Feasibility Study

Former Ken Foster Farm
23000 to 23500 SW Murdock Road
Sherwood, Oregon

June 18, 2015
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EXECUTIVE SUMMARY

This Feasibility Study (FS) was prepared by Geosyntec Consultants Inc. (Geosyntec) for the Oregon Department of Environmental Quality (DEQ) under Task Order 21-13-14 of Geosyntec’s contract to provide consulting services to the DEQ. The purpose of the FS for the Ken Foster Farm site is to evaluate a range of remedial alternatives, and develop and present a recommendation for remedial action for both the upland residential (high use) portions and wetland portions of the site.

The FS was conducted in seven main steps described below.

Identification of Remedial Action Volumes and Areas: Removal depths and volumes were based on the historical data collected in the upland areas and the wetland. For upland soils, the remedial action areas were evaluated based on “high use areas.” The high use areas are defined as the land around existing residential structures (e.g. landscape, grass, or play areas) where potential exposure of residents to contamination is most likely. For the wetland area, the entire wetland area contains total metals at concentrations that exceed ecological hotspot levels. As such, the remedial action area for the wetland has been defined at the boundary of the delineated wetland.

Identification of Remedial Action Objectives and General Response Actions: Remedial action objectives (RAOs) describe what a remedial action is designed to achieve. The remedial action objectives were evaluated to make sure they met applicable laws and regulations. The proposed RAOs for the site are as follows:

- Prevent ecological receptors from exposure to wetland sediments containing total chromium, lead, mercury, and chromium (VI) [Cr(VI)] that exceed ecological hot spot criteria.
- Prevent migration of upland soil or sediments in stormwater or surface water runoff that could result in recontamination of the wetland.
- Remediate soil or sediment hot spots of contamination to the extent feasible.
- Reduce transport of chromium, lead, and mercury in upland surface soil runoff to wetlands that would result in further sediment and porewater contamination.
- Prevent human receptors from exposure to upland soils containing Cr(VI) above exposure scenarios greater than 1x10⁻⁶ risk within high use areas.

General response actions were also developed. General response actions are broad categories of remedial measures and technologies that potentially address RAOs. DEQ guidance requires that the FS develop a range of alternatives, derived from one or more general response actions. General response actions include:
- **No Action** – A no action alternative serves as a baseline for comparison of other potential remedial actions. The no action will be used as the baseline for both the upland and wetland portions of the Site.
- **Institutional Controls** – Institutional controls are legal or administrative measures or actions that reduce exposure to hazardous substances.
- **Engineering Controls** – Engineering controls are physical measures that prevent or minimize exposure to hazardous substances or reduce the mobility or migration of hazardous substances.
- **Removal/Disposal** – Excavation and off-site disposal involves removal of materials to be managed or disposed under local, state, or federal law.
- **Treatment** – Treatment is the permanent and substantial elimination or reduction in the toxicity, mobility, or volume of hazardous substances by using in-situ or ex-situ remedial technologies.

**Identification and Screening of Applicable Remedial Technologies:** Various options associated with each technology were developed. Technologies were initially screened based on a qualitative assessment of effectiveness, implementability, and cost. The purpose of this screening is to produce an inventory of suitable technologies that can be assembled into candidate remedial alternatives capable of mitigating actual or potential risks at the site.

**Development of Remedial Action Alternatives:** Removal action alternatives for the site were developed by combining remedial technologies and options. The following is a summary of the retained alternatives.

- **Upland Alternative 1 (UA1), No Action** – No action will be taken to mitigate risk.
- **Capping in Place (UA2)** – This alternative involves installing a nominal 1-foot-thick soil cap with sod or seed, which is tied into grade along the perimeter of the yard.
- **Excavation with Off-site Disposal (UA3)** – This alternative involves the excavation of soils above the RAO with subsequent transportation and offsite disposal at a permitted facility.
- **Wetland Alternative 1 (W1), No Action** – No action will be taken to mitigate risk.
- **Capping in Place (W2)** – This alternative involves the placement of a nominal 1-foot soil cap over the sediments that exceed RAOs. Residual contamination will be left in place and covered with an on-site soil cover that will restrict direct contact with contaminated soil.
- **Excavation with On-site Consolidation and Capping (W3)** – This alternative is substantially similar to UA3, except that contaminated sediments above the RAO will be excavated and consolidated in a portion of the wetland.
- **Excavation with Off-site Disposal (W4)** – This alternative involves the excavation of sediments above the RAO with subsequent transportation and offsite disposal at a permitted facility. Institutional controls will be implemented as needed.
• Excavation of Ecological Hot Spots with Off-site Disposal with Capping of Remaining Soils (W5) – This alternative involves the excavation of all sediments that exceed ecological hot spot screening values with subsequent capping of the remaining sediments in place.

**Detailed Analysis of Alternatives:** A detailed analysis of the alternatives was conducted to select the best alternative. Each alternative was evaluated against the following criteria:

• Protectiveness;
• Effectiveness;
• Long-term Reliability;
• Implementability;
• Implementation Risk; and
• Reasonableness of Cost.

**Comparative Analysis of Alternatives:** Following the detailed analysis of each of the retained removal action alternatives, it is necessary to compare how each removal action alternative satisfied the evaluation criteria. The comparative analysis discussion centers on the overall site and to identify the advantages and disadvantages of each alternative relative to one another.

**Recommended remedial Action Alternative:** The following is a summary of the recommended remedial actions alternatives.

**Upland Soils – High Use Areas**

Both excavation and capping are viable alternatives for upland soils. A combination of the alternatives UA2 and UA3 may be appropriate based on site-specific conditions. In areas with mature vegetation and trees, the use of UA2 (capping) would be preferred. During the scoring of the upland alternatives, UA2 (capping) scored slightly higher than UA3 (excavation).

**Wetland**

Alternative W4 (excavation) and W5 (hot spot removal and capping) scored the highest, followed by onsite consolidation and capping. Similar to the upland alternative, it is likely that a combination of alternatives may be chosen during the remedial design.
1. INTRODUCTION

This report presents the Feasibility Study (FS) for the former Ken Foster Farm (KFF) site in Sherwood, Oregon (Figure 1). This report was prepared for the Oregon Department of Environmental Quality (DEQ) under Task Order 21-13-14 of Geosyntec’s contract to provide consulting services to the DEQ. The scope of services for the FS are described in the budget and assumptions proposal (BAP) dated December 2, 2014 and the general approach to the FS was presented in the Feasibility Study Planning and Scoping Technical Memorandum dated June 3, 2014 and the Feasibility Study Memorandum dated December 19, 2014.

This FS report has been prepared in general accordance with the requirements of Oregon Administrative Rules (OAR) 340-122-085 and 090, Guidance for Conducting Feasibility Studies (DEQ, 1998), and as appropriate, Guidance for Conducting Remedial Investigations and Feasibility Studies Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3-01 (EPA, 1998).

The KFF site is referenced in DEQ Northwest Region Files as Environmental Cleanup Site Information Number [ECSI#] 2516). Several previous investigations were completed at the KFF site between 2006 and 2011. Results from these investigations indicated that soil had been impacted by chromium-containing tannery wastes from the Frontier Leather Tannery (ESCI# 116 and ESCI# 2638) that were applied to the KFF site.

1.1 Purpose

The purpose of the FS for the KFF site is to evaluate a range of remedial alternatives, and develop and present a recommendation for remedial action for both the upland residential (high use) portions and wetland portions of the site.

2. SITE HISTORY AND REMEDIAL INVESTIGATION SUMMARY

2.1 Site Description

The KFF site is a 40-acre tract of former pasture land at 23000 to 23500 SW Murdock Road in Sherwood, Washington County, Oregon (Figures 1 and 2). The KFF site is located in the northwest quarter of the southwest quarter of Section 33, Township 2 South, Range 1 West of the Willamette Meridian. DEQ file information indicates that between 1962 and 1971, tannery wastes from the former Frontier Leather Tannery (ESCI# 116 and #2638) were land applied at KFF as a soil amendment. The wastes reportedly were covered in lime to control odor and tilled into existing soil. The wastes included animal wastes from the tannery’s hide preparation operations (such as hide scrapings, tissue, fat, and hair), as well as liquid sludge from the tannery’s wastewater settling tanks. Evidence of waste disposal, such as bone fragments and stained soil, is still visible in some areas at the KFF site.

The original KFF site was divided into ten tax lots and redeveloped as low-density residential properties. Tax Lot 900 was further subdivided into eight tax lots in 1995, with four lots
zoned for residential use (Lots 2200, 2300, 2400, and 2500). The other four tax lots to the south (Tracts 2600, 2700, 2800, and 2900) comprise a lowland containing a wetland and surrounding riparian area covering about two acres. There is a small wetland of less than 0.5 acres along the north edge of Tax Lot 1300, adjacent to Ironwood Lane.

Lots 2200, 2300, 2400, and 2500 were remediated (removal and capping) by Ironwood Homes under DEQ oversight and received No Further Action (NFA) determinations from DEQ. Excavated soil from these lots was placed on Tax Lot 2900 and Tax Lot 300, covered with clean imported fill, and seeded to provide a vegetative cover. These two areas are referred to as engineered soil cells and do not present a risk to human health because the caps prevent exposure.

DEQ also issued a NFA determination for Tax Lot 1100 following an investigation by the United States Environmental Protection Agency (EPA). No additional work is anticipated on the five lots that have been issued NFAs by DEQ and EPA. The properties with NFA determinations comprise approximately 3.5 acres of the 40-acre site. DEQ has responsibility for contamination associated with the wetland and surrounding riparian area, with the exception of the engineered soil cell on Tax Lot 2900, under terms of a Consent Decree finalized in 2013.

2.2 Physical Features

Site elevations range from about 250- to 360-feet above mean sea level (MSL). Two 40- to 90-foot high on-site knolls create a rolling topography. One knoll is located in the northeast quadrant of the KFF site; the other crests along the KFF site’s southern boundary. An approximate two-acre persistent, emergent, palustrine wetland area lies between the two knolls, just inside the KKF site’s eastern boundary. It appears to occupy an ancient flood channel, as discussed below. An outlet at the southeast end of the wetland leads to the Rock Creek Drainage. Rock Creek is approximately 1,000 feet to the east at an elevation of about 150 feet.

