ARKEMA UPLAND LEVEL II SCREENING

Ecological Risk Assessment

Prepared for

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Exton, PA 19341-2528

Prepared by
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January 16, 2009

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ACRONYMS AND ABBREVIATIONS

Arkema	Arkema, Inc.
ATOFINA	ATOFINA Chemicals, Inc.
bgs	below ground surface
COI	contaminant of interest
CPEC	contaminant of potential ecological concern
CRD	Columbia River Datum
CSM	conceptual site model
DBP	4,4′-dichlorobenzophenone
DDD	dichloro-diphenyl-dichloroethane
DDE	dichloro-diphenyl-dichloroethene
DDMU	1-chloro-2,2-bis(*p*-chlorophenyl)ethylene
DDT	dichloro-diphenyl-trichloroethane
DDx	Sum of 2,4′- and 4,4′-DDT, DDD, and DDE
DEQ	Oregon Department of Environmental Quality
½ DL	half of the detection limit
DMHSE	Dutch Ministry of Housing, Spatial Planning, and Environment
EBV	ecological benchmark value
ECSI	Environmental Cleanup Site Information
EE/CA	engineering evaluation/cost analysis
ELF	Societé Nationale Elf Aquitaine
GLISP	Guild's Lake Industrial Sanctuary Plan
HCH	hexachlorocyclohexane
HQ	hazard quotient
Integral	Integral Consulting Inc.
IRM	Interim Remedial Measures
Level II SERA	Level II screening ecological risk assessment
LOAEL	lowest-observed-adverse-effect levels
LSS	Legacy Site Services

LWG	Lower Willamette Group
MDC	maximum detected concentrations
NOAEL	no-observed-adverse-effect level
OCTF	Old Caustic Tank Farm
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD/Fs	polychlorinated dibenzo-p-dioxins and dibenzofurans
Pennwalt	Pennwalt Corporation
PID	photoionization detector
QSAR	quantitative structure-activity relationship
RI/FS	remedial investigation and feasibility study
RM	river mile
ROD	record of decision
RTE	rare, threatened, or endangered
SLV	screening level value
SSL	soil screening level
SVOC	semivolatile organic compound
TCDD	tetrachlorodibenzo(*p*)dioxin
TEF	toxicity equivalency factor
TEQ	toxicity equivalent
TMDP	technical management decision point
TPH-D	total petroleum hydrocarbon-diesel
TPH-G	total petroleum hydrocarbon-gasoline
UCL	upper confidence limit
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

1 INTRODUCTION

This report presents a Level II screening ecological risk assessment (Level II SERA; DEQ 2001) for the Arkema, Inc. (Arkema) site (the Site) located adjacent to the Willamette River in Portland, Oregon. The Level II SERA was conducted pursuant to the conclusions of the *Level I Site Ecology Scoping Report* (ERM 2005a) prepared for the Site. The Level I Report focused upon Tract A (the riverbank) and Lots 3 and 4. The ecological risks specific to Lots 1 and 2 were evaluated in *Environmental Summary Report, Lots 1 and 2* (ERM 2003). This report concluded that the upland areas within Lots 1 and 2 do not pose risk to ecological receptors, due to the lack of significant concentrations of contaminants of interest (COIs) in surface soil and the absence of quality habitat due to grading. The area is industrial property that has undergone closure and has not been actively maintained for industrial purposes. The portions of the property that are of concern (Lots 1 and 2 and the riverbank) have passively undergone colonization by opportunistic plant species characteristic of early succession or disturbed habitat[1], which in turn acts as an attractant to other colonizing species, including soil invertebrates and birds. Although these areas have recently developed limited ecosystem function, they are nevertheless industrial in nature and may be redeveloped at any time. Furthermore, as directed in a City of Portland nuisance complaint, Legacy Site Services, LLC (LSS) will continue to provide active maintenance of the nuisance, invasive vegetation on Lots 1 and 2 and elsewhere on the Site on an ongoing basis. However, as directed by Oregon Department of Environmental Quality (DEQ), the Level II assessment is being conducted for the riverbank (riparian habitat), Lot 1, and the northeastern portion of Lot 2 (upland habitat) as a single unit. In addition, the riparian habitat will be used to evaluate the proposed River Environmental Overlay Zone, which is being proposed by the City of Portland Bureau of Planning to protect and preserve ecological habitat along the Willamette River (City of Portland 2008). Lots 3 and 4 do not represent ecological habitat, as they comprise the area where the majority of facility operations occurred historically, and most of the surfaces are paved with asphalt or other temporary cover systems (ERM 2005a, Integral 2006). Consequently, Lots 3 and 4 were omitted from the Level II SERA. Controls, including temporary cover systems and other barriers on Lots 3 and 4, as well as removal of nuisance, colonizing vegetation on Lots 1 and 2, will be used to prevent the encroachment of habitat and the exposure and risk to ecological receptors not evaluated in the Level II SERA.

A Level II assessment is a screening-based approach that extends beyond the qualitative results of the Level I – scoping analysis of the Site. The primary objectives of the Level II assessment

[1] Ecological succession is the predictable and orderly changes in the composition or structure of an ecological community that occur over time and which are initiated by formation of new, unoccupied habitat (e.g., dredged material deposited on a riverbank) or by some form of disturbance of an existing community (e.g., mowing fields in a power line corridor). Disturbance is defined herein as acute, chronic or episodic alteration in habitat structure or function that is caused by external physical or biological agents that can be either natural (e.g., floods) or anthropogenic (e.g., cultivation).

are to identify contaminants of potential ecological concern (CPECs) from the list of COIs determined during the Level I process, develop a site-specific conceptual site model (CSM) including complete exposure pathways and related potential ecological receptors, and provide a preliminary evaluation of the potential for ecological risk at the Site (DEQ 2001).

An updated description of the Site, including the facility's history, regulatory status, and future designation, is provided in Section 2. A review of the existing data, including descriptions of previous investigations and determination of data sufficiency to support a Level II SERA, is provided in Section 3. Section 4 presents a summary of the Level I scoping report results, and Section 5 is an updated site survey. The data used in the Level II assessment are described in Section 6. Section 7 presents the screening approach and results, which ultimately lead to CPEC identification for the entire site. Recommendations for the Site's habitats at potential ecological risk are presented in Section 8.

2 SITE BACKGROUND

2.1 SITE LOCATION

The Site is located along the southwest bank of the Willamette River between approximately River Mile (RM) 6.9 and 7.6 at 6400 NW Front Avenue in Portland, Oregon (Figures 2-1 and 2-2). The property lies within the Guild's Lake Industrial Sanctuary Plan (GLISP; formerly the Northwest Portland Industrial Sanctuary; Integral 2006). The Site is zoned and designated "IH" for heavy industrial use, which precludes it from most nonindustrial uses (Portland Development Commission 2004). The purpose of the GLISP is to maintain and protect this land as a dedicated area for heavy and general industrial uses. Therefore, while future use of the facility is unknown, it will likely be heavy industrial. The proposed River Environmental Overlay Zone would potentially apply to the property since both medium and high relative ranked natural resources were inventoried along the riparian habitat at the Site. This potential overlay is being evaluated as a separate unit in the Level II SERA process.

The Site occupies approximately 54 acres and is generally flat with surface elevations between 25 and 38 feet (National Geodetic Vertical Datum 1929; ERM 2005b). An approximately 30-ft bluff borders the eastern side of the property, forming the bank of the Willamette River. The Site is composed of four lots (Figure 2-3). Lots 3 and 4 comprise approximately 40 acres and are the portion of the Site where chemical manufacturing and processing occurred. Lots 1 and 2, at the north end of the Site, primarily supported manufacturing storage activities and are relatively undeveloped compared to Lots 3 and 4. Lots 1 and 2 are covered by a mixture of grasses, bare soil, and scrub-shrub vegetation that are characteristic of opportunistic colonization of idle industrial soil.

The Site (Figure 2-2) is bordered on the east by the Willamette River and to the south by CertainTeed Roof Product Manufacturing.[2] The Willbridge Bulk Fuel Storage Terminal (Environmental Cleanup Site Information [ECSI] 1549) and Kinder Morgan (ECSI 2104) sites are located immediately south of CertainTeed. Front Avenue borders the Site to the north and west. Four sites are located to the west of Front Avenue, upgradient of the Site. The sites include Starlink (Rhône-Poulenc; ECSI 155), Gould Industries, Doane Lake (ECSI 36), and Kinder Morgan (ECSI 2104; southwest of the Site). The Siltronics Inc. site (ECSI 183) is located immediately north of Front Avenue. Additional details on the adjacent properties can be found in DEQ's ECSI database.[3]

Heavy industrial land use surrounds the Site, isolating it from parks and residential areas. The nearest residential structures are located approximately 0.3 mile west of the facility. Forest Park, a large forested public park, is located 0.5 mile to the west of the facility (ERM 2005b).

[2] GS Roofing Products; DEQ's ECSI database 117
[3] http://www.deq.state.or.us/lq/ecsi/ecsiquery.asp

2.2 SITE HISTORY

A summary of the histories of site ownership and manufacturing are briefly presented below. Further details can be found in the *Upland Remedial Investigation Reports Lots 3 & 4 and Tract A – Revision 1* (Upland RI Report; ERM 2005b) and the *Engineering Evaluation/Cost Analysis - Arkema Removal Action – Portland, Oregon - Revised Work Plan* (Revised Draft Engineering Evaluation/Cost Analysis [EE/CA] Work Plan, Integral 2006). See Appendices A and B, respectively.

2.2.1 Arkema Site Ownership History

The facility manufactured inorganic chemicals from 1941 to 2001. It was constructed and operated by Pennsylvania Salt Manufacturing, which later became known as Pennwalt Corporation (Pennwalt). Purchased by Societé Nationale Elf Aquitaine (ELF) in 1989, Pennwalt was combined with two other companies in 1990 to form Elf Atochem North America, Inc. In 2000, ELF merged with TOTALFINA to form TOTALFINA ELF, and Elf Atochem became ATOFINA Chemicals, Inc. (ATOFINA). In 2004, ATOFINA changed its name to Arkema, Inc. In April 2006, the management of Arkema, Inc.'s environmental work for the Portland property was transferred to LSS, the sole agent for Arkema (Integral 2006).

