GEODESIGN INC

FEASIBILITY STUDY

Ross Island Sand & Gravel

Portland, Oregon

For
Ross Island Sand & Gravel
c/o Perkins Coie, LLP
August 2, 2005

GeoDesign Project: PerkinsCoi-8-01-01

GEODESIGN INC

August 2, 2005

Oregon Department of Environmental Quality
Northwest Region
2020 SW Fourth Avenue, Suite 400
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Attention: Ms. Jennifer Sutter

Feasibility Study
Ross Island Sand & Gravel Company
Portland, Oregon
GeoDesign Project: PerkinsCoi-8-01-01

GeoDesign, Inc. on behalf of the RIS&G, is pleased to submit this final Feasibility Study report for the RIS&G site, which incorporates responses to DEQ comments dated July 1, 2005. We appreciate DEQ's assistance on this project and in the development and review of the Feasibility Study. Please call if you have questions concerning this submittal or if we may be assistance in any regard.

Sincerely,

GeoDesign, Inc.

Craig W. Ware, R.G.
Principal Geologist

cc: Mr. Aaron Courtney, Perkins Coie, LLP
Mr. Jim Rue, Ross Island Sand & Gravel

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1.0 INTRODUCTION AND BACKGROUND

This FS has been prepared on behalf of RIS&G for the RIS&G facility (site) on Ross and Hardtack Islands in Portland, Oregon. The FS was conducted within the DEQ VCP, under OAR 340-122-085 and 344-122-090, and the Order on Consent No. WMCVC-NWR-99-09 (1999 Order) between RIS&G and the DEQ, dated November 9, 1999. Guidance was also obtained using the EPA's Office of Solid Waste and Emergency Response Directive, *Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Response, Compensation and Liability Act* (EPA, 1988) and the *Final Guidance for Conducting Feasibility Studies* (DEQ, 1998a). The site is shown relative to surrounding physical features on Figure 1. A site plan is shown on Figure 2.

1.1 PURPOSE AND OBJECTIVES

The purpose of the RI/FS process is to gather sufficient information to support an informed risk management decision regarding selection of an appropriate remedy for site remediation and overall reclamation of the site. The RI report, dated October 21, 2002, compiled all site characterization data and used this data to evaluate the potential for site-related contaminants to pose a threat to human health and the environment.

The objective of the FS is to evaluate viable remedial alternatives and recommend to DEQ a preferred remedial approach that is protective of both human health and the environment, based on the results of the RI. To achieve this objective, this FS is comprised of the following:

- A summary of site conditions and previous investigations
- RAOs
- Potentially applicable general response actions and remedial technologies
- A screening of each response action and an evaluation of the most viable alternative, based on the remedy selection factors as specified in OAR 340-122-090, giving greater consideration to "treatment or removal" of any identified hot spots
- A recommended preferred remedy, based on this evaluation

1.2 SITE HISTORY AND PREVIOUS STUDIES

The RIS&G facility is a major supplier of aggregate in the Portland area. Mining and processing of sand and gravel from the Willamette River at the site began in the 1920s and continued until the summer of 2001. Between 1926 and the early 1980s, filling at Ross Island involved the return of non-commercial sand/silt material that had been separated from commercial grade material during aggregate processing. A 1979 Conditional Use Permit from the City of Portland formally established the need for RIS&G to reclaim uplands and in-water mined areas. To meet the permit requirements, RIS&G began importing fill material. RIS&G originally developed a reclamation plan in 1979 as required under its USACE/DSL Removal/Fill Permit. Reclamation fill material used at the site from the early 1980s through 1998 is documented to have come from the following three sources:

- The non-commercial material from on-site aggregate processing that historically had been used for filling
- Dredging-related fill material from sites along the Willamette and Columbia Rivers
- Other imported fill material.

Some fill material used to reclaim the lagoon was judged to be chemically unsuitable for unconfined open water disposal (using the guidance available at the time of disposal [EPA/USACE, 1991]). This fill material, placed in depressions within the lagoon, was subsequently capped with clean sand and silt to confine the unsuitable fill. This disposal method is referred to as CAD. There are five CAD cells located within the lagoon, as shown on Figure 3. The placement of fill material in Ross Island Lagoon, including the CAD cells, was approved by the appropriate regulatory agencies, including DEQ. Currently, the cap material for each of the CAD cells acts as an engineering control that prevents the contaminants in the fill material from posing unacceptable risks to human health and/or the environment. As shown on Figure 3, reclamation filling has resulted in a portion of CAD Cell No. 1 now lying beneath upland areas.

Various divisions of DEQ have been involved with the site since at least the 1980s, when the Water Quality Division provided input on water quality certifications associated with the dredging that generated fill imported to the lagoon. The VCP became involved in mid-1998, when the first of many environmental studies was initiated. The following studies, presented in chronological order, have been completed at the site.

1.2.1 Breach Repair Investigation - 1998

CAD Cell No. 5 was inadvertently breached by RIS&G during gravel mining operations in the spring of 1998 (Figure 3). After discovering the breach, RIS&G constructed a new cap to re-confine the material. Confirmation samples were collected from the perimeter and surface of the new cap. The confirmation sample results indicated concentrations were less than the LCRMA screening levels, with the exception of one sample (identified as SVS-18). However, the results of sample SVS-18 were significantly less than concentrations detected in the confined material before its disposal and confined of in the lagoon. Landau Associates (Landau) estimated that approximately 83 percent (approximately 62,250 cubic yards) of the breached material was discharged to the main aggregate settling pond located south of the sand and gravel processing facilities. The breached material included clean cap material, adjacent non-contaminated fill material, and approximately 6,300 cubic yards of impacted confined material. The results of this investigation, completed under a separate Consent Order with DEQ, indicated that TBT and TPH were present in the process settling pond fines. The TBT was considered to be associated with the breached material discharged in the eastern portion of the pond, but the source(s) of the TPH was less clear. RIS&G closed the eastern portion of the settling pond in late 1999, where the highest concentrations of contaminants associated with the breach material were detected, and capped the contaminated material with dredged material from the western portion of the pond. The western portion of the pond was dredged to maintain capacity in the pond for ongoing process operations. The results of the settling pond investigation and groundwater flow and solute transport modeling indicate that residual contamination present in the western operational and closed eastern portions of the settling pond do not pose unacceptable risk to human health or the environment, including the waters of Holgate Slough or Ross Island Lagoon.