DEQ staff observed the drainage in late February 2014 after sustained rainfall events the preceding several weeks. At this time, the wetland was at maximum capacity. Surface water was observed approximately 200 feet downhill from the wetland outlet, beyond which it apparently infiltrated into the soil horizon. There was no indication of flow beyond this point, although a vegetated channel continues down the hillside. It appears this channel is man-made given its rectangular cross-section, and is consistent with linear features on historic aerial photographs (DEQ 2005). There is no evidence of channelized flow or established drainage from the wetland to Rock Creek. Based on these observations, flow from the outland is of low volume and frequency, and it is unlikely that significant runoff volume from the onsite wetland reaches Rock Creek.
2.3 Remedial Investigation Summary

From August through November 2013, Geosyntec and Kennedy/Jenks Consultants (Kennedy/Jenks) completed Remedial Investigation (RI) field activities at the KFF site. The RI focused on establishing the nature and extent of hexavalent chromium [Cr(VI)], total chromium (trivalent chromium Cr[III] + Cr[VI]), lead, and mercury in soil, groundwater, sediments, and surface water in uplands and wetlands areas. RI field activities were conducted using a phased approach. Phase I soil sampling field activities were conducted at Tax Lot 100 and included the collection of discrete surface and subsurface soil samples at 98 locations in decision units (DU) DU-1 through DU-3 and collection of composite surface soil samples at DU-1. Phase II soil sampling was scoped based on the results of the Phase I soil sampling and included the collection of surface and subsurface discrete soil samples at 229 locations at Tax Lots 200, 300, 600, 700, 1000, 1200, and 1300.

In September 2013, a wetland field investigation was conducted that included the collection of wetland sediment, groundwater and surface water samples at seven locations. In September and November 2013, groundwater samples were collected from three on-site wells, the City of Sherwood well #6, and a background well.

In February 2014, DEQ staff collected soil samples in off-site areas to assess regional background concentrations of total chromium and Cr(VI) in soil.

In August 2014 DEQ staff collected samples from the hillside leading to Rock Creek to the east of the KFF properties, and also residential properties immediately south of KFF properties, to assess the extent of KFF Site-related contamination.

2.3.1 Locality of Facility

As defined in OAR 340-122-115(35), the locality of facility (LOF) is “any point where a human or ecological receptor contacts or is reasonably likely to come into contact with facility-related hazardous substances. The LOF takes into account the likelihood of the contamination migrating over time, so is typically larger than the facility. DEQ has recently issued an Internal Management Directive providing guidance that clarifies the role of the LOF in remedial investigations and delineation standards for establishing the extent of contamination. For this site, the LOF is defined as the KFF site properties including the on-site wetlands and also the hillside to the west leading to Rock Creek. Further off-site testing is needed on residential properties to the south to verify the extent of contamination detected during the DEQ 2014 sampling. Based on these results, the LOF will likely be expanded to these properties or a portion of these properties during remedial design.

2.3.2 Local and Site Geology

The KFF site is located at the boundary between the southeast foothills of the Chehalem Mountains and broad lowlands of the Tualatin River Valley. It lies in an upland area on the east side of the Rock Creek drainage basin. Columbia River Basalt (CRB) underlies the entire
Tualatin River Valley and is exposed at the KFF site. The Sherwood Fault trends northeast-southwest near the northwest corner of KFF site.

Soil thickness at the KFF site ranges from approximately 0 to 8 feet. CRB is exposed along hillsides in places. The thickest soil is in the wetland and the lower elevations of the site. Tannery waste has contributed to the soil column over much of the KFF site.

The following provides a summary of shallow subsurface conditions observed during the 2013 RI field activities.

- The soil observed in the borings consisted of either: 1) light brown silty sand to sandy silt with gravelly silty sand, or 2) dark reddish brown to gray brown silty clay to clayey silt.
- Angular to subangular gravel (basalt) was observed in nearly all borings with depths ranging from approximately 0.5 to 5.6 feet below ground surface (bgs) near the soil/bedrock interface.
- No groundwater was encountered in any of the borings in the upland areas.
- In the wetland area, the soil was observed to be silty sand to silty sandy gravel on the west end of the wetland (locations WET-1 and WET-2). The soil observed in the remainder of the wetland sampling locations consisted of clayey silt to silty clay. An organic mat was observed in the upper depths of each wetland boring, except location WET-1, where silty sand typical of uplands was observed.

2.3.3 Local Hydrogeology

The deep groundwater aquifer at the KFF site exists in the CRB. Groundwater supply wells are typically installed at depths of 200 feet or more. A City of Sherwood backup water supply well is located across Murdock Road near the northwest corner of the site. There are three water supply wells located at the KFF site. A well on Tax Lot 100 is used for domestic water supply and is installed to a depth of 330 feet. Wells on Tax Lot 700 (210 feet) and Tax Lot 1300 (69 feet) are reportedly used for irrigation.

There is no seasonal or perched water at the site, with the exception of the lowland area around the wetland. Temporary groundwater monitoring wells were installed to depth of about two feet in three of the wetland sampling locations (WET-2, WET-3, and WET-4). Upon installation of each of the temporary monitoring wells, groundwater stabilized at or near the ground surface.

2.3.4 Beneficial Land and Water Use Determination

The following presents a preliminary beneficial land and water use determination (BLWUD) based on the Screening Level Human Health Risk Assessment (SLHHRA; DEQ 2007).
2.3.4.1 Land Use

Historical use of the KFF site was agricultural and low density residential. Current and reasonably likely future use is residential, with current zoning allowing higher density development up to 0.25 acres per lot. Based upon current land use, the zoning and land use prescribed in the 2006 and the revised plan in 2014, Southeast Sherwood Master Plan, and surrounding land uses, DEQ concluded that the likely future beneficial use is for residential housing. In addition, the KFF site hosts a wetland in close proximity to Rock Creek, which drains into the Tualatin River National Wildlife Refuge. As a jurisdictional wetland, it is not part of the developable land at the KFF site.

2.3.4.2 Water Use

Shallow groundwater is seasonal and localized in the wetland areas. Its primary use is recharge to surface waters and possibly deeper groundwater. Shallow groundwater beneficial use is as recharge to surface waters. Surface waters in the immediate vicinity of the site are not used for drinking water. Surface water rights allocations for irrigation, livestock watering, and fish and wildlife support exist for Rock Creek east of the site.

Deeper groundwater is used for drinking water and irrigation. Public water supply is available to the area near the KFF site from the City of Sherwood. The City of Sherwood obtains its water from the Willamette River water supply program. However, a network of City groundwater wells provides a backup supply. The City well near the site is not currently used. Two groundwater wells are present at the KFF site, but are used only for irrigation and no longer supply drinking water. Based on groundwater well use at and near the KFF site, the current use of deeper groundwater in the site area is for drinking and irrigation uses. Given the availability of City water in the area, it appears unlikely that drinking water supply wells will be installed at the site in the future.

2.3.5 Nature and Extent of Contaminants of Interest

2.3.5.1 Upland Residential Lots

Metal contaminants of concern (COC) concentrations in soil are generally highest at the southern portion of Tax lot 100, which drains to the wetland area at the southeastern portion of the KFF site, and at Tax Lot 600. The Cr(VI) detections along the southern boundaries of Tax Lot 600, Tax Lot 700, and Tax Lot 1000 suggest that Cr(VI) concentrations above the DEQ risk-based concentration (RBC) of 0.29 milligrams per kilogram (mg/kg) may extend outside of the southern extent of the KFF site boundaries. Soil thickness at the KFF site ranges from 0 (exposed bedrock) to 8 feet, and is predominantly less than 2 feet. There are no clear trends of COC concentrations in soil with respect to depth below ground surface.

Sampling data did not show a significant correlation of Cr(VI) to total chromium concentrations, or a clear correlation with soil geochemical parameters such as pH. The sampling data indicated a high degree of heterogeneity in Cr(VI) concentrations at a small
spatial scale, thus confounding the quantitative evaluations of Cr(VI) concentrations to other parameters. The measured soil pH of upland soils (5.1 to 8.9) indicates an increase in pH above anticipated native soil conditions (5.4 to 6.0). The alkaline soil pH conditions are likely a result of historical lime amendments used for odor control.

Increases in soil pH create conditions more favorable for the oxidation of Cr(III) to Cr(VI). Cr(VI) in soil is much more mobile and bioavailable compared to Cr(III). Groundwater well sampling detected low levels of Cr(VI) in two of the three onsite wells sampled, and did not detect Cr(VI) in groundwater collected from the offsite City of Sherwood well or the background well. Detected levels in the onsite wells were above DEQ’s residential RBC of 0.043 micrograms per liter (µg/L). However, sampling results for regional water supplies show similar levels suggesting a regional ambient source of Cr(VI) in surface water and groundwater. Cr(VI) also was detected in background soil samples collected on a number of City of Sherwood properties not impacted by tannery waste, indicating Cr(VI) is likely naturally occurring in local soil.

2.3.5.2 Wetland Area

Metal COCs were elevated throughout the wetland area at the southeastern portion of the KFF site. Total chromium was detected at concentrations up to 97,463 mg/kg (i.e., up to 10% of the sediment mass consists of chromium). Lead, mercury, and Cr(VI) also were detected at elevated concentrations, with the highest detections associated with the drainage pathway from the outfall to the center of the wetland. Near surface sediment concentrations are higher respective to deeper sediment concentrations, suggesting that the overland surface transport pathway may be the primary contributor to metal impacts at the wetland. Sediment samples analyzed for leaching (TCLP) indicated that metals were not present in leachate above Federal hazardous waste criteria.

Low levels of metals were detected in shallow groundwater and surface water collected at the wetland. Detected dissolved chromium and lead concentrations in surface water and groundwater samples did not exceed the Freshwater Aquatic Life Water Quality Chronic Criterion for Toxic Pollutants (Table 30, Proposed Rule; hardness dependent). Detected concentrations of Cr(VI) in the primary and duplicate groundwater samples collected at location WET-002 (0.17 milligrams per liter [mg/L] and 0.18 mg/L) exceeded the Freshwater Aquatic Life Water Quality Chronic Criterion for Toxic Pollutants (Table 30, Proposed Rule) for Cr(VI) of 0.011 mg/L. No other detected Cr(VI) concentrations exceeded the freshwater criterion.