2.2.2 Arkema Site Operational History

The Site operated as a chlor-alkali plant throughout most of its history from 1941 until 2001, when the entire facility was shut down due to escalating electricity costs. The facility used electrolytic cells to reduce concentrated sodium chloride brine to produce chlorine, caustic soda, hydrogen, hydrochloric acid, and sodium chlorate (CH2M Hill 1997).

Other key manufacturing processes that have occurred at the facility are listed below. The major industrial features of the Site and the riverbank features are briefly summarized in this section. The locations of historical processes at the Site are presented in Figure 2-3. Unless otherwise indicated, the information presented below is summarized from the Revised Draft EE/CA Work Plan in Appendix B (Integral 2006).

2.2.2.1 Acid Plant Area

Dichloro-diphenyl-trichloroethane (DDT), magnesium chloride hexahydrate, ammonium perchlorate, solid sodium hydroxide, a grass defoliant[4] (produced by chlorinating acetone with chlorine gas), sodium orthosilicate, and hydrochloric acid were manufactured in the Acid Plant Area (Figure 2-3). The dates of manufacture for each product are provided below:

[4] For only a few months in the early 1950s, Pennwalt Corporation attempted to produce a grass defoliant material for use in the agricultural industry. The operation consisted of chlorinating acetone with chlorine gas. Based on historical information, this material was never mass produced or sold.

- DDT (1947 to 1954)
- Magnesium chloride hexahydrate (1952 to 1962)
- Ammonium perchlorate (1958 to 1962)
- Solid sodium hydroxide (early 1950s to 1980s)
- Grass defoliant (early 1950s)
- Sodium orthosilicate (1950 to 1980)
- Hydrochloric acid (1966 to 2001).

2.2.2.2 Chlorate Plant Area

Sodium chlorate and potassium chlorate were manufactured in the chlorate plant area on Lot 4 (Figure 2-3). Sodium chlorate was produced by electrolysis of sodium chloride solution from 1941 to 2001. Potassium chlorate production (1941 to 1978) was similar to that of sodium chlorate, except that the salt source was potassium chloride rather than sodium chloride.

2.2.2.3 Chlorine Manufacturing Area

Chlorine manufacturing started in 1946 using cells equipped with graphite anodes in the old chlorine cell room on Lot 4 (LSS 2006, pers. comm.). These cells were operated until 1971, when they were shut down and replaced by a new chlorine cell room (1962 to 2001) located north of the old cell room on Lot 3 (Figure 2-3).

2.2.2.4 Salt Pads

Salt was the primary raw material used at the Site throughout its operational history (1941 to 2001). The salt was stored on asphalt-lined Salt Pads in the southeastern corner of the Site on Lot 4 (Figure 2-3). The salt was dissolved in water while on the Salt Pads to produce brine for plant manufacturing operations.

2.2.2.5 Asbestos Ponds and Trenches

The asbestos diaphragm chlorine cells were rebuilt annually. Approximately 12 trenches on Lot 1 (Figure 2-3) were filled with asbestos-containing residue from the diaphragm chlorine cells. The ponds were decommissioned voluntarily to excavate the trenches containing asbestos residue. The asbestos removal work was conducted under a work plan approved by DEQ and under DEQ's oversight (Patterson 1992, pers. comm.). The asbestos removal work was completed in 1992 (Elf Atochem 1999).

2.2.2.6 Former Brine Mud Pond

Calcium and magnesium were precipitated from salt in the form of calcium carbonate and magnesium hydroxide (referred to as dolomite/brine mud) in the later years of plant operation.

This material was stored on soil in a diked area and in a pond located in the northern area of the property on Lots 1 and 2 (Figure 2-3) until it was excavated in the early 1990s (Elf Atochem 1999).

2.2.2.7 Old Caustic Tank Farm

The Old Caustic Tank Farm (OCTF), sometimes referred to as the Former Caustic Tank Farm, is located just south of the Acid Plant area on Lot 4 (Figure 2-3). Tanks within the OCTF were used to store sodium hydroxide from 1946 to 1996. The OCTF was in use until 1996. The idle tanks were removed from the OCTF during the plant demolition activities in the spring of 2002 (ERM 2005b).

2.2.2.8 Ammonia Plant

Ammonia was produced (mid-1950s to 1990) by combining nitrogen (stripped from air) and hydrogen that was produced in the chlor-alkali process. The combined gases were compressed and cooled to form anhydrous ammonia. The operation was located in what is known as the New Caustic Tank Farm Area on Lot 3 (Figure 2-3).

2.2.2.9 Transformer Pads

Electrical transformers were historically installed at various locations throughout the Arkema facility (see Figure 1-5 of the Upland RI Report [ERM 2005b]; Appendix A). During facility demolition, all transformers were properly removed. The transformer pads were tested for the presence of polychlorinated biphenyls (PCBs) and managed or disposed of in accordance with DEQ oversight (Patterson 2003, pers. comm.; McClincy 2003, pers. comm.; Patterson 2004, pers. comm.). The scope and results of that investigation are summarized in the Upland RI report (Appendix A; ERM 2005b).

2.2.2.10 Bonneville Power Administration Substation

The Bonneville Power Administration owned and operated an electrical substation on the Site. The substation, which is divided into the main substation (also referred to as the Pennwalt Substation) on Lot 3 and a substation annex to the north on Lot 2, occupied a total area of 1.28 acres of the facility (Figure 2-3). The substation was decommissioned following plant closure, and the associated equipment was removed from the property in 2002 (ERM 2005b).

2.2.2.11 Riverbank

The riverbank area, mostly between Docks 1 and 2, received miscellaneous fill for several years. Parties responsible for the filling activities included the City of Portland, private excavation contractors, and Elf Atochem. Fill materials included clean soil, asphalt, concrete, metal piping, and miscellaneous materials from spent chlorine cells (ERM 2005b). In addition, dredge spoils which may have contained chemicals of interest were deposited on the riverbank. Details

regarding known and potential dredge/fill activities at the Site can be found in the Revised Draft EE/CA Work Plan (See Appendix B, Section 2.2.4; Integral 2006).

2.3 CURRENT AND FUTURE FACILITY OPERATIONS

Chemical manufacturing operations at the facility ceased in 2001. Decommissioning and removal of the manufacturing infrastructure were completed in early 2005. The only structure remaining is the office building at the Site entrance on Front Street and certain concrete floor slabs left in place as environmental soil caps. Arkema maintains leases from the Oregon Department of State Lands for the docks in the Willamette River, but the structures are not currently in use. Upland remediation measures to address environmental impacts are ongoing.

2.4 REGULATORY STATUS

The Arkema facility is located adjacent to the Study Area of the Portland Harbor Superfund Site, which encompasses about 9 miles of the Willamette River from approximately RM 2 to 11. The Study Area does not legally define the Portland Harbor Superfund Site, the boundaries of which will be determined by EPA upon issuance of a Record of Decision (ROD; Integral and GSI 2004).

In 1995, Arkema (then known as Elf Atochem) submitted an intent to participate in DEQ's voluntary Cleanup Program. In 1996, Arkema entered into a voluntary letter agreement with DEQ that was followed in 1998 by a voluntary agreement with DEQ to complete a remedial investigation and feasibility study (RI/FS) of the former DDT manufacturing area. The RI/FS was later expanded to include other areas and chemicals at the Site (e.g., hexavalent chromium and perchlorate).

Arkema has completed several Interim Remedial Measures (IRMs) to address contaminated soil and groundwater. In 2000 and 2001, Arkema completed two phases of excavation and disposal to remove surface and subsurface soil with elevated DDT concentrations from the former manufacturing process residue pond and trench. Air sparging and soil vapor extraction techniques were employed to address residual chlorobenzene in groundwater in the upland portion of the Site. The system operated between December 2004 and June 2006. Calcium polysulfide was injected into groundwater in the Chlorate Plant area to reduce hexavalent chromium to a trivalent state and immobilize it in groundwater. The full-scale program implemented in June and November 2005 was monitored through April 2006 (Integral 2006). Bench-scale treatability studies of *in situ* treatments for perchlorate in groundwater were conducted between December 2003 and March 2006. Based on these studies, an active (groundwater and nutrient recirculation system) enhanced *in situ* bioremediation was recommended for the perchlorate plume (Integral 2006). In 2006, the *in situ* groundwater IRM work was halted and groundwater remediation efforts were redirected to the design and

installation of a hydraulic control-based approach utilizing a slurry wall and pump and treat system. The *ex situ* groundwater and treatment system was selected in lieu of *in situ* groundwater efforts in order to achieve EPA-directed source control efforts in accordance with the in-water EE/CA schedule. The groundwater IRM infrastructure and system will most likely be implemented in 2009.

An IRM to address stormwater is currently being designed for the Site. A feasibility study is being developed for probable implementation in late 2009.

3 REVIEW OF EXISTING DATA

3.1 SUMMARY OF INVESTIGATIONS

A critical prerequisite for proceeding to a Level II assessment is to determine if the data collected and available are sufficient to effectively characterize the habitats being evaluated at the Site. A number of investigations have been conducted at the Site focusing on the principal COIs (4,4'-DDT and its metabolites, chlorobenzene, perchlorate, hexavalent chromium, and chloride). The sampling efforts and data relevant to the Level II ecological assessment are summarized below. These data were found to be sufficient for the advancement to a Level II evaluation in Sections 6 and 7 of this report.

3.1.1 Riverbank/Beach Sediment Sampling

In November 1998, beach sediment samples were collected from exposed river sediments at six stations (RB-1 through RB-6) during a relatively low river stage. Surface samples were collected using a stainless steel spoon from the depth interval of 0 to 10 cm (0 to 0.33 ft) at each sample station. Sediment coring at depths greater than 10 cm was achieved using a titanium drive corer. The maximum penetration depth was less than 35 cm (1.1 ft), except at station RB-6, where penetration reached 58 cm (1.9 ft; Exponent 1999).

Surface sediments and sediment core samples were submitted for the analysis of semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), organochlorine pesticides, total organic carbon, and grain size. Each sediment increment was also field-screened using a photoionization detector (PID) for VOCs, thin-layer chromatography for DDT, and Sudan IV® hydrophobic dye for non-aqueous phase liquid.