1.2.2 Ross Island Clear Zone Study - August and September 1999

In 1998, DEQ recommended that RIS&G not conduct filling in areas of the lagoon undergoing investigation and suggested a baseline characterization of sediment conditions within an identified "clear zone" area in the lagoon where mining had been completed to the allowed depth and where RIS&G wanted to begin reclamation filling. Additionally, an "uplands clear zone" was identified by RIS&G in August 1999 for baseline characterization purposes and to evaluate whether fill material that had been removed from the settling pond in 1998 and used for reclamation fill on the east side of the dike linking Ross and Hardtack Islands contained hazardous substances at concentrations of concern. Analytical results for the sediment samples collected in the "clear zone" in the lagoon and for soil and groundwater samples collected from the "uplands clear zone" were less than available screening criteria. DEQ subsequently authorized filling in these areas.

1.2.3 Ross Island Turbidity Study - September/October 1999

A turbidity study was completed in the lagoon and in the Willamette River up stream and down stream of the site in September and October 1999 to fulfill a condition in the DEQ water quality certification associated with RIS&G's USACE permit. Dredging and filling activities were not occurring during the time of the study. Results indicated that turbidity levels in both the lagoon and river increased during the study period and that the up-stream and down-stream turbidity levels were identical, suggesting that Ross Island operations were not affecting turbidity within the mainstream of the river during that period.

1.2.4 Ross Island Biological Assessment - Spring and Fall 1999 and Spring 2000

RIS&G conducted reconnaissance level ecological surveys on Ross and Hardtack Islands and in the lagoon to collect site-specific information on habitat types and characteristics and ecological receptors at the site. The surveys included: 1) a salmonid survey; 2) terrestrial habitat, vegetation, and vertebrate surveys; 3) a near-shore aquatic habitat characterization survey; 4) periphyton sampling and identification; 5) macrophyte sampling and identification; 6) a benthic community survey; and 7) a fish survey. The survey results indicated that the terrestrial, aquatic, and benthic environments at the site are a mix of natural and disturbed habitats. Natural and introduced disturbances include flooding, dredging, sorting, and stockpiling of sand and gravel, in-water and uplands reclamation activities, and recreational uses. No evidence was noted during the surveys of stress to the ecological environment that would reflect acute or chronic effects from chemical contamination.

1.2.5 CAD Study - Late 1999 and Early 2000

The Port of Portland (Port) conducted an investigation of the material previously dredged from the Port and disposed in the CAD cells in late 1999 and early 2000 to evaluate whether contaminants of concern originally in the Port's dredged material are now posing, or would likely pose in the future, unacceptable risks to human health and/or the environment. The Port concluded from data collected during the investigation and through fate and transport modeling of the migration of contaminants from the CAD cells that migration would not result in unacceptable levels of hazardous substances at the likely exposure points for human or ecological receptors. The Port noted that a few bioassays conducted with surface sediment from the lagoon failed the test criteria, possibly due to elevated levels of ammonia and pH in the samples. The Port also claimed that underwater slopes near the CAD cells were unstable. Subsequent stability analyses conducted by RIS&G countered the Port finding of instability. DEQ determined that stability issues would be addressed with future filling.

1.2.6 Phase I and II RIs – 1999/2000 and Spring 2001

Phase I of the RI was designed to take advantage of several late-1999 equipment mobilizations (including those associated with the Port's investigation) and included collecting soil and sediment samples from the Port investigation (which the Port did not plan on analyzing for its investigative purposes), as well as additional soil and sediment sampling. The Phase I RI also included completion of a land use study and a beneficial water use study. The results of the Phase I RI are summarized in a September 2000 report (Landau, 2000). During the Phase II RI, completed in the spring of 2001, additional surface and subsurface soil sampling was conducted in the uplands, along with the collection of groundwater data from temporary well screens and the collection of samples of soil and groundwater from East Island, to provide background information. The Phase II RI also included surface and subsurface sediment sampling in the lagoon for a variety of testing. The results of the Phase II RI are summarized in an October 2002 report (Landau, 2002). The Phase II RI report also includes a site-specific human health and ecological RA.

1.2.7 Updated Reclamation Plan

The 1979 reclamation plan was updated in 2002, in order to be based on a more current and complete scientific understanding of the river, the island complex, and surrounding habitat. The updated reclamation goals for Ross Island are to:

- protect and enhance anadromous fish and wildlife habitat of the island.
- protect surface water and groundwater resources.
- protect the structural integrity of the islands as needed to prevent catastrophic erosion and scouring events.
- preserve options for future public ownership and benefit.

The strategies in the updated reclamation plan (Landau, 2002b) reinforce existing public policies, using clean fill to achieve substantial reclamation and diverse habitat development on an accelerated basis. The revised reclamation approach involves the placement of approximately 450,000 cubic yards of reclamation fill each year for 10 years, for a total of 4.5 million cubic yards of clean fill.

This FS primarily evaluates potential remedial alternatives with regard to protection of human and ecological health. Given the substantial overlap between reclamation and remediation, components of the reclamation plan are considered as part of the analysis of remedial alternatives. The plans and goals of the reclamation plan will be taken into account in evaluating the implementability of identified remedial alternatives.

1.3 SITE DESCRIPTION

The site is located at approximately river mile 15 of the Willamette River, approximately 1 mile up stream of downtown Portland, Oregon (Figure 1). As shown on Figure 2, the Willamette River flows to the west of the site and Holgate Slough flows to the east of the site. An earthen dike, constructed in the 1920s to join Ross and Hardtack Islands, formed Ross Island Lagoon, which is now connected to the Willamette River via Holgate Slough (Figure 2). East and Toe Islands lie up stream and to the southeast and southwest, respectively, of the site. East Island is owned by RIS&G, and Toe Island was deeded by RIS&G to the Nature Conservancy in 1979.

The uplands portion of the site currently consists of approximately 180 acres, and Ross Island Lagoon consists of approximately 155 acres. The configurations of shorelines at Ross and Hardtack Islands have varied over the years, due to RIS&G's aggregate removal and filling operations. Mining has not been allowed along the outer shores of Ross and Hardtack Islands since 1979. Mining within the lagoon was terminated in 2001.

For the purposes of the FS, the site has been divided into the following two geographical areas: the uplands and the lagoon. The uplands have been subdivided into the Process Operations Area and the Fill Area. The geographical areas are shown on Figure 3. Currently, the uplands fill area is heavily vegetated with a variety of shrubs, conifers, cotton wood trees, and vine maples.

1.3.1 Current and Future Land Use

RIS&G voluntarily concluded mining operations in Ross Island Lagoon in the fall of 2001, and no mining is planned for the future. Aggregate processing activities by RIS&G continue on Hardtack Island and will continue for the foreseeable future. The processing facilities include an office building, processing plant, two settling ponds (the main settling pond south of the processing plant and a smaller pond located at the northern portion of Hardtack Island) for processing water, and ancillary access roads and facilities. The two settling ponds are still active and used by RIS&G. Reclamation of mined areas of the islands and the lagoon also continues in accordance with the approved reclamation plan and provisions set forth in the DSL Removal-Fill permit.

