland Mitigation Cost = $0 M • Total Alternative Cost[2] = $0.4 M	• Construction Cost = $1.4 M • Long-term Monitoring, Operations, and Maintenance Cost = $0.8 M • Agency Oversight Cost = $0.02 M • Wetland Mitigation Cost = $0.6 M • Total Alternative Cost[2] = $3.2 M	• Construction Cost = $2.4 M • Long-term Monitoring, Operations, and Maintenance Cost = $0 M • Agency Oversight Cost = $0.008 M • Wetland Mitigation Cost = $0.12 M • Total Alternative Cost[2] = $4.2 M	• Construction Cost = $4.5 M • Long-term Monitoring, Operations, and Maintenance Cost = $0.6 M • Agency Oversight Cost = $0.004 M • Off-site Mitigation Cost = $0.7 M • Total Alternative Cost[2] = $7.3 M	

Notes:

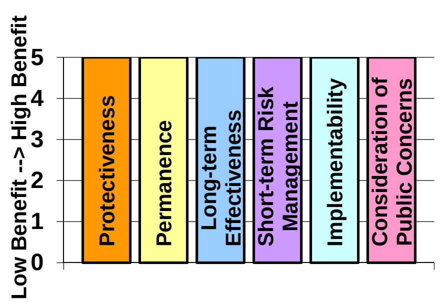
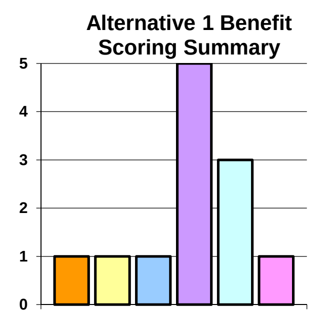
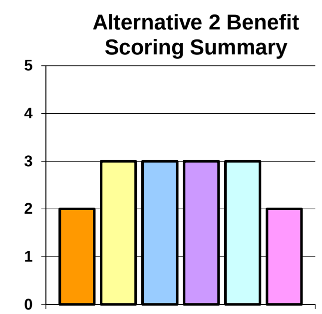
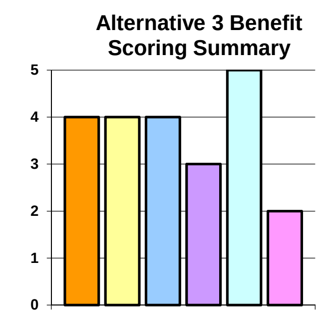
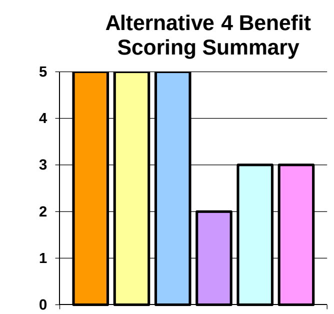
1 This alternatives evaluation table compares each of the alternatives to the MTCA criteria in 173-340-360(3). Because the alternatives are similar to each other, the alternative evaluation descriptions are often the identical or similar.

2 Total Alternative Cost includes contingencies, permitting, and oversight costs not listed in this table. Refer to Appendix Q for cost detail.

Abbreviations:

BMP Best management practice
IC Institutional control
LL Lora Lake
M Million
MTCA Model Toxics Control Act
NRMP Natural Resources Management Plan
O&M Operations and Maintenance
Port Port of Seattle
PPE Personal protective equipment
pptr Parts per trillion
RAO Remedial Action Objective
Site Lora Lake Apartments Site

Table 19.2
Lora Lake Parcel Disproportionate Cost Analysis Summary

Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Alternative Description	Alternative 1 consists of applying engineering controls at the LL Parcel Sediment Cleanup Area to manage exposure routes by controlling sediment movement and fish passage from Lora Lake to Miller Creek. Institutional controls would be implemented to manage risk at the LL Parcel Shallow Source Cleanup Area.	Alternative 2 consists of capping the LL Parcel Shallow Soil Cleanup Area and the LL Parcel Sediment Cleanup Area, which addresses exposure routes through pathway control.	Alternative 3 consists of excavation and off-site disposal of soil from the LL Parcel Shallow Soil Cleanup Area to the dioxins/furans TEQ cleanup level of 5.2 pg/g. Alternative 3 also consists of isolating dioxins/furans, arsenic, and lead sediment contamination in the LL Parcel Sediment Cleanup Area through open water filling of Lora Lake to rehabilitate the wetland.	Alternative 4 consists of excavation and off-site disposal of soil from the LL Parcel Shallow Soil Cleanup Area to the dioxins/furans TEQ cleanup level of 5.2 pg/g. Alternative 4 also includes dredging of the LL Parcel Sediment Cleanup Area to remove all current bottom sediments with dioxins/furans, arsenic, and lead contamination.
Cost per Unit Benefit Ratio[1]	**0.04**	**0.21**	**0.20 [2]**	**0.33**
KEY 				
Compliance with MTCA Threshold Requirements	No[5]	Yes	Yes	Yes
Estimated Alternative Cost[3]	$0.4 M	$3.3 M	$4.3 M	$7.3 M
Restoration Time Frame (to achieve remediation goals)	Following Construction	Following Construction	Following Construction	Following Construction
Benefit Scoring				
Overall Protectiveness	1	2	4	5
Permanence	1	3	4	5
Long-term Effectiveness	1	3	4	5
Short-term Risk Management[4]	5	3	3	2
Implementability	2	3	5	2
Consideration of Public Concerns	1	2	2	3
Total Benefit Score	**11**	**16**	**22**	**22**

Notes:

1 Cost per Unit Benefit Ratio calculated by dividing the total alternative cost (in millions) by the alternative Total Benefit Score. Lower value indicates the most benefit for the associated cost.
2 With the lowest Cost per Unit Benefit Ratio score, Alternative 3 provides the greatest degree of benefit for the associated cost of all the alternatives, making it the preferred remedial alternative.
3 Specific cost estimate information is provided in Appendix Q.
4 Higher scores equate to a higher level of relative benefit. Fewer short-term risks result in a higher score.
5 Alternative 1 cannot be selected as the Preferred Remedy even though it has the lowest cost per unit benefit ratio, because it does not comply with the MTCA Threshold Requirements.

Abbreviations:
LL Lora Lake
M Million
MTCA Model Toxics Control Act
TEQ Toxic equivalency quotient