3.1.2 Riverbank Soil Sampling

In August 2000, surface (0 to 6 in.) soil samples were collected from six riverbank sampling locations (RB-7 through RB-12) and analyzed for organochlorine pesticides, SVOCs, and four metals, including cadmium, total chromium, lead, and zinc. One duplicate sample was collected and analyzed for the same suite of analytes. Samples were collected between Docks 1 and 2 from three paired locations, with one sample location near the top of the slope and the second downslope from the first sample location (Figure 3-1; ERM 2005b).

3.1.3 Acid Plant Area Soil Investigation

In 2000, surface and subsurface soils were collected in the Acid Plant area to characterize the physical properties of soils and to delineate the nature and extent of COIs in this portion of the upland. A total of 48 borings were advanced using either hand-auger, direct-push (Geoprobe®),

or hollow-stem auger drilling methods for the collection of soil and groundwater grab samples. Boring B-63 (located along the top of the riverbank between Dock 1 and the Salt Dock) was the only station screened during the risk assessment. The borehole was advanced to 10 ft below ground surface (bgs) and analyzed for VOCs (ERM 2005b).

3.1.4 Portland Harbor RI/FS Round 1 Sampling

The RI/FS of the Portland Harbor Superfund Site included several rounds of field sampling activities to investigate the nature and extent of contamination in the in-water portion of the Study Area (Integral 2005b). The Portland Harbor RI/FS Round 1 field sampling and reconnaissance activities were conducted between June and December 2002. Surface sediments (0 to 15 cm) were collected in support of the Portland Harbor in-water ecological risk assessment. Sample 07B024, the sole sample screened during this assessment, was collected from RM 7 within the riverbank area defined as riparian habitat for the purposes of the Level II SERA. The sample was analyzed for conventional parameters (total solids, grain size, and total organic carbon), metals (aluminum, antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc), PCB Aroclors, pesticides, and SVOCs (Striplin et al. 2003).

3.1.5 Portland Harbor RI/FS Round 2 Beach and Surface Sediment Investigation

In 2004, a total of 28 composite sediment samples (including field replicate and splits) were collected between RM 2 and 10. Two of these stations (B018-SE and B050-SE) were located between the mean high water and ordinary low water of the Site and were included in this assessment: 1) Sample B018, a 400 m transect at +5 ft Columbia River Datum (CRD) broken by 100 m stretch of riprap, consisting of 12 composited subsamples; and 2) Sample B050[5], a 300 m transect at +5 ft CRD, consisting of nine composited subsamples (Figure 3-1). Samples were analyzed for metals, PCB Aroclors, SVOCs, pesticides, and dioxins/furans (Integral 2005a,b).

3.1.6 Surface Soil Sampling on Lots 1 and 2

In March 2006, seven composite soil samples were collected from Lots 1 and 2. Four discrete locations were sampled from the surface (0 to 1 ft) for each composite. One field duplicate sample was collected during the investigation. Samples were collected using a stainless-steel hand auger and submitted for organochlorine pesticides, PCBs, SVOCs, total petroleum hydrocarbon-diesel (TPH-D), total petroleum hydrocarbon-gasoline (TPH-G), arsenic, cadmium, chromium, lead, and zinc. Two of the samples (SS1-1 and SS2-1 from Lots 1 and 2, respectively; Figure 3-1) were transects located adjacent to the top of the riverbank and were

[5] Note that parts of sample B050 are located on property not owned or controlled by Arkema and that has been impacted by chemicals from neighboring industrial processes.

therefore also evaluated as riparian soils within the proposed River Environmental Overlay Zone in the Level II SERA (ERM 2006).

3.1.7 Supplemental 2007 Riverbank Soil Sampling

A supplemental riverbank soil sampling investigation was conducted to further delineate the extent of contamination in support of the terrestrial ecological risk assessment per DEQ's direction. In March 2007, surface (0 to 6 in.) soil samples were collected from 13 riverbank stations (Figure 3-1, Stations RBC-1 through RBC-13) along the entire property boundary, with the exception of the area between Docks 1 and 2, which had been adequately sampled during previous sampling events. The stations were located near the top of the bank, as well as between the top of bank and mean high water (approximately 12 ft North American Vertical Datum 88). A single composite sample made up of five discrete samples was collected from each station (Figure 3-1). In addition, five deeper (18 to 24 in.) soil samples were collected from select riverbank stations to characterize the shallow subsurface. All samples were field-screened for VOCs using a PID. A total of 14 surface composite (including one field duplicate sample) and five subsurface samples were collected and analyzed for organochlorine pesticides, SVOCs, PCBs, dioxins/furans, total TPH-D, total TPH-G, VOCs (analysis conducted only on two samples that demonstrated the possible presence of volatile organics by PID field screening), and total metals (arsenic, cadmium, chromium, lead, and zinc).

4 SUMMARY OF LEVEL I SITE ECOLOGY SCOPING REPORT RESULTS

The following section reviews the results of the *Level I Site Ecology Scoping Report* (Level I Report; Appendix C; ERM 2005a). The Level I Report focused on Lots 3 and 4 and the riverbank above mean high water (Tract A); however, this section will also briefly discuss Lot 1 and a portion of Lot 2, which are being addressed in this Level II SERA. Constituents of interest, potential ecological habitat, potential ecological receptors, and potential exposure pathways are summarized here.

4.1 CONSTITUENTS OF INTEREST

DDT, dichloro-diphenyl-dichloroethane (DDD), dichloro-diphenyl-dichloroethene (DDE), alpha-hexachlorocyclohexane (HCH), chromium, lead, zinc, polycyclic aromatic hydrocarbons (PAHs), and hexachloroethane were identified as the constituents of interest for soil on and adjacent to the riverbank discussed in the Level I Report. A subset of these chemicals including DDT, DDD, and DDE and chromium are actually known or suspected to have been released at the Site. Although additional constituents were detected in soils on Lots 3 and 4, these areas are covered with building foundations and impervious surfaces that prevent ecologically meaningful contact with the soil.

Perchlorate, hexavalent chromium, DDT, DDD, DDE, and monochlorobenzene were identified as primary constituents of interest for groundwater. However, groundwater is deeper than 3 ft bgs and does not currently discharge to the surface at the Site. Therefore, constituents of interest in groundwater are not considered accessible to ecological receptors and are not evaluated in this Level II SERA.

4.2 POTENTIAL ECOLOGICAL HABITAT

Potential ecological habitat exists in previously developed and disturbed areas along the riverbank and within Lots 1 and 2. Lots 3 and 4 are generally covered by impervious or uninhabitable surfaces including pavement, gravel, and building foundations that preclude establishment of any meaningful ecological habitat and are therefore excluded from this evaluation.

The portion of the Site located between the mean-high-water line of the Willamette River and the top of the bank is steeply sloping and covered with rubble used for bank stabilization; a limited amount of vegetation has opportunistically colonized the area and grows among the bank-armoring material. Riverbank vegetation is characterized by ruderal species, or those

species likely to first colonize an idle industrial area, including Scotch broom, Himalayan blackberry, black mustard, and curly dock.

Lots 1 and 2 were formerly developed to receive process-related materials and graded dredged spoils, but are now idle industrial areas that have been passively colonized by a mixture of native and introduced plant species. On the northeastern edge of Lots 1 and 2 is a stand of black cottonwood trees, a willow thicket, and an area overgrown with scrub-shrub vegetation which has been designated as medium- to high- relative rank (City of Portland 2008). Trees and scrub-shrub vegetation also exist on the western end of Lot 1. The remainder of the property is vegetated with grass or is bare.

In summary, the potential ecological habitat that will be evaluated during the Level II SERA is limited to Lot 1 and the northeastern portion of Lot 2, and the riverbank between the top of the bank and ordinary low water.

4.3 POTENTIAL ECOLOGICAL RECEPTORS

A site visit was conducted in 2003 by ERM staff members, who identified a number of bird species using the Site. Other types of wildlife were not observed by staff but could include small mammals and amphibians. Observed wildlife and potential wildlife are discussed below.

4.3.1 Observed Wildlife at the Site

Wildlife use of the Site was noted to be minimal. During the 2003 site visit, ERM staff documented several common bird species in the area of the riverbank or flying over the Site, including ring-billed gull (*Larus delawarenesis*), California gull (*Larus californicus*), killdeer (*Charadrius vociferous*), American crow (*Corvus brachyrhynchos*), house sparrow (*Passer domesticus*), European starling (*Sternus vulgaris*), mourning dove (*Zenaida macroura*), and American Robin (*Turdus migratorius*). At least one pair of Canada geese (*Branta canadensis*) and common songbirds such as the song sparrow (*Melospiza melodia*) were stated as having been documented to nest at the Site in the past. Osprey (*Pandion haliaetus*) and bald eagles (*Haliaeetus leucocephalus*) have been observed at the Site but were not noted during the 2003 site visit. No mammals were observed during the visit, although staff working at the Site suggested that invasive nutria (*Myocastor coypus*) may occur along the shoreline of the Site. Blacktail deer (*Odocoileus hemionus*) have been observed on Lot 1 and may use the riverbank for river access. Because of the chainlink fence surrounding Lots 3 and 4, and the impervious cover of the Site, large mammalian use of the developed portion of the Site is not expected. However, portions of the site may be accessible to mobile species via migratory corridors associated with Forest Park and Doane Lake (Figure 2-2) to the west and north of the site, or the riparian areas that are used by species that exploit the shoreline of the Willamette River.

4.3.2 Potential Receptors at the Site

Additional species that potentially use the Site, but were not observed, include piscivorous wading birds (e.g., herons) along the shoreline and other species of migratory birds, waterfowl, amphibians, and small mammals.

4.3.3 Threatened and/or Endangered Species

No threatened or endangered species or their habitats are known to occur on the Site. The developed, disturbed nature of the property limits wildlife use to those species that are common to the region and adapted to disturbed, urban conditions. The portion of the Site that contains potential wildlife habitat is characterized by sparse and largely invasive and/or exotic vegetation, precluding suitable terrestrial habitat for species of special interest.

4.4 POTENTIAL EXPOSURE PATHWAYS

The media of potential interest identified in the Level I Report comprised uncovered soils on and near the riverbank. Uncovered soils in Lot 1 and portions of Lot 2 can also be included as an exposure medium of interest, though not explicitly discussed in the Level I Report. (Note: surface soils in Lot 1 and portions of Lot 2 are evaluated as contact media in the Level II SERA.) If constituents of interest are present in surface soils, the primary exposure for potential terrestrial ecological receptors would be to surface soils through the food and incidental soil ingestion pathways.