RIRPAC was convened to advise RIS&G regarding the development of reclamation goals for the reclamation plan. RIRPAC has recommended, and RIS&G concurs, that following reclamation the primary use of Ross Island should be as a natural area focused on providing fish and wildlife habitat. Use as a natural area is consistent with the interests of multiple public agencies, compliments management goals of the Oaks Bottom Urban Wildlife refuge, and preserves options for future ownership and use of Ross Island by the City of Portland.

1.4 NATURE AND EXTENT OF CONTAMINATION

The nature and extent of contamination at the site and the results of previous investigations have been described in detail in the previously submitted RI report and are, therefore, only briefly summarized herein. Results of the various investigations were utilized in the RI to assess areas that pose a potential risk to human health and the environment. Those assessments included comparing individual sample results to site-specific risk-based screening levels and estimating risks to humans and ecological receptors through specific exposure pathways.

In general, the site exhibits little evidence of high level contamination. More than 94 percent of the data points collected from the surface soil, lagoon sediments, surface water, and groundwater do not exhibit levels of contamination that would pose unacceptable risks to human or ecological receptors. In the few areas in which contamination was found, it generally is not expected to migrate significantly or is readily amenable to remedial actions to prevent unacceptable exposures to human health and the environment.

Previous investigative and RI data have been collected from (1) surface and subsurface soil, surface water, and groundwater within the active processing area and previous fill areas of the uplands and (2) from surface and subsurface sediment, surface water and groundwater within the southern and northern portions of the lagoon. Data has also been collected from Holgate Slough, the Willamette River, and East Island to help develop background and/or ambient levels.

1.4.1 Uplands

Uplands data consists of surface soil samples (collected from 0.0 to 3.0 feet BGS, subsurface soil samples (collected from a depth greater than 3.0 feet BGS), surface water samples (from the main process settling pond and the north pond), and groundwater samples (collected from shallow, intermediate, and deep groundwater-bearing zones). The characterization findings for each of these uplands media are summarized in Table 1. Pre-RI data collected during the October 1999 main process settling pond investigation are not included in Table 1.

The most frequently detected contaminants in uplands media (as presented in Table 1) are TPH as diesel- and heavy oil-range hydrocarbons, SVOCs (including several PAHs), and metals. Contaminants present in the fill areas within the uplands reflect the varied chemical nature of the fill material placed there for reclamation. Additionally, elevated field measurements of pH (greater than 8.5) were detected in groundwater samples collected from the shallow groundwater-bearing zone in monitoring well MW02 in January and April 2000 and December 2001. However, these elevated field measurements were not substantiated by laboratory analysis.

As discussed in the RI report, data collected in August 2001 was subjected to special data validation review, due to the significant increase in both occurrence and magnitude of TPH during the August 2001 sampling event. Only six organic chemicals, including one VOC (1,2-DCA), three SVOCs (bis(2-ethylhexyl)phthalate, chrysene, and di-n-octyl phthalate), one report of heavy oil-range hydrocarbons, and one report of TBT, were detected at concentrations that could not be screened out on the basis of the data validation review. These contaminants were not detected in the shallow (fill) zone beneath the site, but were detected in the intermediate (native alluvium) and the deep (Troutdale Formation) groundwater-bearing zones. Additionally, these contaminants were not detected more than once in each well, despite more than four semi-annual groundwater monitoring events. The presence of contaminants in the intermediate and deep groundwater-bearing zones are not likely, due to historical activities at the site, given the upward gradients from the deep groundwater-bearing zone to the shallow groundwater-bearing zone and the lack of evidence of any other mechanism of downward migration from the site.

1.4.2 Lagoon

Lagoon data consists of surface sediment samples (collected from the upper 0.3 foot of sediment), subsurface sediment samples (collected from sediment deeper than 0.3 foot), surface water samples (from within the lagoon), and groundwater samples (from within and below confined and unconfined fill cells in the lagoon). The characterization findings for each of these lagoon media are summarized in Table 2.

The most frequently detected contaminants in lagoon media (as presented in Table 2) are TPH as diesel- and heavy oil-range hydrocarbons, several PAHs, and metals. In the southern, filled portion of the lagoon, results of the RI detected sediment pH at levels toxic to benthic organisms (pH greater than 8.5). Based on our understanding of site activities, concrete material from the ready-mix facility was previously placed in sporadic areas of the southern portion of the lagoon and is the source for localized areas of elevated pH.

1.5 HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS

Site-wide baseline risk assessments were conducted by Landau as part of the RI to evaluate the potential risk, if any, to human and ecological receptors from site contaminants, under both existing conditions and reasonably likely future conditions at the site. The results of the risk assessments are summarized below.

1.5.1 Human Health Risk Assessment

Based on the current and potential future site land and water uses, the human receptor populations that were evaluated with respect to risk from exposure to contaminated environmental media from the site included the following:

- On-site occupational (industrial/commercial) workers, including those who excavate subsurface soil
- Recreational visitors to the site and surrounding area
- Recreational anglers

The risk evaluation concluded that there are no unacceptable risks posed to these human receptor populations under typical exposures. Only in the following cases would site conditions pose unacceptable risks:

- If a long-term site worker were wet for their entire shift, every day for 25 years, from exposure to uplands surface water (water in the process settling ponds).
- If there were anglers who use the site as their only source of fish in their diet, for their entire lives. However, much, if not all, of the predicted risk for these anglers would be the same whether they fished upriver or at the site. This is due in part to naturally occurring metals and in part to the general urban contamination to which the Willamette River is subject.
- If a recreational visitor were exposed via dermal contact to the surface soil with the higher concentrations of organic chemicals at the site for more than one 8-hour day per week, every week for 30 years.

While site-wide risks to human health were generally below protective levels, a few areas of soil and sediment exhibit contaminant concentrations that exceed levels determined to be protective for direct contact exposures or exposures through ingestion of fish that may potentially have accumulated contaminants from sediment. These areas are specifically discussed in Section 3.0 of this report.