Previous EPA data and RI data suggest that chromium impacts may extend off-site downgradient of the wetland area toward Rock Creek and its associated wetlands; however, recent DEQ sampling to the west of the site indicates that off-site contamination is below applicable screening levels (DEQ 2014b; Letter to Snyder LLC dated October 6, 2014). In 2014, the DEQ collected a three-point composite sediment sample from areas with historically elevated total metal concentrations. This sample was submitted for both TCLP and SPLP
analysis. The TCLP results were below the method detection limit for each compound tested (mercury, chromium, and lead). The SPLP results showed 0.27 µg/L of mercury, 540 µg/L of chromium, and 1.9 µg/L of lead (DEQ 2014c).

2.3.6 Summary of Screening Level Human Health Risk Assessment (SLHHRA)

In 2007, DEQ conducted a SLHHRA for the KFF site based on aerial photographs, field observations, and the EPA soil and groundwater data. The SLHHRA findings indicated that only antimony and mercury, based on cumulative effects, posed a potential human health risk. Levels above RBCs were associated with a localized area on the central east side of the KFF site, not in close proximity to occupied structures. In November 2011, the DEQ residential RBC for Cr(VI) in soil was revised from 32 mg/kg to 0.29 mg/kg, thus requiring a re-evaluation of potential human health risk associated with Cr(VI).

The 2013 SLHHRA evaluated potential exposures by residents (surface soil and groundwater), excavation/construction workers (surface and subsurface soil), and adolescent trespasser or site visitor (wetland sediment). The SLHHRA findings indicated that for site residents, there is the potential for cancer risk estimates above the DEQ acceptable level of one in a million (1x10^-6) lifetime cancer risk and non-cancer hazards above the DEQ acceptable level of one.

The following metals and human health exposures are associated with cancer risk and non-cancer hazards above DEQ acceptable levels:

Upland Surface Soil

- Upland surface soil at tax lots 100, 200, 300, 600, 700, 1000, 1200, and 1300, based on potential current and future direct contact exposures to Cr(VI) by residents and cancer risk estimates exceeding one in a million lifetime cancer risk.
- Upland surface soil at southern portion of Tax Lot 100, based on potential current and future direct contact exposures by residents to mercury and non-cancer hazards.

Groundwater

- Groundwater at Tax Lot 100, based on exposure to Cr(VI) through use as domestic water supply and cancer risk estimates exceeding one in a million lifetime cancer risk. Sampling of regional water supplies conducted by others show similar levels suggesting a regional ambient source of Cr(VI) in surface water and groundwater.

The Cr(VI) cancer risks are primarily driven by the ingestion exposure pathway, based on an oral cancer slope factor developed by the New Jersey Department of Environmental Protection. The EPA is currently assessing the carcinogenicity of Cr(VI) through the oral exposure pathway. If the EPA determines that Cr(VI) is not an oral carcinogen, Cr(VI) at the KFF site would not be identified as a soil or groundwater COC. We understand that the EPA will not finalize the toxicity evaluation of Cr(VI) until 2016, at the earliest. Due to detections of mercury in soil, a limited area of the southeastern portion of Tax Lot 100 is associated with
non-cancer hazards (hazard quotient estimate of two) slightly above the DEQ acceptable hazard quotient of one.

Risk estimates for construction/excavation worker or wetland trespasser/visitor exposure scenarios did not indicate unacceptable risk. Based on results from previous sampling and RI sampling, there are no “highly concentrated” hot spots for human exposures, which are discussed in more detail below.

2.3.7 Summary of Ecological Risk Screening

A majority of the KFF site’s upland open spaces are generally vegetated with native grasses and small native and invasive non-native vascular plants, with a few small stands of older trees, including pines and madrones. Portions of the KFF site are heavily vegetated with blackberry briars, and in some areas poison oak is prevalent. Portions of the KFF site that adjoin the Rock Creek drainage have been mapped by Oregon Metro (Metro) as high value wildlife habitat (DEQ, 2005). One of these areas, the northeastern portion of the KFF site (Tax Lot 100) was logged approximately eight years ago in anticipation of subdividing the property. Tax Lot 100 is adjacent to the Rock Creek drainage and provides some of the higher value wildlife habitat in the upland areas of the site. Deer, coyote, smaller mammals, and birds are assumed to use upland areas.

Threatened and endangered (T&E) terrestrial receptors and their habitat are not present at the KFF site. In addition, exposure pathways are not complete for T&E terrestrial receptors to be exposed to contaminants in soils (surface and subsurface).

There is potential for wildlife such as birds, voles, gophers, and deer, in addition to soil invertebrates such as worms, to be in direct contact with contaminated soil. Ecologically important species could be exposed to COCs in soils within the terrestrial upland habitat of the KFF site. For upland soil, the primary ecological risk driver is total chromium (Cr[VI]+Cr[III]) with the majority of locations sampled containing chromium at concentrations exceeding the hot spot level of 1,550 mg/kg. Portions of Tax Lot 100 also contained lead and mercury at concentrations exceeding hot spot levels.

The wetlands area inside the southeast corner of the KFF site, the east-west low-lying area across the center of the KFF site, and the ephemeral pond and wetlands area south of the KFF Site have been mapped by Metro as highest-value riparian habitat (DEQ 2005).

The wetlands are only seasonally inundated and do not provide aquatic habitat for fish species, and provide limited benthic habitat. However, the wetland provides ecologically important habitat for wildlife such as birds, amphibians, and reptiles.

For the wetland area, the primary ecological risk drivers are total chromium and mercury. The majority of wetland locations sampled contained total chromium and mercury above hot spot levels, including some of the furthest down gradient locations. Lead concentrations exceed the ecological screening level values (SLV) at locations within only the western portion of the
wetland. The results for simultaneously extracted metals/acid volatile sulfides (SEM/AVS) analysis of sediment samples indicated that geochemical conditions do not favor a reduction in the toxicity of Cr(VI) or divalent metals.

Exposure pathways are not complete for ecologically important terrestrial receptors to be exposed to contaminants in groundwater. Groundwater is not present within the root zone at which most terrestrial plants could come into contact with groundwater. With the exception of Cr(VI) detections in shallow groundwater collected from one location co-located with high sediment concentrations, groundwater and surface water concentrations were below Freshwater Aquatic Life Water Quality Chronic Criterion for Toxic Pollutants.

2.3.8 Hot Spot Assessment

This section presents a preliminary assessment of soil hot spots, which was performed by comparing the concentration of each individual soil sample result to its corresponding hot spot criteria. OAR 340-122-115(32)(b) defines hot spots in media (other than water) as hazardous substances that present a risk to human health or the environment exceeding the acceptable risk level to the extent that the hazardous substances are:

Highly concentrated and exceed risk-based concentrations corresponding to:

- 100 times the acceptable risk level for human exposure to each individual carcinogen;
- 10 times the acceptable risk level for human exposure to each individual non-carcinogen; or
- 10 times the acceptable risk level for individual ecological receptors or populations of ecological receptors to each individual hazardous substance.

Highly mobile and reasonably likely to migrate to such an extent that:

- A significant adverse effect on beneficial use(s) of water would be created for which treatment is reasonably likely to restore or protect such beneficial uses within a reasonable time, as determined in a feasibility study;
- They would create an unacceptable risk in a media other than water (e.g., sediment) that is a "highly concentrated" condition as described above; or
- They would create an unacceptable risk in a media other than water (e.g., sediment) under conditions where the hazardous substances are not reliably containable, as determined in a feasibility study.
- Are not reliably containable, as determined in a feasibility study.

The following subsections evaluate each of the hot spot criteria.
2.3.8.1 Human Health “Highly Concentrated” Hot Spots

In accordance with DEQ guidance (DEQ 1998), the calculation of “highly concentrated” hot spot levels for human exposures is based on a 100-fold multiplier of the risk-based screening levels (RBSLs) for carcinogens and a 10-fold multiplier of the RBSLs for non-carcinogens. The soil RBSLs used in the screening of “highly concentrated” soil hot spots were the residential DEQ soil RBCs for direct contact with soil. Based on previous sampling and RI sampling, there are no “highly concentrated” hot spots for human exposures.

2.3.8.2 Ecological “Highly Concentrated” Hot Spots

The calculation of “highly concentrated” hot spot levels for ecological receptors is based on a 10-fold multiplier of the acceptable risk levels for individual T&E ecological receptors, if present, as well as for populations of non-T&E ecological receptors. As described in Section 2.3.6, chromium, lead, and mercury were detected at concentrations exceeding the ecological “highly concentrated” hot spot levels at the upland residential lots and at the wetland area at the southeastern portion of the KFF site. The hot spot criteria for upland soils include: total chromium at 1,550 mg/kg, lead at 800 mg/kg, and mercury at 75 mg/kg.

Figure 3 shows the locations where metal concentrations exceed hot spot criteria in areas that were mapped as significant ecological habitat by Metro (Oregon Metro 2013). Although Metro mapped the ecological habitat on Tax Lot 100, the area was subsequently logged and the upland area is currently zoned for residential use.

2.3.8.3 Highly Mobile Hot Spot Criteria

If hazardous substances in soil can migrate to groundwater or surface water and cause significant adverse effects to the beneficial uses of the water, and if treatment is reasonably likely to restore or protect such beneficial uses within a reasonable time, the area of impacted soil is considered a "highly mobile" hot spot. The cleanup rules clearly contemplate that this mobility includes mobility that may be associated with infiltration and leaching of contaminants in subsurface soils into groundwater; it may also be associated with stormwater runoff into surface water. The leaching to groundwater pathway is not considered significant in this hot spot evaluation because it is unlikely that shallow groundwater at the site will be used for beneficial purposes in the future. Municipal water is available for use at the site.

Hazardous substances from the site could also be considered hot spots if they are reasonably likely to migrate to such an extent that they would create an unacceptable risk in media other than water, such as in sediments, and that risk is "highly concentrated” as defined above, or the hazardous substances are uncontainable as determined in a feasibility study. Based on the previous historical leaching tests and recent RI data for surface water and groundwater, there is low mobility of metals in aqueous phase, and thus low bioavailability.
2.3.8.4 Not Reliably Containable Hot Spot Criteria

The extent to which hazardous substances cannot be reliably contained is generally evaluated in the feasibility study. As discussed in future sections of this report, the potential remedies considered, except the “No Action” alternative, can reliably and effectively contain soil and sediment contaminants. Therefore, "not reliably containable" hot spot areas are not identified.