No surface water or surfacing groundwater was identified on the upland portion of the Site that would have provided a mechanism of exposure to terrestrial ecological receptors via these media.

5 SITE SURVEY

A description of habitats and potential receptors was provided by the Level I Report. Integral Consulting Inc. (Integral) staff conducted a site survey of the biological habitats of the Site to identify any changes since the Level I Report and confirm the findings of that report in terms of the extent and status of potential ecological habitats. A series of photographs documenting site conditions were taken (Appendix D). In general, staff found conditions consistent with those described in the Level I Report, including little or no habitat usable by ecological receptors within the property fence line of Lots 3 and 4 (Appendix D, Photos 2 to 15); disturbed vegetated habitat dominated by ruderal/invasive species extending from the top of the riverbank to the mean high water line (Appendix D, Photos 16 to 30); and limited vegetated areas in Lot 2. Staff observed evidence of bird use of the riverbank area (Appendix D, Photo 26) and additional species of wildlife not listed in the Level I Report, including double-crested cormorants (Appendix D, Photo 24).[6]

Consistent with the Level II SERA proposal, Integral assumed the Level I Report information, combined with regional wildlife information available from other sources, to be sufficient. Therefore, a biological inventory to observe and identify receptors was not considered necessary (Integral 2005c). No quantitative survey of habitats or potential ecological receptors was conducted.

[6] Personal observation of Les Williams, Integral Consulting Inc. staff member.

6 DATA EVALUATION

6.1 SAMPLES USED IN THE SERA: SCOPE AND EXTENT

The Site soil chemistry data were collected between 1998 and 2007 as described in Section 3. The Site was screened as a single unit (riverbank and upland), as well as the riparian habitat alone to evaluate the proposed River Environmental Overlay Zone for the purpose of this risk assessment. Lot 1 and the northeast corner of Lot 2 outside of the property fence line are formerly developed terrestrial areas that were designated as potential upland habitat for the Level II SERA. Soil samples used in the assessment of the proposed River Environmental Overlay Zone included those taken along the Site's boundary with the Willamette River, between estimated ordinary low water and inland to within approximately 7.6 m (25 ft) west of the top of the riverbank. As discussed in Sections 3 and 4, Lots 3 and 4 contain negligible habitat and were generally excluded from the risk assessment, with the exception that individual samples from these areas were included if they were located within the proposed River Environmental Overlay Zone.

6.2 DATA SELECTION AND REDUCTION

All relevant data identified in Section 3 above were evaluated for inclusion in the Level II SERA. The samples were reviewed to identify and eliminate duplicate results. Laboratory duplicate samples were treated and removed prior to analysis in accordance with Lower Willamette Group (LWG) protocols (Kennedy/Jenks et al. 2004).

- If sample and laboratory duplicate results were both reported as detected concentrations, the average of the two values was calculated and used in the analysis.
- If the sample and laboratory duplicate results were both reported as undetected, the lower detection limit for the two undetected results was selected and used.
- If either the sample or the laboratory duplicate result was reported as detected and its counterpart was reported as undetected, the detected result was selected and used.

Results for individual discrete samples and their associated field replicates were treated as individual sample points. Following treatment and reduction of duplicate data, all chemicals that were detected at least once were selected for further evaluation. The selected data were then categorized by unit (e.g., entire Site and proposed River Environmental Overlay Zone) and screened as described below.

In addition, an isomeric calculation method was developed to estimate concentrations of 2,4'-isomers of DDD, DDE, and DDT when only 4,4'- data were available (Appendix E). The

estimated 2,4′-isomer concentrations were then added to the database and used in summation of the 2,4′- and 4,4′-isomers for each chemical and in calculation of a total DDx concentration for all chemicals and isomers in the series. The uncertainty of these estimates is discussed in Section 7.7.5.

6.2.1 Site Samples

A total of 59 soil samples were screened during the Level II SERA. Soils were collected from the surface to 0.91 m (3 ft) bgs, which is considered to be the maximum depth relevant to potential ecological receptor activity and exposure (DEQ 2001). Soils within 0.15 m (0.5 ft) bgs were classified as surface soils, accessible to most terrestrial ecological receptors. Soils at depths of 0.15 to 0.91 m (0.5 to 3 ft) bgs were considered subsurface soils accessible to burrowing animals and plant roots. As requested by DEQ (McClincy, pers. com. 2008), surface and subsurface soil samples were combined and screened together during the Level II SERA process even though the subsurface soil concentrations may be different from surface soil concentrations and may not be applicable to some receptors. Samples meeting these criteria are listed below:

- 21 "RB" samples (Sections 3.1.1 and 3.1.2)
- Sample 07B024 (Section 3.1.4)
- Samples B018 and B050 (Section 3.1.5)
- Eight samples (SS1-1, SS1-2, SS1-3, SS1-4, SS1-4D, SS1-5, SS2-1, and SS2-2) collected on Lots 1 and 2 (Section 3.1.6), and
- 27 "RBC" samples[7] (Section 3.1.7).

6.2.2 Proposed River Environmental Overlay Zone Samples

Samples included in the proposed River Environmental Overlay Zone unit were limited to those collected in the riparian habitat, which for this Level II SERA is defined as from the top of the bank to approximately ordinary low water. This includes all samples listed above with the exception of the samples collected in the upland: SS1-2, SS1-3, SS1-4, SS1-5, and SS2-2.

6.3 DATABASE SUMMARY AND APPLICATIONS

Data available for the Level II SERA were consolidated into a flatfile database in Excel format. The data selection and data reduction rules summarized above were used to query the flatfile database and generate pivot table reports that could be used in an initial screen to identify

[7] The composite soil sample collected at RBC-7 (SO7038) was not analyzed for organochlorine pesticides within the required holding time. However, the five discrete samples that originally comprised the composite had been properly archived in frozen storage at the laboratory. Consequently, these individual samples were retrieved, analyzed and reported as discrete samples for this Level II SERA.

Level II COIs Site-wide and within the proposed River Environmental Overlay Zone (Section 6.4 below). Summary statistics were then calculated for the Level II COIs (Section 6.4) and used in a chemistry-toxicity screen to identify chemicals of potential ecological concern for the Site and the proposed River Environmental Overlay Zone (Section 7).

6.4 INITIAL SCREENING AND SELECTION OF CONTAMINANTS OF INTEREST

The Level I Report identified preliminary consituents of interest for the Site based on chemicals used in manufacturing processes and presence of chemicals in soils at Lots 3 and 4 and along the riverbank (Tract A). Consequently, because some samples have been eliminated as a result of site remediation and additional data are available for the riverbank soils, an initial screening comparison comparable to a Level I SERA was conducted to develop a final list of Level II COIs for the Site. The initial screening was based on the following:

- Identification of screening level values for soils
- Comparisons of maximum detected concentrations with minimum screening level values
- Comparisons of inorganic chemical concentrations with background concentrations.

6.4.1 Screening Level Values

Screening level values (SLVs) used during the Level II screening are presented in Table 6-1. A hierarchical approach for selecting soil SLVs for plants, invertebrates, and wildlife was used for this Level II SERA. Pursuant to DEQ (McClincy 2008, pers. comm.), EPA Eco-SSLs (soil screening levels) were used as the primary standards of comparison for judging potential toxicity and risk associated with chemicals in soils from the Site. When Eco-SSLs were not available for a COI, DEQ SLVs (DEQ 2001) were applied. In cases where SLVs were not available from either source, alternative sources, including EPA Regions 4 and 5 SLVs as directed by DEQ (McClincy, pers. com. 2008), were used. Uncertainty associated with SLV selection is discussed in Section 7.7.1. Chemicals that did not have SLVs were removed from further evaluation and are listed in Table 6-2.

6.4.2 Comparisons with Maximum Detected Concentration

The maximum concentration of all detected analytes for soils from the Site, including the proposed River Environmental Overlay Zone were compared against minimum SLVs for plants, invertebrates, and wildlife (Table 6-3). An initial hazard quotient (HQ) was calculated by dividing the maximum detected concentration by the lowest of the available soil screening level values (Table 6-1). Given the conservative assumptions of this calculation, analytes with

HQs <1 were considered unlikely to pose risk to potential ecological receptors at the Site and were not carried forward as Level II COIs.

In addition, sample specific HQs were calculated for all Level II COIs for each receptor (Appendix F) to facilitate judgments of contaminant distribution and risk (see Section 7).

6.4.3 Background Comparisons

Pursuant to DEQ (2002) guidance, metals for which there were no available SLVs or that exceeded their respective SLVs were compared to the Washington State Department of Ecology (Ecology 1994) statewide 90th percentile value for background metals concentrations in soils. If maximum detected metals concentrations were at or below background concentrations, the metal was removed from further consideration (Table 6-4).

6.4.4 Contaminants of Interest

Chemicals whose maximum concentrations exceeded minimum SLVs or background levels were identified as Level II COIs for the Site and the proposed River Environmental Overlay Zone (Table 6-3). Overall, 23 chemicals or chemical groups were identified as Level II COIs for the Site and the proposed River Environmental Overlay Zone. These Level II COIs represent a wide range of compound categories, including the following:

- Trace metals
- SVOCs
- Phthalate esters
- PAHs
- Dioxin/furans
- Pesticides.

The Level II COI data were summarized statistically for the entire Site (Table 6-5) and for the proposed River Environmental Overlay Zone (Table 6-6). Summary statistics include number of samples, number of samples with detected and nondetected concentrations, frequency of detection, minimum and maximum values of both detected and ½ nondetected concentrations, mean concentrations, standard deviations, and upper confidence limit (UCL) estimates of each analyte.

Detection frequencies were calculated by dividing each analyte's number of detected values by the total number of samples in which it was analyzed. The frequency of detection was greater than 5 percent for all but two of the COIs for both the Site-wide data and the proposed River Environmental Overlay Zone; the frequency of detection was less than 5 percent for alpha-HCH

and beta-HCH. For nondetected samples, values of one-half the detection limits (½ DLs) were used in subsequent calculations of means, standard deviations, and 90% UCLs. Central tendency and 90% UCLs were calculated using ProUCL (U.S. Environmental Protection Agency [USEPA], Version 4.00.02, Washington, DC; Appendix G).