1.5.2 Ecological Risk Assessment

Based upon the current and potential future ecological habitats at the site, 24 functional groups of species (e.g., terrestrial mammalian invertivores) are predicted to potentially inhabit the site. Six ecological communities and five specific species were evaluated with respect to risk from site contaminants. The selected representative communities and species included the following:

- **Ecological communities:** Terrestrial plants, terrestrial invertebrates, freshwater fish (e.g., sculpin, crappie, and smallmouth bass), anadromous fish (e.g., salmon and steelhead), benthic invertebrates, and freshwater aquatic life (e.g., plants, invertebrates, and fish; also representing aquatic reptilian omnivores and amphibian invertivores)
- **Ecological species:** The American robin (representing terrestrial avian herbivores, invertivores, and omnivores), the masked shrew (representing terrestrial mammalian herbivores, invertivores, and omnivores), the great blue heron (representing aquatic avian carnivores/piscivores and invertivores), the bald eagle and its eggs (another aquatic avian carnivore/piscivore that is addressed alone, due to its status as a threatened or endangered species), and the river otter (representative of aquatic mammalian carnivores/piscivores, omnivores, and invertivores)

The ecological risk assessment concluded that no unacceptable risks are predicted for threatened or endangered species (e.g., salmon and bald eagle), nor for all but 2 of the 24 ecological functional groups that may be present at the site. The risk assessment does indicate a potential for unacceptable risk to two ecological communities: benthic invertebrates and freshwater fish. There appears to be a reasonable potential for unacceptable risk to the benthic invertebrate community inhabiting the surface sediments in the southern (filled) portion of the lagoon, due to the presence of PAHs, PCBs, elevated pH, and the related un-ionized ammonia concentrations in those sediments. All but two of the PAH concentrations in site surface sediments that result in the finding of probable risk are essentially the same, or lower than, ambient sediment conditions in the Willamette River.

The potential for unacceptable risk to resident freshwater fish is predicted from surface sediment concentrations of the pesticide endrin aldehyde. However, endrin aldehyde was detected in only 7 of 26 samples in the southern portion of the lagoon, and results of the ecological risk assessment concluded that the populations of most freshwater fish populations in the lagoon are unlikely to be adversely affected.

1.6 SITE-SPECIFIC RBCS

As presented in the RI report, chemical analytical results for samples collected from soil, surface water, and sediment were compared to site-specific RBCs to identify areas that may present a risk to human or ecological receptors. Site-specific RBCs were not developed in the RI for site groundwater constituents, since there is no direct pathway between receptors and site groundwater. Therefore, site groundwater constituent data were assessed through fate and transport modeling by predicting groundwater concentrations at discharge locations along the shorelines of the lagoon and Holgate Slough. These predicted concentrations were then compared to surface water RBCs. The fate and transport modeling is discussed in Section 1.7 of this report.

Site-specific RBCs were also not developed in the RI for site TPH. Concentrations of TPH (identified as diesel- and heavy oil-range hydrocarbons) were detected in uplands surface and subsurface soil samples, lagoon surface and subsurface sediment samples, and groundwater samples, as summarized in Tables 3 through 7.

The uplands surface soil TPH as diesel results were compared to DEQ's most stringent generic TPH as diesel RBC of 2,800 mg/Kg, as presented in Table A of DEQ's *Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites* guidance document (DEQ, 2003) as an initial screening process (Table 3). Additionally, since the pathway for direct contact with a human receptor is not considered to be complete for impacted subsurface soil, and will remain incomplete as long as the contaminants are not exposed or disturbed, we considered only the volatilization pathways a complete exposure pathway for subsurface soil. Uplands subsurface soil TPH as diesel results were compared to DEQ's occupational TPH as diesel RBCs (greater than 100,000 mg/Kg) for the volatilization to indoor and outdoor air exposure pathways (Table 4).

Generic RBCs for TPH as heavy oil-range hydrocarbons have not been developed for soil or groundwater to evaluate potential human health risk, nor have generic RBCs for TPH as diesel- and heavy oil-range hydrocarbons been developed to evaluate potential ecological risk. Further, generic RBCs for TPH in sediment have not been developed; therefore, we did not compare the surface and subsurface sediment TPH results (Tables 5 and 6) to any generic RBCs.

The TPH concentrations detected in select groundwater samples do not pose unacceptable risk to human or ecological receptors, since there is no direct pathway between the receptors and site groundwater; therefore, we did not compare groundwater results (Table 7) to any generic RBCs. However, there is a complete pathway between human and ecological receptors via migration of groundwater to surface water (there is a direct contact pathway for groundwater contaminants to human and ecological receptors at the groundwater/surface water interface). Generic RBCs for TPH have not been developed for surface water to evaluate potential human health or ecological risk. Based on review of data included in Table 7, and considering information discussed in Section 1.4.1 of this report, TPH was detected at relatively low concentrations that would not appear to represent a significant risk in the event of discharge to surface water.

1.6.1 ER Calculations for Constituents and TPH as Diesel

ERs were calculated to express the relative concentration of each chemical in relation to its site-specific RBC (for constituents) or generic RBC (for TPH as diesel, where applicable). ERs greater than 1.0 represent exceedances of an RBC. If RBCs for metals are less than the background concentrations, the background concentration was substituted for the RBC in the ER calculation. Calculated ERs for each of the site media are presented in Tables 3, 4, and 8 through 15.

The following sections identify specific samples collected in the uplands and lagoon media, and the associated constituents or TPH that indicate unacceptable risk to human and/or ecological receptors due to ERs greater than 1.0.

1.6.1.1 Uplands Surface Soil

Six uplands surface soil samples (LS03, LS10, LB205, MW03, LS02, and LS18) detected benzo(a)pyrene, arsenic, and/or zinc at concentrations exceeding site-specific RBCs based on exposure to human and ecological receptors; therefore, remedial evaluation is required at these sample locations. Human and ecological ERs for the uplands surface soil samples are summarized in Tables 8 and 9, respectively. Two of the surface soil samples (LS03 and LS10) were "J flagged" by the analytical laboratory, indicating the results were estimated. Additionally, the detected concentrations of benzo(a)pyrene from surface soil samples LB205 and LS10 only slightly exceed the established site-specific RBC. Since the concentrations of benzo(a)pyrene detected in uplands surface soil samples LB205 and LS10 and concentrations of zinc detected in uplands surface soil samples LS02, LS10, and LS18 are only slightly above the established site-specific RBCs, remedial action does not appear to be warranted at these locations. The locations of surface soil samples LS03, LS10, LB205, MW03, LS02, and LS18 are shown on Figures 4 and/or 5. None of the surface soil samples with detected concentrations of TPH as diesel exhibit human health ERs greater than 1.0, as summarized in Table 3.

1.6.1.2 Uplands Subsurface Soil

With the exception of the capped pond material discussed in Section 2.3 of this report, none of the subsurface soil samples from the uplands areas with detected concentrations of constituents exhibited human ERs greater than 1.0. One subsurface soil sample collected from a depth of 27.5 to 29.0 feet BGS from boring LB02 was predicted to pose unacceptable risk to ecological receptors along the Holgate Slough shoreline. The fate and transport modeling of this subsurface sample from boring LB02 is addressed in Section 1.7 of this report.

None of the subsurface soil samples from the uplands areas with detected concentrations of TPH as diesel exhibited human ERs greater than 1.0, as summarized in Table 4.