3. IDENTIFICATION OF AREAS AND VOLUMES OF MEDIA FOR REMEDIAL ACTIONS

This section discusses at the Site. This information is used to assess the technologies that make up the remedial action alternatives. The remedial action areas were broken down by two categories; upland soils and wetland area.

3.1 Upland Soils

For upland soils, the remedial action areas were evaluated based on defined “high use areas”. The high use areas are defined as the land around existing residential structures (e.g. landscape, grass, or play areas) where potential exposure of residents to contamination is most likely. To assess a range of remedial alternatives, each high use area was evaluated for overall risk reduction to one in one million (1x10^(-6)), 3x10^(-6) and 5x10^(-6) cancer risk levels.

The remedial risk reduction areas for human health were determined with the objective to sequentially remediate larger areas of greater impact to reduce risk estimates until the calculated cancer risk estimate did not exceed 1 x 10^(-6). Risk estimates were based on the 90 percent upper confidence limit (UCL) on the mean (90%-UCL) concentrations for Cr(VI), and comparison to the RBC for direct contact for residential receptors. To re-calculate the 90%-UCL, a replacement value was assumed for the Cr(VI) concentration for each soil sample located in an area slated for remediation, using the background data set DEQ generated for the site.

Soil sample locations were selected for the residual risk evaluations based on following criteria:

- **Magnitude of Cr(VI) concentration.** Sample locations with highest concentrations were generally prioritized for remediation.
- **Spatial clustering of sample locations.** To the extent practicable, locations were clustered to define preliminary remedial areas.
- **High use areas including soil in proximity to residential structures.** Sample locations farther from residential structures were generally considered lower priority for selecting remediation areas. Sample locations outside of the high use areas (DU1) were not included.

Figures 4 through 8 show the remedial action areas for upland soils for each tax lot with a high use area (DU1), and Table 1 provides a summary of the area and volume estimates for
the corresponding remedial action areas in each DU1. Soil volume calculations were based on depth to bedrock estimations (as measured during RI field activities). For the majority of the locations, the depth to bedrock is 3 feet bgs or less. For locations where depth to bedrock exceeded 3 feet bgs or where the depth to bedrock was unknown, a soil removal depth of 3 feet was used for the soil volume calculations.

3.2 **Wetland Area**

A wetland delineation survey (Wetland Solutions, 2015) was completed in February 2015 to determine the wetland remedial action area. Based on the historical data, the entire wetland to depths of 1.5 feet bgs up to 2.5 feet bgs for a few samples contain total metals at concentrations that exceed ecological hotspot levels. As such, the remedial action area for the wetland has been defined at the boundary of the delineated wetland. Figure 9 shows the boundaries of the wetland, and Figure 10 shows the drainage area of the wetland. Based on the survey, the wetland is approximately 2.47 acres in size. Assuming a removal depth of 3 feet this corresponds to approximately 12,000 cubic yards of sediment. A copy of the wetland delineation and a wetland functionality assessment are included in Appendix A.

4. **REMEDIAL ACTION OBJECTIVES**

Remedial action objectives (RAOs) are medium-specific goals for protecting human health and the environment and provide the framework for developing and evaluating remedial action alternatives. RAOs were developed to: 1) address pathways that pose the potential for unacceptable risk, 2) prevent or minimize migration of contamination that would result in the unacceptable risk or impairment of beneficial uses of soil, water, and 3) remediate hot spots to the extent feasible. The proposed RAOs are based on a combination of human and ecological risk. The proposed RAOs for the site are as follows:

- Prevent ecological receptors from exposure to wetland sediments containing total chromium, lead, mercury, and Cr(VI) that exceed ecological hot spot criteria.
- Prevent migration of upland soil or sediments in stormwater or surface water runoff that could result in recontamination of the wetland.
- Remediate soil or sediment hot spots of contamination to the extent feasible.
- Reduce transport of chromium, lead, and mercury in upland surface soil runoff to wetlands that would result in further sediment and porewater contamination.
- Prevent human receptors from exposure to upland soils containing Cr(VI) above exposure scenarios greater than \(1 \times 10^{-6}\) risk within high use areas.

4.1 **Applicable or Relevant and Appropriate Requirements**

Applicable or Relevant and Appropriate Requirements (ARARs) were identified in developing this FS. Applicable requirements are those standards, requirements, criteria, or limitations determined to be legally applicable or relevant and appropriate under Federal or State laws that specifically address a hazardous substance, pollutant, contaminant, response action, location, or other circumstance at a CERCLA site. Relevant and appropriate
requirements are those standards, requirements, criteria, or limitations promulgated under Federal and State laws that address problems or situations similar to those encountered at the CERCLA site, and therefore, are well suited for that site. Although not legally applicable, these requirements are relevant and appropriate for a particular CERCLA site [NCP (40CFR 300.415(j))].

A requirement under other environmental laws may be either applicable, or relevant and appropriate, but not both. Identification of ARARs must be done on a site-specific basis and involves a two-part analysis: 1) a determination whether a given requirement is applicable; then, if it is not applicable, 2) a determination whether it is nevertheless both relevant and appropriate. ARARs may be applicable, relevant, and appropriate.

Applicable standards include standards of control and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State environmental or facility siting laws that specifically address a hazardous substance, pollutant or contaminant, response action, location, or other circumstances at a CERCLA site.

To Be Considered (TBC) criteria are non-promulgated advisories or guidance issued by the federal government or a State government that are not legally binding and do not have the status of potential ARARs. However, in many circumstances TBCs will be considered along with ARARs. For example, the EPA Region 4 and 5 Screening Levels [EPA, April 2009] are considered TBCs for specific contaminants.

Potential ARARs are summarized in Tables 2, 3, and 4 and are broken out into three categories; 1) chemical-specific ARARs; 2) location-specific ARARs; and 3) action-specific ARARs.

4.1.1 Chemical-Specific ARARs

Chemical-specific ARARs address management of specific chemicals, including the release into the environment of materials possessing certain chemical or physical characteristics or containing specific chemical compounds. These requirements generally set health or ecological risk-based concentration limits for specific chemicals or hazardous substances. Summaries of chemical-specific ARARs for the Site are presented in Table 2.

4.1.2 Location-Specific ARARs

Location-specific ARARs are based on the geographical or physical location of the Site, rather than the nature of the contaminants or the proposed remedial actions. These requirements may restrict activities in certain sensitive environments, such as wetlands, endangered species habitats, or areas of historical or cultural significance. For example, federal and State ARARs exist for sites where removal activities would impact wetlands, flood plains, critical habitats, wilderness areas, fault zones, or areas of historic and/or archeological preservation areas. Summaries of potential location-specific ARARs for the Site are presented in Table 3.
4.1.3 Action-Specific ARARs

Action-specific ARARs are activity-based or technology-based requirements, and typically affect performance, design, or other similar action-specific controls or restrictions on certain activities related to remediation.

This group of requirements includes ARARs that are action-specific for the management of hazardous substances, such as Resource Conservation and Recovery Act (RCRA) regulations for facility closures, Clean Air Act (CAA) standards for air contaminant emission sources, and Clean Water Act (CWA) standards for effluent discharges to surface water bodies. Summaries of potential action-specific ARARs for the Site are presented in Table 4.

4.2 Evaluating Remedial Alternatives

The evaluation of potentially feasible alternatives was completed in general accordance with OAR 340-122-085(4). As such the OAR requires an initial evaluation of protectiveness. Protectiveness is a threshold requirement; only alternatives that meet the protectiveness requirements were evaluated. The protectiveness standards are:

- Ability of remedial action to protect present and future public health, safety and welfare;
- Ability of remedial action to achieve acceptable risk levels specified in OAR 340-122-115;
- Ability of remedial action to prevent or minimize future releases and migration of hazardous substances in the environment; and
- Requirements for long-term monitoring, operation and maintenance (O&M) and review.

Alternatives that meet the protectiveness threshold, were subsequently evaluated for the required Balancing Factors (OAR 340-122-090(3)) – These include the following:

- **Effectiveness**: Ability and timeframe of remedial action to achieve protection through eliminating or managing risk;
- **Long-Term Reliability**: Reliability of remedial action to eliminate or manage risk and associated uncertainties;
- **Implementability**: Ease or difficulty of implementing a remedial action considering technical, mechanical and regulatory requirements;
- **Implementation Risk**: Potential impacts to workers, the community and the environment during implementation; and
- **Reasonableness of Costs**: Considers capital costs, O&M and periodic review, and includes a net present value evaluation of the remedial action.

Additionally, hot spots were evaluated based on the feasibility of treatment of the hot spot using the above balancing factors with a higher threshold for cost reasonableness. The higher
threshold was applied only as long as the Hot Spot exists (OAR 340-122-085(5,6,7) and 340-122-090(4)).

4.3 General Response Actions

General response actions are broad categories of remedial measures and technologies that potentially address RAOs. DEQ guidance requires that the FS develop a range of alternatives, derived from one or more general response actions. Within this discussion, we have identified general response actions for the upland soils and the wetland area. We have also included a discussion of stormwater management alternatives in the screening of the wetland remediation technologies.

The alternative development process includes identifying general response actions and corresponding technologies; screening technologies to eliminate technologies that are clearly not feasible; and assembling remaining technologies into a list of Site-specific remedial action alternatives. Section 5 of this report describes the development of the remedial action alternatives to be evaluated in detail. General response actions include:

- **No Action** – A no action alternative serves as a baseline for comparison of other potential remedial actions. The no action will be used as the baseline for both the upland and wetland portions of the Site.
- **Institutional Controls** – Institutional controls are legal or administrative measures or actions that reduce exposure to hazardous substances.
- **Engineering Controls** – Engineering controls are physical measures which prevent or minimize exposure to hazardous substances or reduce the mobility or migration of hazardous substances.
- **Removal/Disposal** – Excavation and off-site disposal involves removal of materials to be managed or disposed under local, state or federal law.
- **Treatment** – Treatment is the permanent and substantial elimination or reduction in the toxicity, mobility, or volume of hazardous substances by using in-situ or ex-situ remedial technologies.