Pursuant to DEQ (2001) guidance, the Level II COIs represented by these chemical classes were evaluated further to identify CPECs in a Level II SERA (Section 7).

7 LEVEL II SERA

This section reviews Site characteristics, identifies Site-specific ecological receptors, and describes assessment endpoints relevant to those receptors. A chemical-toxicity screen is then conducted to identify CPECs. The CPECs are then discussed in terms of potential ecological effects and potentially relevant exposure pathways at the Site. This information is then presented in a conceptual site model.

7.1 SITE DESCRIPTION

As discussed in Section 4, potential ecological habitat, primarily low-quality ruderal vegetation, exists in previously developed and disturbed areas along the riverbank and within Lots 1 and 2. These areas are formerly developed shoreline and industrial property that have undergone passive colonization by native and exotic plants and presently exist as fragmented and highly disturbed habitat. As directed in a City of Portland nuisance complaint, LSS will continue to provide active maintenance of the nuisance, invasive vegetation on Lots 1 and 2 and elsewhere on the Site on an ongoing basis. The primary sources of CPECs to the upland and riparian habitats include activities associated with former chemical manufacturing (e.g., spills, leaks, discharges to floor drains) and historical placement of dredged material. These sources and CPEC release mechanisms are discussed further in Section 7.6.1.

7.2 SITE-SPECIFIC ECOLOGICAL RECEPTORS

Pursuant to DEQ (2001) guidance, ecological receptors of concern in a Level II SERA are broadly categorized into four major guilds: terrestrial plants, terrestrial invertebrates, terrestrial mammals, and terrestrial birds. Although amphibians were listed as potential ecological receptors in the Level I Report, lack of surface water and open, scrub-shrub habitat dominating the Site are conditions that preclude quality habitat for most amphibians; therefore, amphibians are not considered particularly relevant ecological receptors for this SERA. Nevertheless, LSS is aware of the Willamette River natural resources inventory conducted by the City of Portland (2007) that identified frogs in Doane Lake, which is located northwest of the Site. Some amphibians may have non-aquatic life stages and could exist in upland or riparian habitat. Consequently, amphibians will be included qualitatively in the Level II SERA. However, toxicity reference values and information needed to build exposure and uptake models are generally not available to evaluate exposure and effects of soil contaminants on amphibians. Therefore, representatives from similar feeding guilds may be used as surrogates for judging potential risks to amphibians. The plant community along most of the riverbank area is dominated by invasive, weedy species indicative of a high level of anthropogenic disturbance. On the northeastern edge of Lots 1 and 2 is a stand of black cottonwood trees, a willow thicket,

and an area overgrown with scrub-shrub vegetation which has been designated as medium- to high-relative rank (City of Portland 2008).

As discussed in Section 4.3, a number of common bird species, including passerines (e.g., American robin, song sparrow, and American crow) and gulls, were observed on the Site. No mammals were observed, although invasive nutria and blacktail deer were suggested to potentially use the Site. In addition, small mammals, such as rodents that dwell in vegetated, disturbed habitat, and insectivores (e.g., shrews) that may forage on soil invertebrates could be present at the Site. No invertebrates were discussed in the Level I Report; however, earthworms were encountered and documented in soils during the March 2007 riverbank soil sampling event. No endangered or threatened species were identified at the Site, nor was habitat likely to support such species.

7.3 CANDIDATE ASSESSMENT ENDPOINTS

Four candidate assessment endpoints were selected for the Level II SERA pursuant to DEQ (2001) guidance. These endpoints are explicit expressions of valued ecological attributes that are important to protect. The assessment endpoints are expressed in terms of potential relevant ecological function and methods for measuring possible effects that are consistent with the screening level values selected for the four guilds of plants and animals described above:

- Potential for a viable[8] plant communities in ecological habitat as measured by comparisons of chemical concentrations in soil with risk-based SLVs
- Potential for a viable soil invertebrate community in ecological habitat as measured by comparisons of chemical concentrations in soil with risk-based SLVs
- Potential for viable populations of herbivorous and invertebrate-feeding birds that may live and forage in ecological habitat as measured by comparisons of chemical concentrations in soil with risk-based SLVs
- Potential for viable populations of herbivorous and invertebrate-feeding mammals that may live and forage in ecological habitat as measured by comparisons of chemical concentrations in soil with risk-based SLVs.

These assessment endpoints are designed to evaluate possible effects to populations or communities of organisms in an ideal unperturbed ecosystem. Given the history of industrial and shoreline development at the Site and its frequency of physical disturbance, it does not meet the criteria of such an ideal ecosystem, and it is unlikely that population- or community-level effects of chemical stressors could be distinguished from those of non-chemical stressors.

[8] Viable is defined as the capacity for growth, survival, and reproduction of individuals or populations under favorable conditions.

7.4 CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN

Level II COIs in soils (Section 6.4) for the Site and the proposed River Environmental Overlay Zone were evaluated independently in a chemistry-toxicity screen to identify CPECs for these areas. The following sections describe the methods and results of the chemical-toxicity screen.

7.4.1 Chemical-Toxicity Screening Methods

A chemistry-toxicity screen was conducted pursuant to DEQ (2001) guidelines independently for four categories of receptor (plants, soil invertebrates, mammals, and birds). Screening was conducted to evaluate potential risk associated with exposure to individual COIs and with exposure to multiple COIs in soil.[9] For individual chemicals, a hazard quotient was calculated using the expression:

$$HQ_{ik} = \frac{C_i}{SLV_k} \qquad \text{(Eq. 7-1)}$$

Where:

C_i = the concentration of chemical i in soil

SLV_k = the screening level value for receptor k.

For plants and soil invertebrates, C_i is the maximum detected concentration of an individual chemical in soils. For birds and mammals, C_i is an exposure point concentration for a chemical that is determined from the lower of either the 90th percentile UCL of the mean or the maximum detected values (Tables 6-2 and 6-3; Appendix G). For individual chemical and receptor comparisons, an HQ > 5 indicates that the substance is a CPEC.

To assess the potential for ecological risk associated with multiple chemical exposure, the individual hazard quotients were added and if the total HQ was greater than 5, the potential for cumulative ecological risk was determined from the following expression:

$$HQ_{total,ik} = \sum_{i=1}^{i} HQ_{ik} \qquad \text{(Eq. 7-2)}$$

and

$$\frac{HQ_{ik}}{HQ_{total,\,ik}} \geq \frac{5}{N_{total,k}} \qquad \text{(Eq. 7-3)}$$

Where:

[9] DEQ guidance for screening multiple media is not applicable to the Site because our only medium of concern is soil. Nor is DEQ guidance applicable to screening rare, threatened, or endangered (RTE) species because the Level I assessment did not identify any RTE species or habitat that would support such species.

HQ_{ik}	=	the individual chemical hazard quotient for receptor k as defined above (Eq. 7-1)
$HQ_{total,ik}$	=	the sum of the individual hazard quotients for receptor k
$N_{total,\ k}$	=	the total number of chemicals of interest for receptor k.

Individual chemicals that exceeded the threshold for multiple receptors described in Equation 7-3 were identified as CPECs.

7.4.2 Chemical-Toxicity Screening Results

The chemical-toxicity screens for both individual and multiple chemical exposure are presented in Table 7-1 for the Site and in Table 7-2 for the proposed River Environmental Overlay Zone. The CPECs and associated receptors at potential risk in each habitat evaluated during the Level II SERA are listed below and presented in Table 7-3.

The CPECs identified for the Site are as follows:

- Chromium – individual risk to plants, invertebrates, and birds; aggregate risk to plants and invertebrates
- Lead – individual risk to plants and birds
- Dioxin TEQ (WHO1998 Bird) – individual risk to birds
- Total of 2,4'- and 4,4'-DDx – individual and aggregate risk to birds and mammals.

The CPECs identified for the proposed River Environmental Overlay Zone are consistent with those for the entire Site with one exception. Mammals were added to the list of potential receptors based on individual risk associated with lead exposure.

Hazard quotients were also elevated for alpha-HCH (individual risk to plants and invertebrates) and beta-HCH (individual risk to plants, invertebrates, birds, and mammals). However, neither alpha-HCH nor beta-HCH are identified as a CPEC because the frequency of detection for each substance was less than 5 percent and because for most samples their detection limits were greater than their respective SLVs. It should also be noted that neither of these constituents, nor gamma-HCH, were used or produced at the Site. Consequently, these limitations preclude meaningful assessment of risk and determination of their status as CPECs. Nevertheless, both alpha-HCH and beta-HCH are carried through the remaining sections of this Level II SERA to provide a complete assessment of their relative importance with respect to other chemicals identified as CPECs.

7.5 POTENTIAL ECOLOGICAL EFFECTS OF CPECs

Brief descriptions of the potential ecological effects for the CPECs are provided below, as available from the current literature. Evaluations of select trace metal SLVs are also discussed.

7.5.1 Trace Metals

7.5.1.1 Chromium

The chromium biogeochemical cycle is not well understood, and its speciation between two major valences, including Cr(III) and Cr(VI) in soils is complex. Cr(VI), or hexavalent chromium, is generally more stable and bioavailable in the presence of oxygen, higher pH, low organic matter, and manganese and iron oxides (USEPA 2005a). Cr(III), the trivalent form, tends to dominate in more acidic, anaerobic soils with higher organic matter content. Cr(VI) tends to be more water soluble and mobile since it has a low binding affinity for clay particles and organic matter.

The biological effects of chromium concentrations on ecological receptors in the environment are largely unknown. The toxic effects of Cr(VI) appear to be linked to the strong oxidizing potential of chromates. Further, chromates are reduced to Cr(III) during biological interactions and subsequently coordinated to organic molecules. However, chromium appears to be an essential metal for both the insulin/glucose system in humans and carbohydrate metabolism in mammals (Eisler 1986a). In addition, Cr(III) is important for activating some enzymes and providing stability to proteins and nucleic acids. The importance of chromium to plant nutrition has not been established, though some investigators have observed stimulatory growth effects of chromium in some plants (USEPA 2005a).

The anionic forms of chromium species tend to be absorbed more readily than the cation forms (USEPA 2005a). Cr(VI) is absorbed three to five times more efficiently in the intestine compared to Cr(III) (USEPA 2005a). The primary toxicological effects of chromium in ruminants include severe digestive tract inflammation, as well as kidney and liver damage (USEPA 2005a).