1.6.1.3 Uplands Surface Water

Three surface water samples (SW-GS-1, SW-1, and SW-2) detected levels of arsenic at concentrations that resulted in ERs ranging from less than 1.0 to 1.4. The detected levels of arsenic are generally consistent with the background concentration for the Willamette River presented in the Port confined disposal site study. None of the surface water samples collected from the process settling ponds exhibit concentrations of contaminants exceeding RBCs based on exposure to ecological receptors; therefore, remedial action does not appear warranted for the surface water in the process settling ponds. Human health ERs for the uplands surface water samples are summarized in Table 10. The locations of samples SW-GS-1, SW-1, and SW-2 collected in the process settling ponds are shown on Figure 4.

1.6.1.4 Lagoon Surface Sediment

As many as 60 surface sediment samples collected from the lagoon contain levels of PAHs, metals, and/or PCBs (aroclor 1254 and 1260) at concentrations exceeding site-specific RBCs based on exposure to human and/or ecological receptors. However, only 19 of the 60 surface sediment samples exhibit concentrations of PAHs greater than their corresponding ambient concentrations. Human and ecological ERs for the lagoon surface sediment samples, and their associated ambient concentrations, are summarized in Tables 11 and 12, respectively. The locations of the surface sediment samples collected from the southern portion of the lagoon that exceed ambient concentrations and exhibit human and ecological ERs greater than 1.0 are shown on Figures 4 and 5, respectively.

Nickel was detected in each of the surface sediment samples collected from the lagoon that resulted in ERs generally ranging from 1.1 to 1.4. One sample exhibited an ER of 1.5, while another exhibited an ER of 1.7. Since the nickel ERs are generally low (less than 2.0) and consistent, it appears that these concentrations are indicative of background sediment concentrations of nickel. As shown in Table 11, silver was also detected in only one sample (CZ06) at a concentration only slightly above the background concentration. Although these nickel exceedances are not identified on Figure 5, the majority of nickel exceedances are located in the vicinity of the former cell breach, an area that will warrant remedial evaluation as discussed in Section 3.6 of this report.

Study results also indicate that conditions toxic to benthic organisms inhabiting the surface sediment exist due to elevated pH (greater than 8.5) in sediment pore water likely associated with the cement component of concrete material in some of the reclamation fill within the lagoon. The locations of the surface sediment samples with pH measurements greater than 8.5 are shown on Figures 4 and 5.

A total of 20 surface sediment samples collected from the lagoon exhibited concentrations of TPH as diesel (Table 5) from 60 to 200 mg/Kg. TPH concentrations detected in the ambient samples from outside of the lagoon, as presented on Table C-9 in Volume II of the RI, ranged from 28 to 260 mg/Kg (Table 13); therefore, the detected TPH concentrations in surface sediment collected within the lagoon are within the range of ambient concentrations.

1.6.1.5 Lagoon Subsurface Sediment

None of the subsurface sediment samples collected from the lagoon (and outside the perimeters of the CAD cells) contain levels of constituent data at concentrations exceeding site-specific RBCs based on exposure to human and/or ecological receptors. However, a total of 37 subsurface sediment samples collected from the lagoon (outside the perimeters of the CAD cells) at depths ranging from 4.5 to 69.5 feet BGS (Table 6) exhibited concentrations of TPH, primarily as diesel, with minor detections of lube oil, ranging from 8 to 640 mg/Kg.

1.6.1.6 Groundwater

Neither site-specific constituents nor TPH RBCs were developed for groundwater, since there is no direct pathway for exposure to potential ecological or human receptors, based on the conceptual site model developed in the RI. Potential exposure and risk to ecological or human receptors was evaluated through fate and transport modeling by predicting groundwater concentrations at discharge locations along the shorelines of the lagoon and Holgate Slough, the results of which are summarized in Section 1.7 of this report. Only at the groundwater/surface water interface is there a direct contact pathway for groundwater contaminants to human and ecological receptors.

Concentrations of TPH as diesel- and heavy oil-range hydrocarbons have been detected in all three groundwater zones (shallow, intermediate, and deep) beneath the site, as summarized in

Table 7. Detected concentrations of TPH ranged from 20 to 850 µg/L. However, as discussed in Section 1.4.1 of this report, the August 2001 data was rejected subsequent to data validation and any prior, sporadic detections of TPH (as summarized in Table 7) are considered to be uncertain indicators of the presence of petroleum hydrocarbons in groundwater at the site.

Leaching tests were conducted on surface soil sample LS14 and subsurface soil samples LB207 and LB208 (both collected from the uplands fill material at depths of 5 to 6.5 feet BGS) to evaluate potential leaching of contaminants in soil to groundwater. These samples were apparently selected for the leachate analysis due to the elevated concentrations of TPH detected in each sample, as well as the proximity to the soil and groundwater interface. TPH was detected in surface soil sample LS14 at a concentration of 2,040 mg/Kg and in subsurface soil samples LB207 and LB208 at concentrations of 7,500 and 1,740 mg/Kg, respectively (Tables 3 and 4). Results of the leaching tests indicate that constituent leachate concentrations were either not detected or were detected at concentrations less than screening levels. The results do indicate TPH leachate concentrations ranging from 0.30 to 2.7 mg/L, exceeding DEQ's most stringent generic RBCs for ingestion and inhalation of tap water. However, as described in the RI, the groundwater ingestion and inhalation of tap water exposure pathway is incomplete.

It should be noted that ecological impacts are not addressed by DEQ's generic TPH RBCs. However, the THP leachate results are between the NPDES discharge limits for oil and grease in stormwater (10.0 mg/L) and industrial discharge (1.0 mg/L).

1.6.1.7 Uplands Surface Soil Erosion to Lagoon Sediment

The RI report considered all surface soil sample locations (at depths between 0.0 and 1.5 feet BGS) within 100 feet of the Ross Island Lagoon shoreline as surface soil that could potentially be transported via surface erosion to the lagoon, even though a Hydraulics and Sediment Transport Model completed by West Consultants, Inc. (incorporated into the Ross Island Reclamation Plan), concluded no areas of existing uplands or present in-water fill are in danger of erosion, even under high water conditions. Surface soil samples collected from borings LB202, LB203, LB207, LB210, LB211, and MW01 were identified as those that could result in unacceptable impacts to surface sediment in the lagoon if significant erosion of soil represented by these samples and subsequent transport into the lagoon were to occur. Detected concentrations of PCBs (aroclor 1254 and 1260), several PAHs, and two metals (nickel and silver) and their corresponding ERs are summarized in Tables 14 and 15. The locations of surface soil samples LB202, LB203, LB207, LB210, LB211, and MW01 with human health and ecological ERs greater than 1.0 are shown on Figures 4 and 5, respectively.