The general response actions are listed in Table 5 together with potentially applicable technologies within each of the general response actions.

5. IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

Table 5 provides an initial screening and evaluation of technologies for upland soils and wetland sediments. Potential technologies are grouped within general response actions as described in the prior section. Categories of remedial technologies were identified based on a review of literature, vendor information, performance data, and experience in developing other FSs under CERCLA. Technologies considered potentially applicable to achieving the RAO were selected for screening. The technology screening process reduces the number of potentially applicable technologies by evaluating factors that may influence process-option effectiveness and implementability.
Technologies were initially screened based on a qualitative assessment of effectiveness, implementability, and cost. The purpose of this screening is to produce an inventory of suitable technologies that can be assembled into candidate remedial alternatives capable of mitigating actual or potential risks at the Site. Consistent with EPA guidance, an extensive list of potential technologies representing a range of general response actions was considered to develop the candidate remedial alternatives.

The effectiveness evaluation focuses on: 1) whether the technology is capable of handling the estimated areas or volumes of media and meeting the contaminant reduction goals identified in the RAO; 2) the effectiveness of the technology in protecting human health and the environment during the construction and implementation phases; and 3) how proven and reliable the technology is with respect to contaminants and conditions at the site.

Implementability encompasses both the technical and administrative feasibility of implementing a technology process. Technical implementability is used as an initial screen of technology types to eliminate those that are clearly ineffective or unworkable at a site. Technical implementability is used as a check that the technology is applicable to the site. The more detailed evaluation of technologies places greater emphasis on the institutional aspects of implementability, such as the ability to obtain necessary permits for off-site actions; the availability of treatment, storage, and disposal services (including capacity); and the availability of necessary equipment and skilled workers to implement the technology.

Cost plays a limited role in the screening of technologies. Relative capital and operation and maintenance (O&M) costs, rather than detailed estimates, are considered. At this stage in the process, the cost analysis is made on the basis of engineering judgment, and each technology is evaluated as to whether costs are high, low, or moderate relative to other technology options for the same medium. The relative cost for each technology was estimated in terms of general technology cost, not site-specific cost.

A two-step process was used in this effort. The initial step was to identify a wide range of potential technologies based on past experience and general knowledge of remedial options. The second step was to conduct the initial screening of these technologies as described above. The product of this effort is a list of retained technologies to be considered when developing potential remedial alternatives to be carried forward to the FS alternatives evaluation process. The following sections identify and discuss the possible remedial technologies for the Site.

### 5.1 Candidate Technology Screening

The potential technologies identified in Table 5 were screened for effectiveness, implementability, and relative cost as described above. The potential technologies were screened based on the COCs for Site. The results of this screening effort are presented in Table 5, which includes the assessment of effectiveness, implementability, and relative cost of each identified technology. The table also notes whether the technology is to be retained.
5.2 Retained Candidate Technologies

The potential remedial technologies that remained in consideration following the initial candidate screening for mitigation of identified risk are presented in Table 6, which also includes comments on the potential application of each technology to the Site. The retained technologies listed in Table 6 are the building blocks used to develop the potential remedial alternatives in Section 4.0 of this FS.

While institutional controls were retained, they are not considered effective as standalone remedies for upland soils or the wetland, but have been retained for use in combination with other remedial technologies.

6. DEVELOPMENT AND SCREENING OF PRELIMINARY REMEDIAL ACTION ALTERNATIVES

Technically feasible technologies that are retained after screening in Section 5 above were combined to form remedial alternatives that may be applicable to the Site. Technologies potentially capable of attaining the proposed RAO are assembled, either singly or in combination, into remedial alternatives for: 1) upland soil and 2) wetland sediments and stormwater. Retained RAOs are shown in Table 6 and are described below.

6.1 Remedial Alternative Development for Upland Soil High Use Areas

- **Upland Alternative 1 (UA1), No Action** – No action will be taken to mitigate risk. The NCP requires that this alternative be evaluated.

- **UA2, Capping in Place** – This alternative involves installing a nominal 1-foot-thick soil cap with sod or seed, which is tied into grade along the perimeter of the yard. A visual barrier (filter fabric) will be placed over the remedial action area prior to capping. Residual contamination will be left in place. Institutional Controls will be implemented to maintain the integrity of the soil cover for the protection of site users from exposure to COCs in soil. In accordance with CERCLA requirements, 5-year reviews will be required with this alternative since impacted soil will be left in place.

- **UA3, Excavation with Off-site Disposal** – This alternative involves the excavation of soils above the RAO with subsequent transportation and offsite disposal at a permitted facility. Upon completion of the excavation, the area will be backfilled with clean fill.

- **UA4, Excavation with On-site Consolidation and Capping** – This alternative is substantially similar to UA2, except that contaminated soils above the RAO will be excavated and consolidated on-site at a central location(s) for each tax lot or decision unit.

Institutional Controls will be included for remedies UA2 and UA-4. Institutional Controls in general include property use restrictions (deed restrictions), property access restrictions,
signage and fencing to restrict site access and use. Institutional Controls are also detailed in Table 6.

6.2 Remedial Alternative Development for Wetland

- **Wetland Alternative 1 (W1), No Action** – No action will be taken to mitigate risk. The NCP requires that this alternative be evaluated.
- **W2, Capping in Place** – This alternative involves the placement of a nominal 1-foot soil cap over the sediments that exceed RAOs. Residual contamination will be left in place and covered with an on-site soil cover that will restrict direct contact with contaminated soil. Institutional Controls will be implemented to maintain the integrity of the soil cover for the protection of wildlife receptors from exposure to COCs in sediments. In accordance with CERCLA requirements, 5-year reviews will be required with this alternative, because impacted soil will be left in place. Under this scenario, treatment of removal of the ecological hot spots would not be achieved.
- **W3, Excavation with On-site Consolidation and Capping** – This alternative is substantially similar to UA3, except that contaminated sediments above the RAO will be excavated and consolidated in a portion of the wetland.
- **W4, Excavation with Off-site Disposal** – This alternative involves the excavation of sediments above the RAO with subsequent transportation and offsite disposal at a permitted facility. Institutional controls will be implemented as needed.
- **W5, Excavation of Ecological Hot Spots with Off-site Disposal with Capping of Remaining Soils** – This alternative involves the excavation of all sediments that exceed ecological hot spot screening values with subsequent capping of the remaining sediments in place.

Institutional Controls and stormwater management controls will be included for remedies W2 through W5. The following provides a brief overview of the expected stormwater controls for the site.

Approximately 12.6 acres of the site drains to the wetland, and 11.4 of those acres are potentially subject to development/redevelopment (Figure 9). The current quantity of surface stormwater runoff to the wetland has not been assessed. While there is a single storm drain on the north side of the wetland, very little flow appears to enter this pipe and a buildup of moss and other vegetation is visible in the inlet. If this inlet regularly received significant flow, vegetative growth would be limited, and there would be a defined flow path near the approach to the inlet. Based on this observation, surface water inflows to the wetland are only expected to occur during large storm events when surface soils are saturated, or when the rainfall intensities exceed the infiltration capacity of native soils. Also, since there are no signs of sedimentation or buildup of floating debris near the inlet or in upland gullies, there appears to be very limited sediment transport, even during large events, into the inlet. Consequently, surface runoff contributes a minor volume of water to the wetland, and most input is provided in the form of sheet flow from direct rainfall on the banks of the wetland and localized emergent seeps from upland shallow groundwater. The highest potential for stormwater
discharges to impact the wetland is future stormwater runoff during land disturbing activities (i.e. redevelopment).

Therefore, stormwater control must be based on implementing, verifying, and enforcing enhanced construction erosion controls during future land disturbing activities. At a minimum, these controls should include phasing construction activities to limit the disturbed area, temporary stabilization measures (e.g., straw mulch or bioswales) to reduce the amount of soil lost due to raindrop impact and wind forces, and perimeter controls (e.g., silt fences) to minimize the amount of sediment transported off the site. Enhanced construction BMPs, such as erosion control blankets, double silt fences, sedimentation basins with permeable baffles, and/or the use of coagulants and flocculants, could also be employed to further minimize the mobilization and transport of sediment. Turbidity monitoring may also be considered to ensure the selected controls are performing as expected. It has been assumed that enhanced erosion and sediment control beyond the minimum that would be required for general construction activities would consist of the following:

- Application of hydoseed across the steeper portion of the drainage area (~1.6 acres across portions of Tax Lots 700 and 1000), and
- A double silt fence installed around the upslope perimeter of wetland and the existing roads (~2,700 linear feet).

For costing purposes, implementation and payment of most of the stormwater management costs assume handling by future developers. Within each wetland alternative, we have included a line item cost for the installation of a site-wide vegetated swale treating the entire 11.3 acres as the minimum post-construction stormwater management control. The costs assume the swale would be installed on the north or west side of the wetland.

During the Remedial Design phase, it may be determined that a more robust stormwater treatment system is needed. Options include the use of enhanced bioretention systems with an engineered media bed filter, containing targeted media such as granulated activated carbon, zeolite, biochar, peat, or a combination thereof.

### 6.3 Screening of Retained Remedial Alternatives

In accordance with EPA and DEQ guidance, during the FS the potential remedial alternatives identified above were also screened against three broad criteria: short- and long-term effectiveness, implementability (including technical and administrative feasibility), and relative cost (capital and O&M). The purpose of the screening evaluation was to reduce the number of alternatives chosen via a more thorough and extensive analysis. This screening is similar to the general technology screening performed in Section 5 of this FS.

Based on the initial screening of alternatives during the preparation of the general response actions, we have eliminated alternative UA4 (consolidation and capping) from consideration for upland high use area soils. Based on the lack of depth within the soil profile with the upland sites the use of onsite consolidation is not a viable option for the upland soil areas.
7. DETAILED ANALYSIS OF REMEDIAL ACTION ALTERNATIVES

7.1 Upland Soils in High Use Areas

The detailed analysis of upland soils is based on the remediation of contaminated soil to a 1x10^-6 risk, based on each defined high use area. As such, the area and volumes of soils requiring remediation are based on human health risk exposure on only the high use areas. For the evaluation of the required balancing factors, the implementation of upland soil cleanup alternatives is evaluated across each high use area. During the detailed comparative analysis for upland soils, a discussion of how the retained upland alternatives may be scaled for implementation at a smaller scale (acreage specific) is included.