7.5.1.2 Lead

This element is shown to be of no benefit to plants or animals, and produces only negative effects in organisms exposed to it. It is also readily incorporated into the body through ingestion, inhalation, absorption, and placental transfer. Lead is toxic in many forms, and is a potent metabolic poison with substantial bioaccumulative properties. It modifies the structure and function of bone, tissues, and organ systems, causing a wide variety of negative effects, including skeletal deformities and reductions in survival, reproduction, body weight, and litter size. It has also shown to be carcinogenic, mutagenic, and teratogenic. In plants, excess lead causes reductions in mitosis, mitochondrial respiration, photosynthesis, and water absorption, as well as causing growth inhibition (Efroymson et al. 1997; Eisler 1988). Lead may be taken up

by roots but its translocation to shoots is limited (Efroymson et al. 1997). It tends to bind to root surfaces and may enter cell walls and organelles of root cells.

7.5.2 Organic Compounds

7.5.2.1 Total DDx

An overview of the historical uses, chemical fate, environmental toxicity, and ecological soil screening level values for DDT and related compounds is provided below.

Historical Uses

DDT was first synthesized in Germany in the late 19th century, and its insecticidal properties were later discovered and put to use just prior to World War II. It was manufactured and used in the United States to control agricultural pests and eradicate disease vectors until 1972. DDT was produced by the Pennwalt Corporation at what is now known as the Portland Arkema facility from 1947 to 1954. By the 1960s, DDT and other organochlorine pesticides came under regulatory and public scrutiny for potential environmental effects. Following the publication of *Silent Spring* by Rachel Carson in 1962, its use was the subject of much research and debate; it remains controversial especially with respect to effects on human populations (USEPA 1975; Gold et al. 2002; Safe 2003; Edwards 2004). DDT was one of the first substances to undergo critical review by EPA, and most uses were phased out and ultimately banned in the United States beginning in 1973. The decision to ban DDT in the United States was influential in controlling its usage in other parts of the world, where it was particularly important in the control of insect populations that are vectors of tropical diseases such as malaria. Recently, the net environmental and human health benefit of a complete ban on DDT usage has come into question because malaria and other diseases continue to be of epidemic concern (National Geographic 2007; WHO 2004).

Chemical Fate

DDT is the name that is commonly applied to 1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane. DDT has several isomeric forms, including *o,p*′-DDT (2,4′-DDT), but the collective ecological toxicity data on DDT has focused on *p,p*′-DDT (4,4′-DDT) as being the most toxicologically significant.

DDT and its primary metabolites, DDE and DDD, are persistent in the environment (USEPA 2007a) and can bioaccumulate. The degradation of 2,4′- and 4,4′-isomers of DDx is dependent upon environmental conditions such as physicochemical properties of the soil (e.g., presence of molecular oxygen and organic carbon) and the microbial community structure. In the presence of oxygen, DDT can be transformed to DDE via dehydrohalogenation (Alvarez and Illman 2006). This degradation process can occur microbially or chemically and does not require an input of electrons. In addition, DDE can be further degraded to 4,4′-dichlorobenzophenone (DBP) and ultimately mineralized to carbon dioxide (Aislabie et al. 1997).

In anoxic environments, DDT is reductively dechlorinated by microorganisms to DDD. This is a co-metabolic transformation because the degrading anaerobic microbes require an alternative carbon source, since nutrients and energy cannot be derived exclusively from DDT (Aislabie et al. 1997). DDD can be further reductively dechlorinated and degraded to a variety of metabolites (Aislabie et al. 1997), including the following:

- DDMU—1-chloro-2,2-bis(*p*-chlorophenyl)ethylene
- DDMS—1-chloro-2,2-bis(*p*-chlorophenyl)ethane
- DDNU—2,2-bis(*p*-chlorophenyl)ethylene
- DDOH—2,2-bis(*p*-chlorophenyl)ethanol
- DDA—bis(*p*-chlorophenyl)-acetic acid
- DDM—bis(*p*-chlorophenyl)methane
- DBH—4,4′-dichlorobenzhydrol
- DBP— 4,4′-dichlorobenzophenone.

Research indicates that DDT may be degraded by ligninolytic fungi in the presence of oxygen (Aislabie et al 1997). In fact, DDx may be completely mineralized to carbon dioxide by several groups of fungi (Bennet et al. 2002). DDT can be photolytically transformed to DDE in the presence of sunlight and further degraded photolytically to DBP and DDMU, although this process is less important than microbial biotransformation.

The literature suggests that DDT can also be metabolized to DDE in higher trophic levels (e.g., squid, fish, and mammals) (Tanabe et al. 1984; Nortstrom 2002). A group of oxygenases (CYP450) in vertebrates can rapidly transform 4,4′-DDT to 4,4′-DDE (Nortstrom 2002). This author also reported that 2,4′-DDT may be less persistent than the 4,4′-isomer, because it can be degraded to water soluble metabolites and subsequently excreted.

Environmental Toxicity

The potent insecticidal properties of DDT, which led to its widespread usage in the post-World War II era, act by opening sodium channels in insect neurons, causing them to fire spontaneously. This process leads to uncontrolled spasming and eventual death (USEPA 2007a). Chronic effects of DDT and its metabolites on ecological receptors include changes in enzyme production, hormonal balance, and calcium metabolism, which may cause changes in behavior and reproduction.

The best documented response is eggshell thinning in birds, which can result in embryo mortality and decreased hatchling survival (e.g., Heath et al. 1969; Lincer 1975). Overall avian sensitivity is highly variable. Raptors, waterfowl, passerines, and nonpasserine ground birds have been documented to be more susceptible to eggshell thinning than domestic fowl and

other gallinaceous birds, and DDE appears to have been a more potent inducer of eggshell thinning than DDT (USEPA 2007a). The leading hypothesis for DDE-induced thinning involves an inhibition by *p,p'*-DDE (but not by *o,p'*-DDE, -DDD, or -DDT) of prostaglandin synthesis in the shell gland mucosa (USEPA 2007a). Additional documented avian reproductive effects include decreased egg size, embyrotoxicity, delayed oviposition after mating, increased testicular effects, increases in broodless females, and decreases in mating pairs (e.g., Heath et al. 1969; Lincer 1975; Hoffman et al. 1995).

Overall, there is still some question as to the primary toxic mechanism, and reviewers have suggested that these may differ between bird species or differ with environmental conditions or physiological state for a given species (USEPA 2007a). Some higher trophic level fish-eating birds or raptors appear to be particularly sensitive, while others within these foraging guilds appear to have been relatively unaffected even during the peak period of organochlorine pesticide usage (Hoffman et al. 1995). This kind of variability is evident in toxicological studies (see Section 7.7.5) where lowest-observed-adverse-effect levels (LOAEL) ranged from doses as low as 0.3 mg/kg bw/d up to 50 mg/kg bw/d for reproduction and growth.

The effects of DDT on other receptor groups are not as well studied. USEPA concluded that there was not sufficient evidence to develop Eco-SSLs for either soil invertebrates or plants (USEPA 2007a). However, USEPA (2007a) has published Eco-SSL values for DDT and metabolites (DDx) for birds and mammals. The Eco-SSLs are based on 105 studies for birds and 73 studies for mammals that met the data quality requirements. The minimum Eco-SSL for DDT in soils is 0.093 mg/kg for birds and 0.021 mg/kg for mammals (USEPA 2007a).

As noted below, there is a very high degree of uncertainty in the Eco-SSL for DDT, which may be several orders of magnitude lower than needed to make conservative screening level judgments. Consequently, recommendations for Site management decisions (Section 8.2) will focus on soil concentrations in comparison to screening level values and Eco-SSLs for birds.

7.5.2.2 Alpha- and Beta-Hexachlorocyclohexane

HCH isomers generally have low mobility in soils due their tendency to adsorb to soil particles. These pesticides tend to break down via biodegradation in soils. Hydrolysis and photolysis may also represent fate processes in moist alkaline soils. Biologically-rich anaerobic environments appear to favor the HCH transformation processes. Alpha-, beta-, and delta-HCH tend to be the most environmentally persistent isomers of the group (ATSDR 2005).

HCH uptake from soils and bioconcentration in plants and soil invertebrates appear to be limited (ATSDR 2005). This may be due to its metabolism by terrestrial organisms. These isomers may be neurotoxic, cytotoxic, and hepatotoxic in mammals at high dosages. Beta-HCH is the most toxic following chronic exposures (followed by the alpha-HCH) due to its longer biological half-life (most prevalent isomer in animal fat) and eventual accumulation in the body over time. However, beta-HCH is the least toxic (of the four major isomers) following acute

exposure. Elevated concentrations of HCHs may inhibit seed germination in plants and have also been shown to be toxic to soil invertebrates. HCHs may cause adverse reproductive effects in birds, although the chronic effects on mammal reproduction, growth, and survival are not well understood (ATSDR 2005).

7.5.2.3 2,3,7,8-Tetrachlorodibenzo(p)dioxin

Dioxin/furans are produced from the incomplete combustion of organic material (e.g., fossil fuels) and chlorine bleaching process employed by pulp and paper mills. They are lipophilic compounds that tend to persist in the environment (ATSDR 1998). Dioxins are also believed to cause alterations to developmental, endocrine, and immune function in animals. Exposure to 2,3,7,8-tetrachlorodibenzo(p)dioxin (TCDD) has been shown to cause reproductive damage and birth defects in animals (ATSDR 1998).

The 2,3,7,8-TCDD congener is the most toxic and best studied of the various polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) and dioxin-like co-planar PCB compounds. The 2,3,7,8-TCDD congener has been associated with lethal, carcinogenic, teratogenic, reproductive, mutagenic, histopathologic, and immunotoxic effects (Eisler 1986b). The biological effects of other PCDD/Fs and dioxin-like compounds are not as well understood, but their toxic potency relative to that of 2,3,7,8-TCDD has been inferred using a quantitative structure-activity relationship (QSAR) process. These QSARs have been used to derive toxicity equivalency factors (TEFs) for PCDD/Fs and dioxin-like substances (e.g., some co-planar PCBs). The TEFs are based on an order of magnitude estimate of the toxicity of a compound relative to 2,3,7,8-TCDD (Van den Berg et al. 1998).