Bathymetry data (collected in December 2001 and 2003) and recent pH assessment data (collected in November 2004) indicate the shoreline in the vicinity of borings LB203, LB207, LB210, and MW01 has been extended into the lagoon due to filling activities since the samples were collected in December 1999. The resulting shorelines are less steep and conform more closely with the designed slopes in the 2002 reclamation plan (as shown on cross section A-A' on Figure 7); therefore, unacceptable impacts to surface sediment in the lagoon via erosion of soil into the lagoon in the vicinity of borings LB203, LB207, LS210, and MW01 no longer appear possible. The location of cross section A-A' is shown on Figures 4 and 5.

1.7 FATE AND TRANSPORT MODELING

The near-surface hydrogeologic system at the site consists of a shallow, unconfined aquifer. The unconfined aquifer exists within reclamation fill material where the site has been mined and then filled and in native uplands alluvial soils where mining has not occurred. The shallow groundwater is in direct connection with the deeper and more extensive unconfined, unconsolidated sedimentary aquifer (the native alluvium), which in turn is in direct connection with deeper groundwater in the regional Troutdale Formation. In general, shallow groundwater flows from the longitudinal "centerline" of the site, radially outward to the shorelines where it discharges to the lagoon and the Willamette River system. Deeper groundwater generally flows upward, discharging to the lagoon floor and the Willamette River.

The RI report included groundwater flow and contaminant transport modeling to estimate future contaminant concentrations in groundwater at points of discharge into surface water that would be expected to result from the contaminants currently in soil, sediment, and groundwater. Two transport routes were modeled, including the following:

- Groundwater that flows through the uplands areas of the site to discharge to either Ross Island Lagoon or Holgate Slough
- Groundwater that flows upward through lagoon sediments to discharge into the base of Ross Island Lagoon

For uplands groundwater, the fate and transport model predicted future concentrations of groundwater at points of discharge into the lagoon and Holgate Slough and predicted concentrations were then compared to the site-specific surface water RBCs to evaluate the potential for risk to ecological and human receptors in the future. Results of the fate and transport modeling predicted the following:

- Five chemicals (DDT, aroclor 1254, benzo(a)pyrene, TBT, and cadmium) could be transported from uplands groundwater sampling locations (MW04A, MW05A, and Geoprobe® boring LB213) to the lagoon shoreline, exceeding RBCs
- Benzo(a)pyrene could be transported from one uplands groundwater sampling location (LB209) to the slough shoreline at concentrations exceeding the RBC

Based on the results of the fate and transport modeling for the lagoon area, three chemicals (DDT, aroclor 1254, and benzo(a)pyrene) could be transported from the subsurface sediments at concentrations that exceed ecological and human health RBCs.

For the purpose of this FS, ERs that are not predicted to occur until after 1,000 years are likely to not be significant due to limits to the extension of the models in time and the degradation processes that are likely to occur (but were not included in the models) during this time frame. Therefore, samples with ERs that are not predicted to occur until after 1,000 years do not appear to present a significant risk, and will not be addressed in this FS.

Based on the above criteria, benzo(a)pyrene was predicted to pose a risk to human receptors along the lagoon shoreline from a groundwater sample collected from Geoprobe® boring LB213, 4,4-DDT was predicted to pose a risk to ecological receptors along the Holgate Slough shoreline from a soil concentration detected in LB02, and aroclor 1254 was predicted to pose a risk to human health in lagoon surface water from a subsurface concentration detected in G07 (within port fill material in CAD Cell No. 1).

The predicted human health exceedance for benzo(a)pyrene along the lagoon shoreline was based on the results of one groundwater sample collected from a Geoprobe® boring (LB213). Given that the groundwater sample was collected from a temporary boring as opposed to a properly installed groundwater monitoring well, the reported concentrations would be considered estimated only and would likely be biased high given turbidity commonly associated with undeveloped wells. Nonetheless, the potential for migration of benzo(a)pyrene in groundwater to the lagoon shoreline will be addressed in the FS.

The predicted exceedance for 4,4-DDT was based on the soil concentration detected in boring LB02, which was J flagged by the analytical laboratory, indicating that the reported value was estimated. The resulting analytical data quality for both the groundwater sample collected from the temporary boring and the laboratory results for 4,4-DDT are considered less than optimal for use in fate and transport modeling and may not accurately reflect predicted concentrations and potential future risk. The modeled concentration of 4,4-DDT in Holgate Slough, based on data from boring LB02, is low enough and occurs far enough into the future (1,133 years into the future) that it is not considered a significant potential source of risk from the site. Therefore, the potential for migration of 4,4-DDT from subsurface soil at boring LB02 to the groundwater/surface water interface along Holgate Slough will not be addressed in this FS.

For the lagoon area, only one potential exceedance was predicted by the fate and transport modeling (aroclor 1254), which was estimated to occur in approximately year 500 and last beyond year 650,000. The predicted exceedance for potential risk less than 1,000 years is based on the detected concentration of aroclor 1254 in the subsurface sediment sample from G07, which occurred in the vicinity of CAD Cell No. 1 for which previous modeling by the Port yielded conflicting results. Further, the fate and transport models predicted potential future risk based on the then-current bathymetry in the lagoon, not accounting for planned reclamation filling as set forth in the reclamation plan. As presented in the reclamation plan, additional fill is planned in the area of CAD Cell No. 1, resulting in an additional placement of at least 10 feet of sediment cap not accounted for in the fate and transport model. Given the various uncertainties and conservative tendencies of the modeling efforts, and considering the planned reclamation filling, actual risk associated with the potential for migration of aroclor 1254 from subsurface sediment to the groundwater/surface water interface appears to be low, if any. Nevertheless, the potential for migration of aroclor 1254 from subsurface sediment to the groundwater/surface water interface will be addressed in this FS.

2.0 IDENTIFICATION OF HOT SPOTS

The potential for hot spots (as defined by ORS 465.315 and OAR 340-122-115(32)) to exist within environmental media at the site was evaluated in the RI using the guidance developed by DEQ (DEQ, 1998b). The first step in identifying hot spots, which was completed during the RI, involved comparing individual sample results to RBCs. Under DEQ guidance, groundwater or surface water samples that exhibit an ER of 1.1 or greater are potential hot spots. For environmental media other than water (i.e., soil and sediment), the exceedance ratios undergo further screening as follows (DEQ, 1998b):

- Ten times the human health RBC if the chemical is a non-carcinogen
- One hundred times the human health RBC if the chemical is a carcinogen
- Ten times the ecological RBC for all chemicals

The following sections describe the media identified as hot spots, based on the above ER criteria. Volume estimates for each hot spot are presented in Section 3.7 of this report.

2.1 SURFACE WATER

Although surface water sample concentrations from samples collected in both the main process settling pond and in the smaller north settling pond exhibit ERs slightly greater than 1.1 (Table 10), there is no identified site-related source for arsenic in the settling ponds and the concentrations detected are generally consistent with the background concentration for the Willamette River presented in the Port's confined disposal site study; therefore, these surface water bodies are not considered hot spots. Additionally, there were no surface water hot spots identified for the lagoon.