7.1.1 Alternative UA1 – No Action

The No Action alternative assumes that no further action is taken and no monitoring is performed.

7.1.1.1 Protectiveness

The No Action alternative does not achieve the protectiveness requirements as contaminated soil is left in place, exceeding protective levels. This alternative does not treat Hot Spots of contamination.

7.1.1.2 Effectiveness

The alternative is not effective at reducing or managing risk. The magnitude of residual risk posed by contamination remaining at the site is unacceptable.

7.1.1.3 Long Term Reliability

This alternative does not achieve long-term reliability, as there is no long-term management of soil contamination.

7.1.1.4 Implementability

Because there is no action, there are no difficulties associated with implementation of this alternative.

7.1.1.5 Implementation Risk

There are no risks from this alternative associated with implementation.

7.1.1.6 Reasonableness of Cost

This alternative has no costs.

7.1.2 Alternative UA2 – Capping in Place

Alternative UA2, the capping in place alternative, includes remedial action components to contain contaminants in upland high use areas soils. Under Alternative UA2, soils within high use areas that exceed the RAOs will be contained by a soil cover. This alternative controls potential risks and hazards from exposure to contaminated soils by limiting direct contact with impacted soil that exceeds the RAOs by covering the soil under a 12-inch soil cover. Residual contamination will be left in place and covered with a 12-inch-thick cover that will restrict direct contact with contaminated sediments. The cover will be placed directly on top of the
existing grade. Based on the residual risk calculations (Figure 4 through 8, Table 1), assuming a 1-foot cap, approximately 855 cubic yards of top soil will be required to cover the approximately 0.54 acres of upland high use area soils.

Following installation of the soil cap, hydro-seeding and re-vegetation efforts would be completed to reintroduce vegetation. In addition, the hydro-seeding will provide erosion control for the new soil cap.

O&M costs are based on semi-annual inspections and repairs as needed for the first 5 years, and then every 5 years for 30 years. Annual repairs will include re-grading portions of the soil cover, placing additional soil to maintain the 12-inch cover, and seeding or planting as needed. Institutional controls will be implemented to maintain the integrity of the soil cover for the protection of site users from exposure to COCs in soil. Institutional controls could include a notice of environmental contamination on the property deed, risk communication on reducing exposure to soil, and implementation of a soil management plan in the event the cap is disturbed.

5-year reviews will be required with this alternative because impacted soil will be left in place.

7.1.2.1 Protectiveness

The primary concern within the upland soils is human health risk. A soil cap will greatly reduce direct contact with the COCs and would be protective as long as properly maintained.

7.1.2.2 Effectiveness

Controls for exposure and long-term management measures will be implemented through the use of remedial action to cover the impacted upland soils with a soil cover and impose institutional controls to minimize disturbances of the soil cover. Inspections and repairs will be required to retain integrity of the soil cover and will be conducted at various intervals.

The long-term effectiveness or permanent control of current and potential future risks would be based on inspections and repairs to verify and maintain the integrity of the soil cover. Inspections and maintenance of the soil cover will need to be conducted as long as the cover is in place.

7.1.2.3 Long Term Reliability

As long as the soil cap is maintained, this remedial approach would remain reliable. Over time the soil cap could be disturbed by animals such as moles and gophers. The thickness of the cap and placement of demarcation barrier is expected to result in little if any residual contaminated soil reaching the surface.

7.1.2.4 Implementability

The installation of a soil cover is straightforward. However, in high use areas the cap will need to be incorporated into existing grade to match the elevation of existing structures and features. If placement of a cap is required on slopes, retaining walls or enhanced erosion control methods may be needed. There may be access limitations on heavy equipment. Portions of remedial areas already covered with concrete, asphalt, bricks or other hardscape,
or otherwise have an existing cap deemed sufficient, will be left intact. Identifying and working around these areas may affect implementability.

Because of the large volume of soils that would be capped, alternative UA2 has a medium to high implementation risk due to human health and safety concerns that may arise as part of the soil management, including soil staging, fugitive emission and soil transportation. It is anticipated that Alternative 1 should take up to 12 days to complete.

### 7.1.2.5 Implementation Risk

There would be limited potential impacts to workers during implementation of this remedy. Residents will be restricted from yard areas during construction to reduce potential risk from heavy equipment. Local road traffic may increase during construction. In addition, there would be limited potential for stormwater releases due to heavy equipment use.

### 7.1.2.6 Reasonableness of Cost

The costs associated with this alternative are detailed in Table 7. The present worth for Alternative UA2 is estimated to be approximately $525,000.

### 7.1.3 Alternative UA3 – Excavation with Offsite Disposal

Under Alternative UA3, soils that exceed the RAOs will be excavated and transported off-site for disposal. This alternative controls potential risks and hazards from exposure to contaminated soils by removal. Any residual contamination left at the bottom of an excavated area will be left in place and covered with clean backfill materials to the former existing grade. Backfill materials will include either topsoil or a mixture of sandy loam and topsoil.

Based on the residual risk calculations (Figure 4 through 8, Table 1), the volume of soil that could potentially be excavated in the upland portions of the site is 2,180 cubic yards, based on a removal depth to either bedrock or to a depth of 3-feet bgs.

Hydro-seeding and re-vegetation efforts will be completed to reintroduce vegetation and provide erosion control for the backfill material.

Long term O&M is not required for Alternative UA3, however, limited institutional controls may be necessary, including the implementation of a CMMP for future soil disturbance.

### 7.1.3.1 Protectiveness

Alternative UA3 is protective of human health in high use areas as contaminated soil will be removed to the extent practical. Residual soil will be backfilled to the previous existing grade and hydro-seeded as needed to establish vegetation or support construction of other surfaces.

### 7.1.3.2 Effectiveness

This alternative is effective in removal of COCs to the extent practical. Soil excavation is a proven effective remedial action for reducing contaminant mass and direct contact with contaminated soil.

### 7.1.3.3 Long Term Reliability

The long term reliability of soil removal is high because contaminated soils are physically removed from the Site. No formal long term inspection and maintenance is needed.
7.1.3.4 Implementability

Implementing excavation on multiple properties in the upland areas will be moderately difficult to implement. There may be access limitations for heavy equipment. In addition, excavated areas would need to be restored to match existing grade, which will add complexity to this alternative. On hillsides targeted for removal, it may not be possible to remove significant amounts of soil and capping alone would be used.

Portions of remedial areas already covered with concrete, asphalt, bricks or other hardscape, or otherwise have an existing cap deemed sufficient, will not be excavated. Excavating around mature trees could complicate removal. Identifying and working around these areas may affect implementability. Proper permits and workplans will be required. The disruption to the surrounding neighborhood during this alternative would be moderate to high. It is anticipated that the implementation of Alternative UA3 will take 22 days.

7.1.3.5 Implementation Risk

Because of the large volume of soils that would be excavated, alternative UA3 has moderate to high implementation risk due to human health and safety concerns that may arise as part of the soil management procedures, including excavation procedures, increased noise, soil staging, fugitive emissions, and soil transportation and disposal.

7.1.3.6 Reasonableness of Cost

The costs associated with this alternative are detailed in Table 8. The present worth for Alternative UA3 is estimated to be approximately $773,000.

7.2 Wetland Sediments

7.2.1 Alternative W1 – No Action

The No Action alternative assumes that no further action is taken and no monitoring is performed.

7.2.1.1 Protectiveness

The No Action alternative does not achieve the protectiveness requirements as contaminated soil is left in place. In addition, this alternative does not treat hot spots.

7.2.1.2 Effectiveness

This alternative is not effective at reducing or managing risk. The magnitude of residual risk posed by contamination remaining at the site is unacceptable.

7.2.1.3 Long Term Reliability

This alternative does not achieve long-term reliability, as there is no long-term management of soil contamination.

7.2.1.4 Implementability

Because there is no action, there are no difficulties associated with implementation of this alternative.
7.2.1.5 **Implementation Risk**

There are no risks from this alternative associated with implementation.

7.2.1.6 **Reasonableness of Cost**

This alternative has no costs.

7.2.2 **Alternative W2 – Capping in Place**

Under Alternative W2, sediments that exceed the RAOs will be contained by a soil cover. This alternative controls potential risks and hazards from exposure to contaminated sediments by limiting direct contact with impacted soil that exceeds the RAOs by covering the soil under a gravel and soil cover. Residual contamination will be left in place and covered with a 18-inch-thick cover (composed of 6 inches of gravel, 8 inches of sandy loam, and 4 inches of topsoil). The cover will be placed directly on top of the existing grade. Based on the 2015 wetland delineation survey, approximately 2.5 acres of wetland will need to be capped. This does not include the existing soil cell. Assuming a 1.5-foot cap, ~6,100 cubic yards of capping material will be required.

Hydro-seeding and re-vegetation efforts will be completed to reintroduce wetland vegetation and provide erosion control for the new soil cap.

As part of the site O&M costs, the soil cover will be inspected and repaired as necessary on an annual basis for the first 5 years, followed by every 5 years for 30 years. Annual repairs will include re-grading portions of the soil cover, placing additional soil to maintain the 18-inch cover, and seeding or planting as needed. Institutional controls will be implemented to maintain the integrity of the soil cover for the protection of site users from exposure to COCs in soil. Institutional controls may include signage and/or designated access and viewing areas. A soil management plan will be required in the event the wetland cap area is disturbed.

5-year reviews will be required with this alternative, because impacted soil will be left in place. We have also assumed that up to 25% of the vegetation will require replacement every 5 years.

The consolidation and capping of sediments normally requires off-site wetland mitigation. Based on our conversations with the Oregon Department of State Lands (DSL), a waiver may be granted to the DEQ.

As discussed in Section 6.2, Alternatives W2 through W5 will also include the design and implementation of stormwater controls. A budgetary cost is included in each estimate for future design of the stormwater treatment system.

7.2.2.1 **Protectiveness**

A soil cap will be protective for organisms that colonize the new cap, and potentially for organisms that migrate from existing impacted sediment, but does not prevent direct sediment contact with existing or future deep dwelling benthic organisms. Capping will reduce contact with hotspot levels or contamination but does not constitute treatment of hotspots. Based on the historical analytical results for the wetland, nearly the entire wetland from ground surface to depths of 1.5 up to 2.5 feet bgs are above ecological hot spots screening levels for total
chromium, lead, or mercury concentrations. The exposure to contaminated soil will be reduced but not eliminated, since the contamination will remain onsite.