7.6 CONCEPTUAL SITE MODEL

A CSM was developed for the Site's potential ecological habitats evaluated during the Level II SERA. The following sections provide details regarding chemical release mechanisms, fate and transport pathways, exposure pathways and uptake routes, and potentially affected Site receptors. The inter-relationships of these CSM components are illustrated in Figure 7-1.

7.6.1 Release Mechanisms

The following release mechanisms have led to the presence of COIs in abiotic exposure media at the Site:

- Migration to upland surface soils via spills and leaks and geogenic sources of naturally occurring inorganic chemicals
- Migration to riparian surface soils from fill material historically deposited on the riverbank

- Leaching to subsurface soils from surface (upland) soils, from unlined ponds and trenches, and from the floor drain installed during the DDT manufacturing process.
- Deposition of river sediments on the riverbank during higher river stages and flooding.

These release mechanisms and impacted media (surface and subsurface soils) and exposure pathways leading to potential ecological receptors are discussed below.

7.6.2 Contaminated Media: Surface and Subsurface Soils

Chemicals released to surface soils from spills and leaks during historic Site operations would have been incorporated into the soil matrix. The chemicals would thus be available to biota via direct physical contact or ingestion routes. Chemicals associated with fill material imported to the Site and deposited in the upland and on the riverbank, as well as dredge spoils from the Willamette River, would have impacted surface upland and riparian soils, which would then be potentially taken up by biota living in the soil. In addition, chemicals transported in suspended sediment loads in Willamette River surface water would have been deposited on the riverbank during flood events.

Subsurface soils would have been impacted by the leaching of chemicals from surface soils, especially during precipitation events. Leached chemicals in subsurface soils could be taken up or deposited onto the tissues of ecological receptors. Chemicals associated with fill materials (i.e., dredge spoils or imported fill) would be associated with the subsurface soil matrix and would be available to biota via direct physical contact and ingestion.

7.6.3 Potentially Complete Exposure Pathways

Based on the identified CPECs and their fate and transport characteristics, the following ecological exposure pathways are considered potentially relevant and complete.

- Plant exposure to CPECs in upland and riparian soils – Possible exposure mechanisms are direct contact and chemical uptake via plant roots.
- Soil invertebrate exposure to CPECs in upland and riparian soils – Possible exposure mechanisms are direct and incidental ingestion of soil while foraging for food and ingestion of contaminated plant or animal food.
- Mammal exposure to CPECs in upland and riparian soils – Possible exposure mechanisms are direct and indirect ingestion of soil while foraging for food and ingestion of contaminated plants or animal food.
- Avian exposure to CPECs in upland and riparian soils – Possible exposure mechanisms are direct and incidental ingestion of soil while foraging for food and ingestion of contaminated plant or animal food.

7.6.4 Incomplete Transport Pathways

Groundwater and surface water are considered incomplete exposure pathways for the Site and for the proposed River Environmental Overlay Zone. Although groundwater occurs in four distinct soil or bedrock zones beneath the Site (shallow, intermediate, deep, and basalt zones; ERM 2005b), it is not likely to be available to potential ecological receptors using the Site. Minimum depth to groundwater is approximately 6 ft (Integral 2006) below the ~1 m root zone of most terrestrial plants (DEQ 2001), and therefore unavailable to terrestrial plants and the animals that would feed on them.

No areas of standing surface water that could support potential ecological receptors have been documented in terrestrial portions of the Site. As a result of periodic precipitation, surface water may occur as transient puddles in shallow depressions at the site. However, this surface water rapidly penetrates into Site soils, where it either becomes part of the bulk soil matrix, infiltrates to groundwater, or is lost through evapotranspiration. With the exception of some minor erosion of bank soils, little overland transport of chemicals is expected via soil erosion. Lots 3 and 4 are served by a storm sewer system that conveys stormwater directly to the Willamette River; therefore, overland sheet runoff to the river is not expected.

7.7 DISCUSSION AND UNCERTAINTY EVALUATION

Discussion of the results of the Level II SERA and associated uncertainties is provided below in the context of the general methods used to estimate risk, habitat quality and value, and chemical specific SLVs and risk estimates.

7.7.1 Method Uncertainty

A Level II SERA is only a first approximation of potential risk and is appropriately based on conservative standards of comparison (i.e., SLVs). The SLVs are based on no-observed-adverse-effects levels (NOAELs) to screen for possible risks to individual organisms or on five times the SLV to screen for possible risk to populations of organisms that may inhabit the site. This Level II SERA is based on 5X weighting of SLVs because protected species do not inhabit the site. The 5X weighting factor effectively adjusts the NOAEL to a LOAEL. For a Level III or Level IV ecological risk assessment, these SLVs are replaced by ecological benchmark values (EBVs) to judge risk. The EBVs complement and may be derived from the same data as the preceding SLVs. EBVs may be derived from NOAELs to evaluate risk to individual organisms (applicable in the case of protected species) or may be weighted at 100 times the NOAEL or 20 times a LOAEL to assess population level risk. These differences between SLVs and EBVs indicate that risks in a Level II SERA are conservatively based, are unlikely to underestimate risk, and may yield risk estimates that are 20 times greater than those that might be generated in a Level III or Level IV analysis.

7.7.2 Habitat Quality

The plant community along the riverbank area is largely dominated by invasive, weedy species, and the upland areas of Lot 1 and the northeast portion of Lot 2 have a limited amount of grassy and deciduous tree cover. Given the history of industrial and shoreline development at the Site and its frequency of disturbance, it is unlikely that population or community level effects of chemical stressors can be distinguished from and may be outweighed by nonchemical stressors.

7.7.3 Trace Metals

The trace metal analytical data in soils were evaluated to identify the specific areas at the Site that pose potential risk to ecological receptors. The data were also examined to determine the existence of outliers in the data set and to determine the influence of more recent and relevant toxicological benchmarks (Section 7.5).

7.7.3.1 Chromium

The maximum detected concentration (MDC; 810 mg/kg at Station RBC-1) appears to be associated with a localized area of high-concentration soil material since four of the six highest concentrations were measured in this vicinity adjacent to the top of the riverbank along the border of Lots 1 and 2 (410 mg/kg at Station RBC-2; 170 mg/kg at Station RBC-4; and 113 mg/kg at Station SS1-1). The chromium HQs for each sample and receptor were plotted on maps for assisting with spatial interpretation (Figure 7-2). It should be noted that the chromium concentrations at RBC-1, RBC-2, and SS1-1 exceeded the SLVs for all four receptors by at least five times.

Contrary to the findings that ultimately led to the determination of Eco-SSLs for chromium (which were lower for the trivalent form; USEPA 2005a), the toxicity of Cr(III) is thought to be generally low due to its limited membrane permeability (Eisler 1986a). This low permeability prevents it from being bioaccumulated in food chains. Further, Cr(VI) is generally considered to be more toxic than the trivalent form due to its high oxidizing potential and membrane permeability (Eisler 1986a). In addition, the Eco-SSLs for Cr(III) (the lower of the two species) are below Washington State background concentrations. Due to the uncertainties resulting from differing opinions regarding chromium toxicity, and the fact that SLVs are below background, the selection of these Eco-SSLs results in unrealistic values that cannot be used to make effective site-management decisions. Consequently, the range of background concentrations (95% confidence interval of 20 – 120 mg/kg dw) in the western U.S. should be considered in judging risks and making site management decisions (USEPA 2005b, 2007b).

Finally, in comparison with DDx the hazard quotients for chromium are relatively low and therefore do not represent significant risk drivers at the Site.

7.7.3.2 Lead

Lead concentrations in soils appear elevated in comparison to DEQ's (2001) SLVs for both plants and birds. The MDC (2,090 mg/kg at Station RB-8; HQs for each sample and receptor are presented in Figure 7-3) appears to be associated with a localized portion of high-concentration soil material, because it is an order of magnitude greater than the next highest concentration (130 mg/kg at Station RBC-11; Figure 7-3). The MDC sample is located between Docks 1 and 2 within the footprint of the in-water EE/CA removal action that is being conducted with EPA. By removing the MDC, the new Site maximum (130 mg/kg) and EPC (63 mg/kg) soil concentrations would still be greater than background levels (Figures 7-4 and 7-5) but would nevertheless achieve HQs less than 5 for plants and birds. Following removal of the MDC area, lead would not be a CPEC for either plants or birds at the remainder of the Site. Consequently, it is recommended that the soil between Dock 1 and Dock 2 be incorporated into and addressed at the same time as the EE/CA remedy proposed for this area.

Finally, in comparison with DDx the hazard quotients for lead are relatively low and therefore do not represent significant risk drivers at the Site. It should also be noted that the source of lead is not known and has not been implicated in any historical Site processes.

7.7.4 Dioxin TEQ

Three of the four highest Dioxin TEQ WHO1998 Bird concentrations (MDC equals 0.00116 mg/kg at Station RBC-5) were measured in samples collected along the riverbank adjacent to Lot 2 (RBC-3 and RBC-5; HQs for each sample and receptor are presented in Figure 7-6). The third highest concentration was measured at RBC-11 (0.000734 mg/kg) near the southern extent of the property along the riverbank.

The individual dioxin/furan congener TEQ concentrations were evaluated to determine their contribution to the total Dioxin TEQ WHO1998 Bird values. The congeners that contribute 25 percent or more of the total TEQ for the various samples are:

- 1,2,3,4,6,7,8-Heptachlorodibenzofuran
- 1,2,3,7,8-Pentachlorodibenzo-p- Dioxin
- 2,3,7,8-Tetrachlorodibenzofuran
- Octachlorodibenzofuran
- Octachlorodibenzo-p- Dioxin.

PCB congeners were only measured in a single sample at location BO18. TEQ concentrations for the PCB congeners collectively accounted for only 2.6 percent of the total TEQ for birds and 3.9 percent of the total TEQ for mammals. Consequently, it is likely that the dioxin congeners listed above dominate total TEQ concentrations and related risks for both birds and mammals

throughout the site. A complete summary of the relatively contribution of individual substances to total TEQ for each sample is provided in Appendix H.