Landau's previous fate and transport modeling predicted that benzo(a)pyrene may pose unacceptable risk to human receptors in surface water along the lagoon shoreline via migration through groundwater. Since the predicted exceedance results in an ER significantly greater than 1.1, the area of discharge along the lagoon shoreline and at the location near CAD Cell No. 1 is considered a potential hot spot.

2.2 LAGOON SEDIMENT

A total of 18 surface sediment samples collected in the lagoon that exceed background/ambient sediment concentrations were identified as hot spots, as summarized in Tables 11 and 12. The locations of these sediment hot spots are shown on Figure 6. In general, hot spots are located in the vicinities of the CAD cells, and in particular, the area of the former breach. These exceedances are based on potential exposures occurring due to ingestion of fish. There were not hot spots identified in the sediment in the northern portions of the lagoon.

2.3 CAPPED MATERIAL

Although ERs are not presented for the contaminants beneath the cap material in the eastern portion of the settling pond or for the contaminants within each of the CAD cells in the lagoon, these areas have been identified as hot spots, based on the concentrated levels of contaminants.

Based on the results of Landau's groundwater flow and solute transport model, the concentrations of contaminants contained in the settling pond sediments do not pose a potential unacceptable risk to human health or the environment, including the surface water of Holgate Slough or Ross Island Lagoon. Additionally, based on the results of the Port's fate and transport model, migration of contaminants from the CAD cells would not result in unacceptable levels of hazardous substances at the likely exposure points for human or ecological receptors. Based on available data and the modeling results, it appears that the capped material in the eastern portion of the settling pond and within each of the CAD cells in the lagoon are reliably contained hot spots (Figure 6).

2.4 TREATMENT OF HOT SPOTS

According to DEQ (1998b) guidance, hot spots are given special consideration in the FS. A higher cost threshold is applied to the cost reasonableness of treatment or removal of hot spots in the balancing of other remedy evaluation criteria (i.e., effectiveness, long-term reliability, implementability, and implementation risk). For example, a non-treatment alternative such as sediment capping may be justified for hot spots if this alternative would result in equal or better effectiveness, long-term reliability, implementability, and implementation risk, but at a significantly lower cost.

3.0 REMEDIAL AREA IDENTIFICATION

The objective of this section is to summarize those locations at the site where COPCs or COPECs exceed the RBCs or other sample characteristics potentially detrimental to human health or the environment (such as surface sediment toxicity related to elevated pH). These data, combined with the site conceptual model developed in the RI, provide the basis for identification of areas at the site that warrant additional remedial evaluation. These areas, presented by area and media, are described in the following sections.

3.1 UPLANDS SURFACE SOIL

The aerial extent of the uplands surface soil requiring remedial action have been identified as the following areas:

- Area A1: Isolated areas where surface soil exceeds RBCs based on exposure to uplands human or ecological receptors
- Area A2: Isolated areas where surface soil represents a potential threat to the lagoon via erosion and in turn, would exceed RBCs based on exposure to human or ecological receptors

For the purposes of this FS, the aerial extent of the uplands surface areas requiring remedial action have been defined by an approximate 100-foot-diameter radii around each impacted surface soil sample or where bound by site facilities (Figure 6). The 100-foot-diameter radii are presented as conservative assumptions of extent, so that volume estimates can be calculated and alternatives compared. The 100-foot-diameter radii may not represent the actual aerial extent of contamination; the actual extent is anticipated to be significantly less. The results of confirmation samples that would be collected during remedy implementation would determine the actual aerial extent. The vertical depth of impact in these areas, based on the results of the RI sampling, ranges from the surface to 1 foot BGS for Area A1 and from the surface to 1.5 feet BGS for Area A2. Based on these limits, the calculated total volume of uplands surface soil requiring remedial action is approximately 11,000 cubic yards (in-place volume). The remedial action limits will be refined during development of the remedial action plan.

Surface Areas A1 appear limited in extent, and based on the hydraulics and sediment transport model, Areas A2 are in not subject to erosion (even under conditions of high water); however, these isolated areas of uplands surface soil are carried forward for further remedial action analysis. Areas A1 and A2 are shown on Figure 6.

3.2 UPLANDS SUBSURFACE SOIL

Area B is identified as former eastern portion of the main process settling pond that is currently capped and would exceed RBCs based on exposure to human or ecological receptors if the cap is removed. The capped material consists of breached material from CAD Cell No. 5, including clean cap material, adjacent non-contaminated fill material, and approximately 6,300 cubic yards of impacted, confined material. Area B is shown on Figure 6.

3.3 UPLANDS SURFACE WATER

Since there is no identified site-related source for arsenic in the settling ponds and the concentrations detected are generally consistent with the background concentration for the Willamette River, remedial action does not appear to be warranted for the settling ponds.

3.4 GROUNDWATER

For Area C, the estimated volume of the impacted groundwater represented by a sample collected from boring LB213 predicted to migrate and pose unacceptable risk to human receptors along the lagoon shoreline is unknown. However, based on review of data collected from MW-02 in the general area of boring LB213, benzo(a)pyrene has not been detected during several recent sampling events. These data suggest that the occurrence of benzo(a)pyrene at boring LB213 is limited in aerial extent. The entire migration pathway area, identified on Figure 6 as Area C, will be carried forward for further analysis.

3.5 LAGOON SURFACE SEDIMENT

Area D includes surface sediment in the lagoon that exceeds RBCs and background/ambient concentrations, based on exposure to human or ecological receptors, or with toxicity to ecological receptors related to elevated pH.

For the purposes of this FS, the aerial extent of the lagoon surface sediment requiring remedial action in Area D has been defined by an approximate 100-foot-diameter radii around each impacted surface sediment sample (Figure 6). As with the uplands surface soil, the 100-foot-diameter radii are presented as conservative estimates of extent, so that volume estimates can be calculated and to allow for comparison of alternatives. The 100-foot-diameter radii may not represent the actual aerial extent of contamination. The results of confirmation samples will determine the actual aerial extent. The vertical depth of impact in these areas ranges from the surface to a depth of 0.3 foot. Based on the aerial and vertical limits, the total volume of sediment impacted by elevated concentrations of contaminants is estimated at approximately 4,500 cubic yards (in-place volume), of which, approximately 3,800 cubic yards (in-place volume) is considered a hot spot. The total volume of sediment impacted by elevated pH is estimated at approximately 3,500 cubic yards (in-place volume). The remedial action limits will be refined during development of the remedial action plan. These isolated areas of lagoon surface sediment are carried forward for further remedial action analysis. Area D is shown on Figure 6.