A permeable geotextile barrier between the contaminated sediments and the new cap would serve as a witness layer for future demarcation of the interface between contaminated sediments and overlying clean fill. This geotextile could also potentially diminish upward migration of particulates with sorbed COCs.

### 7.2.2.2 Effectiveness

The long-term effectiveness or permanent control of current and potential future risks will be based on inspections and repairs to verify and maintain the integrity of the soil cover. Long-term effectiveness is contingent on maintenance of the soil cover. Inspections and maintenance of the soil cover will need to be conducted as long as the cover is in place.

### 7.2.2.3 Long Term Reliability

As long as the soil cap is maintained, this remedial approach would be effective in management of COCs. However, it is unknown how the seasonal filling and draining of the wetland will affect a soil cap. With the small basin size and the relatively low hydraulic energy in the wetland, it is likely that with regular maintenance, concerns with COCs, flushing through the soil cap is minimal.

### 7.2.2.4 Implementability

The installation of a soil cover is straightforward; however, the placement of the soil cover will require the design and implementation of a robust construction stormwater pollution control plan (SWPCP) and vegetation plan. Other concerns include the limited access to the wetland area. In an effort to gain better truck and equipment access to the site, it will be necessary to remove the existing soil stockpile (~2,500 cubic yards). The removal of this pile will allow for better access to the wetland. It is anticipated that Alternative 1 should take up to six weeks to complete.

### 7.2.2.5 Implementation Risk

There would be moderate to high potential impacts to workers during implementation of this remedy. In addition, there would be a high potential for surface water or stormwater releases due to heavy equipment use within the wetland, or from loading of the soil cap onto saturated sediment.

### 7.2.2.6 Reasonableness of Cost

The costs associated with this alternative are detailed in Table 9. The present worth for Alternative 2 is estimated to be approximately $1,412,000.

### 7.2.3 Alternative W3 – Excavation with On-site Consolidation and Capping

This alternative is similar to Alternative W2, except that all sediments that contain COCs above the wetland RAOs in the northern portion of the wetland will be excavated and stockpiled on the contaminated sediments in the southern portion of the wetland. It is anticipated that up to 6,050 cubic yards of contaminated sediments will be removed and staged on the southern 1.25 acres of the wetland. Once the excavated sediments are staged, the entire soil pile would be capped in a manner consistent with the methods discussed in
Alternative W2 (18 inch cap). In addition to the need for a soil cap on the excavated material, the placement of 1.5-foot of clean topsoil in the excavated area will be required. This topsoil layer will serve as the base for the new wetland vegetation and seeding.

Hydro-seeding and re-vegetation efforts will be completed and provide erosion control. As discussed under alternative W2, O&M will be required for this alternative for 30 years.

The consolidation and capping of sediments normally requires off-site wetland mitigation. Based on our conversations with the Oregon Department of State Lands (DSL), a waiver may be granted to the DEQ.

As discussed in Section 6.2, Alternatives W2 through W5 will also include the design and implementation of stormwater control. A budgetary cost is included in each estimate for future design on the stormwater treatment system.

Institutional controls may include signage and/or designated access and viewing areas. A soil management plan will be required in the event the wetland cap area is disturbed.

**7.2.3.1 Protectiveness**

A soil cap will be protective for organisms that colonize the new cap, and potentially for organisms that migrate from existing impacted sediment, but does not prevent direct sediment contact with existing or future deep dwelling benthic organisms. Capping will reduce contact with hotspot levels or contamination but does not constitute treatment of hotspots. Based on the historical analytical results for the wetland, nearly the entire wetland from ground surface to depths to depths of 1.5 up to 2.5 feet bgs are considered ecological hot spots due to elevated total chromium, lead or mercury concentrations. The exposure to contaminated soil will be reduced but not eliminated, since the contamination will remain onsite.

**7.2.3.2 Effectiveness**

The effectiveness of Alternative W3 is substantially similar to those of Alternative W2, except that under Alternative W3, the wetland left after the remedial action will not contain COCs above the wetland RAOs. The capping of the excavated sediments will be easier, since the material will now be above the seasonal high water level.

**7.2.3.3 Long Term Reliability**

As long as the soil cap is maintained, this remedial approach would be effective in management of COCs. However it does not address the ecological hot spots. It is unknown how the continued flooding and draining of the wetland will affect a soil cap, but as discussed under Alternative W2, the probability of COC migration is low.

**7.2.3.4 Implementability**

The installation of a soil cover is straightforward and is substantially similar to Alternative W2. Including the development of a SWPCP and vegetation plan. The time to complete alternative W3 is approximately eight weeks.
7.2.3.5 Implementation Risk

There would be medium to high potential impacts to workers during implementation of this remedy. In addition, there would be a high potential for surface water or stormwater releases due to heavy equipment use within the wetland.

7.2.3.6 Reasonableness of Cost

The costs associated with this alternative are detailed in Table 10. The present worth for Alternative W3 is estimated to be approximately $2,367,000.

7.2.4 Alternative W4 – Excavation with Off-site Disposal

Based on the wetland delineation survey and the results of the historical analytical testing, approximately 12,100 cubic yards of sediments would be excavated, transported to a Subtitle D landfill and disposed of as non-hazardous waste. Excavation work may require the construction of an onsite drying area to allow for wetland sediments to dry prior to transportation.

Nine inches of fill (5 inches of silty loam and 4 inches of topsoil) would be placed back in the excavation to promote future wetland re-vegetation. The entire disturbed area would then be hydro-seeded and planted in accordance with the re-vegetation plan.

In order to access the wetland, the existing soil stockpile (2,500 cubic yards) will need to be excavated and disposed.

Long term O&M under alternative W4 will include inspections of the re-vegetated areas, however, formal maintenance of the soil cover will be minimal.

As discussed in Section 6.2, Alternatives W2 through W5 will also include the design and implementation of stormwater control. A budgetary cost is included in each estimate for future design on the stormwater treatment system.

7.2.4.1 Protectiveness

Alternative W4 is protective of both potential future ecological and human receptors. In addition, this alternative addresses ecological hot spots via complete source removal.

7.2.4.2 Effectiveness

This alternative is effective in removal of COCs. Soil excavation is an effective remedial action for sediments and completely eliminated the contaminants.

7.2.4.3 Long Term Reliability

The long-term reliability of soil removal is high because contaminated sediments are physically removed from the Site.

7.2.4.4 Implementability

Implementing such a large excavation within the wetland will be difficult to implement. The proper permits and work plans will be required. In addition, the excavation and import of over 12,000 cubic yards of material will be challenging. The disruption to the surrounding neighborhood during this alternative would be high. It is anticipated that the implementation of Alternative 4 will take 10 to 12 weeks.
7.2.4.5 Implementation Risk

Because of the large volume of soils that would be excavated, Alternative 4 has a high implementation risk due to the concerns relative to soil management, including excavation procedures, soil staging, fugitive emission and soil transportation and disposal, or from loading of the soil cap onto saturated sediment.

7.2.4.6 Reasonableness of Cost

The costs associated with this alternative are detailed in Table 11. The present worth for Alternative W4 is estimated to be approximately $2,936,000.

7.2.5 Alternative W5 – Excavation of Ecological Hot Spots with Off-site Disposal with Capping of Remaining Soils

Alternative W5 includes a combination of Alternatives W2 and W4. Under Alternative W5, sediments that are considered ecological hot spots will be excavated and disposed off-site. After the ecological hot spots have been removed, the remaining sediments will be capped with an 18-inch deep cap and re-vegetated. Under Alternative W5, approximately 6,050 cubic yards of hot spot material will be removed, and approximately 2.5 acres of wetland area will be capped with 18 inches of cap material.

Similar to Alternative W2, long term O&M will be required under this alternative.

As discussed in Section 6.2, Alternatives W2 through W5 will also include the design and implementation of stormwater control. A budgetary cost is included in each estimate for future design on the stormwater treatment system.

7.2.5.1 Protectiveness

Alternative W5 is protective of both future human and ecological receptors. In addition, Alternative W5 addresses the ecological hotspots.

7.2.5.2 Effectiveness

The use of a combination of excavation and capping are both effective in reducing future exposure. Excavation is very effective, since source material is removed. The effectiveness of capping is contingent on long term O&M.

7.2.5.3 Long Term Reliability

The long-term reliability of the excavation portion of Alternative W5 is very reliable and the reliability of the soil capping is contingent on long term O&M of the cap.

7.2.5.4 Implementability

Implementing such a large excavation and capping project within the wetland will be difficult to implement. The proper permits and work plans will be required. In addition, the excavation and import of over 6,000 cubic yards of material will be challenging. The disruption to the surrounding neighborhood during this alternative would be high. The estimated time to implement Alternative W5 is 10 to 12 weeks.
7.2.5.5 Implementation Risk

Because of the large volume of soils that would be excavated and/or hauled to the site, Alternative W5 has a high implementation risk due to the concerns relative to soil management, including excavation procedures, soil staging, fugitive emission and soil transportation and disposal.

7.2.5.6 Reasonableness of Cost

The costs associated with this alternative are detailed in Table 12. The present worth for Alternative W5 is estimated to be approximately $2,059,000.

8. COMPARATIVE ANALYSIS OF REMEDIAL ACTION ALTERNATIVES

This section of the FS presents a comparative analysis of the remedial alternatives for each decision unit. As described in FS guidance (EPA 1988), “the purpose of this comparative analysis is to identify the advantages and disadvantages of each alternative relative to one another so that the key tradeoffs the decision maker must balance can be identified.” Comparative analysis of remedial alternatives and total costs associated with each alternative are described below.

For the balancing factors, each alternative was ranked in relation to every other alternative for each of the evaluation criteria. For the sole purpose of evaluating overall relative ranking, the rankings within each Balancing Factor were given a score of 1, 0.5 or 0 respectively. The scores are summed at the right of the table for each alternative, and the alternatives are ranked overall. The following discussion provides a rationale for the comparative evaluation presented in Tables 13, 14, and 15.