7.7.5 Total DDx

Based upon the concentrations present in Site soils and comparisons to the Eco-SSLs for DDT (USEPA 2007a), DDx is the primary ecological risk driver for the Site. The Total DDx HQs for each sample and receptor were plotted on maps for assisting with spatial interpretation (Figure 7-7). The primary areas of concern with respect to risk are commensurate with the highest DDx concentrations. These include the riverbank just north of Dock 2 (RB-9 and RB-10), between Docks 1 and 2 (RB-8 and RB-11), a portion of the upland on Lot 1 adjacent to the former DDT trench (Station SS1-3 and SS1-4), and the northern portion of the riverbank adjacent to Lot 2 (Station RBC-3). However, even though the highest concentrations tend to be localized, elevated soil concentrations and risk levels associated with DDx appear to be widely distributed throughout the majority of the upland and riverbank areas.

Uncertainty in this estimate of risk concerns the method of calculation of total DDx and the Eco-SSL adopted as the standard of comparison to soil concentrations. A number of samples were only analyzed for the 4,4′-isomers of DDD, DDE, and DDT. Consequently, a regression analysis based on detected analytes (for samples where both 2,4′- and 4,4′-isomers were detected) was conducted to estimate soil concentrations for missing 2,4′-isomers. The coefficient of determination for the regressions ranged from 0.85 to 0.99, indicating a strong linear relationship. Consequently, the 2,4′-isomers could be estimated from their respective 4,4′-isomers with a relatively high degree of confidence. This analysis indicates that site-soil concentrations were not underestimated (Appendix E).

The Eco-SSLs adopted as the SLVs for comparison with soil screening level values may overestimate risk substantially. USEPA (2007a) has published final Eco-SSL values for DDT (and metabolites DDD and DDE). Studies accepted by USEPA (2007a) in developing avian soil screening levels for DDT and metabolites report concentrations ranging over several orders of magnitude, from a NOAEL dose of 0.0396 mg/kg bw/d DDE for an American kestrel study with an eggshell thinning endpoint, to a no-effects level dose of 100 mg/kg bw/d for survival in a study of starlings (USEPA 2007a). The NOAEL selected by EPA for use in developing the Eco-SSL for birds of 0.227 mg/kg bw/d [10] was the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival. The LOAEL for the selected study is 10 times greater than the NOAEL that was selected to calculate an Eco-SSL. The geometric mean of all NOAEL values was 4.66 mg/kg bw/d. Hence, depending on the selected study, species and endpoint, actual effects may not be observed until exposure levels reach approximately 10 to 20 times the selected NOAEL.

[10] A concentration associated with no observed effects on body weight in chicken (*Gallus domesticus*) (Cecil et al. 1978 as cited in USEPA 2007b).

Several toxicity studies have been conducted for DDx in various mammals. The bulk of the studies have been conducted on rodents, although toxic effects on sheep, dogs, rabbits, and bats have also been evaluated (USEPA 2007a). Reproductive and growth NOAELs used by USEPA (2007a) to develop an Eco-SSL for DDT and metabolites in soil range over four orders of magnitude. The NOAEL selected by EPA for use in developing the Eco-SSL for mammals of 0.147 mg/kg bw/d[11] was the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, and survival, and is one of the lowest NOAELs of all the studies included in EPA's review. A preliminary review of this study (Wrenn et al. 1970) reveals several flaws in its derivation that are generally incompatible with USEPA (2003) guidance for evaluating such values:

- The primary endpoint used (vaginal patency in juvenile rats) should have been classified as a pathology or physiology endpoint rather than a reproductive endpoint, which would have excluded the values cited from determination of an Eco-SSL.
- The exposure was in a carrier medium (olive oil) that was delivered via gavage.[12] Gavage and capsule studies are less desirable because they do not generally reflect natural feeding behaviors, and the vehicle used to deliver the gavage dose can alter the kinetics of absorption.
- Statistical analyses were not presented to confirm whether the percent vaginal patency at any of the doses were significantly different from control.
- Supporting studies based on exposure via ingestion of food were not sufficiently documented and precluded determination of the weight of exposed animals and the dose associated with reported differences in ovarian weight.

These issues raise substantial uncertainty in the validity of the selected NOAEL and its subsequent conversion to an Eco-SSL for mammals. If the Wrenn et al. (1970) study is disqualified, then the NOAEL may be 1.71 mg/kg/d based on the information provided by USEPA (2007a). The LOAEL for this alternative study is 17.1 mg/kg/d, which is more than 100 times greater than the NOAEL that was selected to calculate an Eco-SSL. Hence, for the selected study and endpoint, actual effects may not be observed until exposure levels were approximately 100 times the selected NOAEL.

7.7.6 Alpha-HCH and Beta-HCH

There are several sources of uncertainties concerning alpha-HCH and beta-HCH that affect judgments pertaining to their presence at the site and the standard for judging their potential risk to ecological receptors.

[11] A concentration associated with no observed effects on reproduction in rat (*Rattus norvegicus*) (Wrenn et al. 1970 as cited in USEPA 2007b).
[12] Delivery through a tube that is inserted through the mouth and into the stomach.

Alpha-HCH was only detected in two samples (4%) collected in support of the Level II SERA with a MDC of 0.11 mg/kg at Station RB-8. Beta-HCH was only detected in two samples (4%) collected in support of the Level II SERA with an MDC of 74 mg/kg at Station RBC-10. In general, chemicals with a frequency of detection less than 5 percent do not need to be carried through chemistry-toxicity screening for CPEC identification (DEQ 2001). The low frequency of detection for both alpha-HCH and beta-HCH was accompanied by detection limits that were often above the SLV adopted as the standard of comparison for calculating hazard quotients and determining risk levels.

Additional uncertainty is associated with the SLVs for both alpha-HCH and beta-HCH, which were derived from the USEPA Region 4 website[13] table of soil SLVs. Both HCH isomer values (0.0025 mg/kg for alpha-HCH, and 0.001 mg/kg for beta-HCH) are attributed parenthetically to a 1994 publication by the Dutch Ministry of Housing, Spatial Planning, and Environment (DMHSE). However, Region 4 does not provide a full citation for this source. In support of this Level II SERA, the DMHSE (1994) publication was obtained and reviewed to determine the basis for the SLVs. Here too actual methods and sources for derivation of these values are not provided. DMHSE (1994) indicates only that the selected SLVs represent target values, which are cleanup goals based on consideration of background concentrations as well as other factors. DMHSE (1994) also provides a 2 mg/kg "intervention value" for total HCH compounds, which is based on ecological effects. The intervention value is approximately 150 times greater than the sum of the target values for alpha-HCH and beta-HCH. A more recent Dutch Ministry Circular (DME 2000) was also obtained in an effort to verify these values. DME (2000) indicates that the SLV for beta-HCH has increased 9 fold to 0.009 mg/kg and also suggests that the HCH values were derived from water management standards. Given these uncertainties neither the methodology nor the accuracy used in deriving either of these SLVs could be verified.

Given the low frequency of detection (less than 5%), high detection limits and inherent uncertainties in the toxicological basis the SLV derivation for neither alpha-HCH nor beta-HCH can be evaluated meaningfully and neither is recommended as a CPEC for Site management decisions.

[13] http://www.epa.gov/region4/waste/ots/epatab4.pdf, updated on November, 2001.

8 RECOMMENDATIONS

The DEQ (2001) guidance includes a set of technical management decision points (TMDPs) that need to be addressed during the ecological risk assessment process. These TMDPs include evaluating whether the available data are sufficient for the assessment, determining if ecological risk is probable, and the possibility of recommending a remedial action. The Level II screening process was effective for evaluating the available data, identifying CPECs for each habitat, and establishing potential for chemical exposure and ecological risk. However, given the nature of the Site and ongoing remediation and source control activities, a Level III ecological risk assessment is not recommended. The Site has been used for 50 or more years to support industrial activities in the shoreline and in the upland areas, and its future use will continue to be as an industrial property. Also, in the short term, ongoing Site closure and remediation activities in upland, shoreline, and in-water areas will contribute to ecological disturbance and further diminish habitat quality. Consequently, there would be little net environmental benefit gained from a more detailed risk analysis and any ensuing cleanup or restoration activities. Based on the Level II SERA, determination of appropriate cleanup levels and focused remedial action is recommended for areas of concern associated with DDx in soils.

8.1 CLEANUP LEVELS

Screening level values such as those promulgated by DEQ (2001) or the more recent Eco-SSLs generated by USEPA (2005a,c; 2007a,c) are not designed to be used as cleanup levels, but are intended to broadly and conservatively assess site conditions and guide decisions to conduct a more detailed evaluation. Consequently, it is recommended that the screening level benchmarks used as metrics to judge risk at the Site for the Level II SERA be revisited in the hotspot analysis to determine practical target cleanup levels commensurate with populations of receptors that may actually occur at the Site and which can be used to facilitate focused remedial activities as discussed below.

8.2 FOCUSED REMEDIATION

Focused Site remediation is recommended through the following activities:

1. Removal or capping soils in areas shared with the proposed EE/CA removal action
2. Removal or capping of soils in areas proposed for Site management construction activities (e.g., a stormwater management basin)
3. Continued mitigation, as necessary, by elimination of habitat to deter colonization by opportunistic plant species that serve to attract soil invertebrate, small mammal, and avian species

4. Evaluation of areas not addressed by Items 1 to 3 above in the full site feasibility study as appropriate.

These directed soil remedial actions would be the most practical and cost-effective solution for reducing ecological risk at the Site from potential DDx exposures.

Parts of the riverbank are already being considered for a response action pursuant to the early action of the in-water removal with EPA during the Site's EE/CA process. There will be considerable activity on the riverbank in support of the in-water action. Excavating equipment present during the in-water action will be available for riverbank remedial efforts. Riverbank material may be removed or capped in place so that chemicals are below relevant site-specific cleanup levels or physically isolated at depths where they no longer qualify as CPECs at the Site.

The future use of the upland portion of the Site including Lot 1 and the northeast portion of Lot 2 will remain heavy industrial with frequent physical disturbance or complete habitat elimination associated with Site management, construction activities, and redevelopment. Furthermore, as directed in a City of Portland nuisance complaint, LSS will continue to provide active maintenance of the nuisance, invasive vegetation on Lots 1 and 2 and elsewhere on the Site on an ongoing basis. LSS, therefore, does not believe that the transformation of this area to preindustrial pristine open space, which is also not in line with past, present, or future zoning and property use, is a relevant or appropriate approach to Site management.

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