8.1 Comparative Analysis of Upland Alternatives

Following the detailed analysis of each of the retained removal action alternatives, it is necessary to compare how each removal action alternative satisfied the evaluation criteria. Table 13 describes the relative abilities of the upland remedial action alternatives to meet the required criteria. While the site has multiple upland high-use decision units, the alternatives for most are the same. As such, the comparative analysis discussion below is centered on the overall site and to identify the advantages and disadvantages of each alternative relative to one another.

8.1.1 Protectiveness

Except for Alternative 1, alternatives discussed for upland soils would be protective of human health and the environment by eliminating, reducing, or controlling risks posed by the contamination through engineering control/land use controls (LUCs) and/or removal of the contaminated soil. The degree of protection of human health and the environment is greater for the removal alternative. Under the capping alternative, engineering controls will assist in maintaining protective conditions.

8.1.2 Treatment of Hot Spots

There are no human health hotspots identified in the upland soils. No action (UA1) and the capping in place alternative (UA2) do not treat or reduce contaminant concentrations. The remaining alternative (UA3) addresses ecological hot spot contamination.
8.1.3 Effectiveness

Alternative 1 does not provide long-term effectiveness and permanence. The risk associated with the contaminated soils would not be eliminated or controlled. The remaining alternatives for upland soils would satisfy this criterion. Additionally, Five-Year Reviews would be performed to verify the protectiveness of the alternatives. Alternative UA3, involves removing the contaminated soils thus eliminating the potential of contaminant migration. Therefore, UA3 is more effective than UA2. Based on removal being more effective, Alternative UA3 (capping only) has scored lower.

None of the alternatives contain treatment components as a part of the alternative. The nature of the site, the waste materials, and the land use are not conducive to the selection of a treatment-only alternative.

8.1.4 Long Term Reliability

The no action alternative has the lowest long-term reliability. Alternative UA3 has a longer-term reliability that Alternative UA2 (capping). The reliability of excavation with off-site disposal (UA3) is highest since the contamination is removed from the site and managed in a permitted landfill. The requirement for ongoing management of residual contamination through institutional controls for the UA2 make it less reliable than UA3.

Managing of the contamination through capping (UA2) has is slightly less reliable than UA3.

8.1.5 Implementability

Alternative UA1 would be easily implemented because no actions are required. The capping alternative (UA2) and the excavation and disposal alternative (UA3) use similar equipment and procedures, and have a similar ease of implementation. Excavation will take longer and may be somewhat more difficult to implement as more strict controls may be required to minimize fugitive emissions.

8.1.6 Implementation Risk

The no action alternative carries no implementation risks, including being the most sustainable approach. Both the capping in place alternative (UA2) and the excavation alternative (UA3) have similar implementation risks. Both require the handling of large volumes of soil, long-distance transportation of the soil (either excavated materials or capping material), and the relatively unsustainable practices associated with energy use, disturbance of land, and greenhouse gas emissions.

8.1.7 Reasonableness of Cost

Cost estimates were developed for each of the upland remedial options based on present worth of capital costs and long term costs. The following list summarizes the cost estimates for the identified alternatives to achieve a residual risk level of $1 \times 10^{-6}$ for high use properties (ordered in rank from least to most expensive):

- No Action ($0$)
- Alternative UA2, Onsite Capping ($535,000$)
- Alternative UA3, Excavation and Offsite Disposal ($773,000$).
The cost to implement UA3, which has greater protectiveness and effectiveness and long term reliability, is approximately 25% greater than UA2.

### 8.1.7.1 Other Cost Scenarios

Costs for various risk reduction scenarios and alternatives are summarized on Table 15 and depicted on Figure 11. Included are estimates to remediate undeveloped, low use tax lots 600 and 1000 on a 1-acre lot basis.

Detailed estimates are provided on the tables and supporting documentation provided in Appendix B. The appendix contains risk reduction figures on a tax lot basis and the accompanying cost estimates for each risk reduction scenario.

A review of the cost estimates for the remediation of upland high use soils indicates:

- Capping is more cost effective than removal to attain a risk level of $1 \times 10^{-6}$.
- Removal cost is similar to capping costs to attain a $3 \times 10^{-6}$ risk level.
- For both removal and capping, the cost to cleanup to a $3 \times 10^{-6}$ risk level are only slightly higher than cleanup to a less protective standard of $5 \times 10^{-6}$.
- For tax lots with limited remedial action areas, Alternative UA3 (excavation and off-site disposal) is more cost effective. On parcels with smaller remedial action areas, Alternative UA2 (capping) costs more due to the long term O&M costs associated with the placement of cap.
- For tax lots with large remedial action areas, capping can be a more cost effective approach.

In addition, cost comparisons were made for upland cleanup by individual tax lot and by 1-acre parcels within each tax lot, although a detailed discussion of each is not provided in this report. Preliminary cost estimates showed that costs to remediate on a 1-acre decision unit basis are comparable to the costs required to remediate on a tax lot basis. While the volume and/or area of the remedial action area is smaller for the 1-acre decision units, the sampling, administrative, road maintenance, and reporting costs would be similar.

### 8.2 Comparative Analysis of Wetland Alternatives

Following the detailed analysis of each of the retained removal action alternatives, it is necessary to determine if the alternative satisfies the evaluation criteria. Table 14 describes the relative abilities of the wetland removal action alternatives to meet the required criteria.

#### 8.2.1 Protectiveness

Except for Alternative W1, all alternatives discussed for the wetland area would be protective of human health and the environment by eliminating, reducing, or controlling risks posed by the contamination through engineering control/LUCs and/or removal of the contaminated soil. The degree of protection of human health and the environment provided by each of the alternatives varies. Alternative W2 (capping in place) has the lowest protectiveness because all the contamination is left in place, followed by Alternative W3 (consolidation and capping), then Alternative W4 (hot spot removal and capping). Alternative W4 (excavation and off-site disposal) provides the most protection.
8.2.1.1 Treatment of Hot Spots

The no action (W1), the capping in place alternative (W2) and to some degree, the consolidation and capping alternative (W3), do not treat or reduce contaminant concentrations, as such, they do not treat “highly concentrated” hot spots; however, they do contain the contamination (hot spot criteria for “highly mobile”). The two excavation alternatives (W4 and W5) treat hot spot levels through removal.

8.2.2 Effectiveness

Alternative 1 does not provide long-term effectiveness and permanence. The risk associated with the contaminated soils would not be eliminated or controlled. The remaining alternatives for remediation of the wetland would satisfy this criterion, at various levels. Additionally, Five-Year Reviews would be performed to verify the protectiveness of the alternatives. Alternative W4, involves removing the contaminated soils thus eliminating the potential of contaminant migration. Therefore, W4 is more effective than other wetland alternatives, followed by W5 under which the contamination above ecological hot spot values is removed. None of the alternatives contain treatment components as a part of the alternative. The nature of the site, the waste materials, and the land use are not conducive to the selection of a treatment-only alternative.

8.2.3 Long Term Reliability

The no action alternative has the lowest long-term reliability. Alternatives W4 and W5 (excavation alternatives) scored higher than Alternatives W2 and W3 (capping alternatives). The reliability of excavation with off-site disposal (W4 and W5) is the highest since the contamination is maintained in a managed facility. Management of the contamination through capping (W2 and W3) is slightly less reliable than W4 and W5.

8.2.4 Implementability

Alternative W1 would be easily implemented because no actions are required. The remaining alternatives (W2 through W5) are equally easy to implement and rank next because they all utilize standard construction equipment and procedures.

8.2.5 Implementation Risk

The no action alternative carries no implementation risks, including being the most sustainable approach. The remaining alternatives (W2 through W5) have similar implementation risks. They require the handling of large volumes of soil, long-distance transportation of the soil (either excavated materials or capping material), and the relatively unsustainable practices associated with energy use, disturbance of land, and greenhouse gas emissions.

8.2.6 Reasonableness of Cost

Cost estimates were developed for each of the wetland remedial options based on present worth of capital costs and long-term costs. The following list summarizes the cost estimates for the identified alternatives (ordered in rank from least to most expensive):

- No Action ($0)
- Alternative W2, Capping in Place ($1,412,000)
- Alternative W5, Hot Spot Excavation ($2,059,000)
- Alternative W3, Consolidation and Capping ($2,367,000)
- Alternative W4, Full Excavation ($2,936,000)

The cost for full excavation, which is the most protective and reliable, is approximately two times the capping alternative, and would be moderately difficult to implement.

### 9. RECOMMENDED REMEDIAL ACTION ALTERNATIVES

The following conclusions are based on the results of the upland and wetland alternative assessment.

#### 9.1 Upland Soils – High Use Areas

Both excavation and capping are viable alternatives for upland soils. A combination of the alternatives UA2 and UA3 may be appropriate based on site-specific conditions. In areas with mature vegetation and trees, the use of UA2 (capping) would be preferred. During the scoring of the upland alternatives, UA2 (capping) scored slightly higher than UA3 (excavation).

#### 9.2 Wetland

The scoring of the wetland alternatives is included in Table 14. Alternative W4 (excavation) and W5 (hot spot removal and capping) scored the highest, followed by onsite consolidation and capping. Similar to the upland alternative, it is likely that a combination of alternatives may be chosen during the remedial design.

### 10. RESIDUAL RISK ASSESSMENT

OAR 340-122-084(4)(c) requires a residual risk evaluation of the recommended alternative that demonstrates that the standards specified in OAR 340-122-040 will be met, namely:

- Assure protection of present and future public health, safety, and welfare, and the environment;
- Achieve acceptable risk levels; and
- Prevent or minimize future releases and migration of hazardous substances in the environment

The purpose of the Residual Risk Assessment (RRA) is to estimate the risks to human health and ecological receptors that may be present after the preferred remedial action alternative is implemented. Implementation of the recommended remedial action alternative for upland soils and wetland sediments would theoretically removal upland soil, wetland sediment, and stormwater with concentrations greater than the target risk level or RAO resulting in no residual risk to human receptors. If capping in place is selected for the wetland remediation, there would be a potential risk due to direct contact with sediments, although the cap would limit this contact and associated risk. To better understand residual risk to benthic receptors would require biological testing.
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Tables
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Appendix A

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Appendix B

Tax Lot 600 and 1000 Risk Reduction Figures and Summary Tables