3.6 *LAGOON SUBSURFACE SEDIMENT*

As previously described, there are five CAD cells in the lagoon, identified as Areas E on Figure 6. Concentrations of TBT, heavy metals, and SVOCs (including PAHs, VOCs and PCBs) may present a risk to human and/or ecological receptors should the caps be removed. One subsurface sediment sample collected from a boring within CAD Cell No. 1 was predicted by Landau to pose unacceptable risk to human receptors in the lagoon surface water in less than 1,000 years. However, as previously mentioned, the Port concluded through fate and transport modeling of the migration of contaminants from the CAD cells that migration would not result in unacceptable levels of hazardous substances at the likely exposure points for human or ecological receptors. Nonetheless, since the CAD cells have been identified as reliably contained hot spots, all of the CAD cells will be carried forward for further remedial action analysis. The total volume of confined material for all of the CAD cells is approximately 162,000 cubic yards.

3.7 *REMEDIAL AREA SUMMARY*

In summary, the following areas and associated impacted volumes of site media that currently or potentially could represent unacceptable risk to human or ecological receptors and require remedial evaluation or action are presented in the following sections.

3.7.1 Uplands Areas

Areas A1 and A2: A total of approximately 11,000 cubic yards of surface soil where:

- benzo(a)pyrene, arsenic, and zinc exceed RBCs based on exposure to potential human and/or ecological receptors.
- PCBs (aroclor 1254 and 1260), several PAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(k)fluoranthene, and indeno(1,2,3-cd)pyrene), and two metals (nickel and silver) could result in unacceptable impacts to surface sediment in the lagoon if significant erosion of soil represented by these samples and subsequent transport into the lagoon were to occur.

3.7.2 Uplands Subsurface Areas

Area B: Approximately 6,300 cubic yards of capped material east of the main settling pond where concentrations of TBT and TPH may present a risk to human and/or ecological receptors should the cap be removed.

3.7.3 Groundwater Area

Area C: An unknown volume of groundwater in the vicinity of Geoprobe® boring LB213 where fate and transport modeling predicted that benzo(a)pyrene may pose unacceptable risk to human receptors in surface water along the lagoon shoreline via migration through groundwater.

3.7.4 Lagoon Areas

Area D: Approximately 4,500 cubic yards of surface sediment in the lagoon where:

- PAHs, PCBs, pesticides, and metals exceed RBCs based on exposure to human and/or ecological receptors.

Area E: Approximately 3,500 cubic yards of surface sediment in the lagoon where:

- levels of pH are toxic to benthic organisms.
- select surface sediment samples failed direct toxicity testing.

3.7.5 Lagoon Subsurface Areas:

Area E: A total of approximately 162,000 cubic yards of subsurface sediment contained in CAD Cells No. 1 through 5, where concentrations of TBT, heavy metals, and SVOCs (including PAHs, VOCs, and PCBs) may present a risk to human and/or ecological receptors should the caps be removed.

4.0 DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES

4.1 REMEDIAL ACTION OBJECTIVES

The objective of remedial action for the site is to provide cost-effective remedial alternatives that effectively mitigate and minimize threats to, and provide adequate protection of, public health and welfare and the environment. The RAOs described below are based, in part, on regulatory criteria and site-specific information in the RI report and the baseline risk assessment (Landau, 2002a) and meet the following two primary criteria:

- Remedial actions must achieve the standards for "protectiveness" specified in OAR 340-122-040(2). These standards are the acceptable risk levels defined in OAR 340-122-115. Furthermore, as specified in OAR 340-122-040(4), remedial actions shall prevent or minimize future releases and migration of hazardous substances in the environment.
- Remedial actions must treat hot spots (OAR 340-122-115) of contamination to the extent feasible based on the remedy selection balancing factors.

RAOs are medium-specific goals for protecting human health and the environment and specify the following for each impacted medium:

- The COPCs/COPECs
- Exposure routes and receptors for the current and reasonably likely anticipated future land and water use(s)

The RAOs for the site are relevant only to the specific points or areas described in Section 3.0 of this report where the particular exposure pathway is applicable. The RAOs for each impacted media are described below.

4.1.1 Uplands Soil

4.1.1.1 Surface Soil - Areas A1

The RAO for the uplands surface soil in Area A1 is to reduce risk to occupational workers, recreational visitors, and/or ecological receptors to exposure of uplands surface soils impacted with the PAH benzo(a)pyrene, arsenic and zinc.

4.1.1.2 Surface Soil - Areas A2

The RAO for the uplands surface soil in Area A2 is to reduce exposure to potential human receptors (consumers of fish) and ecological receptors (aquatic life) in the lagoon by preventing the soil impacted with concentrations of PAHs, PCBs, and metals from eroding into the lagoon.

4.1.1.3 Subsurface Soil Area B – Capped Pond Material

The RAO for subsurface Area B (capped pond material identified as a reliably contained hot spot) is to prevent exposure of the capped material impacted with TBT and TPH to occupational and potential future recreational visitors and prevent migration of the contaminants from the capped areas.

4.1.2. Groundwater

4.1.2.1 Groundwater - Area C

The RAO for groundwater represented by a sample collected from boring LB213 (identified as a potential hot spot at the discharge location) is to mitigate the potential risk to human health as a result of the potential modeled exceedance of benzo(a)pyrene in groundwater discharging to surface water in the lagoon after 400 years.

4.1.3 Lagoon Sediment

4.1.3.1 Surface Sediment - Area D

The RAO for the lagoon surface sediment, in which some samples were identified as hot spots, is to reduce risk to human health via consumption of fish (based on the assumption that a certain level of chemical uptake will occur from the contaminated sediments in the lagoon, primarily endrin aldehyde, to fish tissue), and to benthic invertebrates from exposure to PAHs, PCBs, metals, and elevated pH in the surface sediments in the lagoon.

4.1.3.2 Subsurface Material Capped - Area E (CAD Cells No. 1 through 5)

The RAO for the capped subsurface material in Area E (CAD Cells No. 1 through 5, identified as reliably contained hot spots) is to prevent human and ecological exposure to material impacted with TBT, heavy metals, SVOCs, VOCs, and PCBs and the spread of the contaminants from the capped areas.

4.2 IDENTIFICATION OF GENERAL RESPONSE ACTIONS

General response actions are measures that are implemented to manage and/or control a specific contamination problem to meet the RAOs. In accordance with DEQ's *Final Guidance for Feasibility Studies,* dated July 1, 1998, and specified in OAR 340-122-085(2), these include: 1) no action, 2) engineering and/or institutional controls, 3) treatment, 4) excavation and off-site disposal without treatment, and 5) any combination of the aforementioned, as appropriate. These general response actions are briefly summarized as follows.

4.2.1 No Action

The "no action" alternative serves at the baseline for comparison of other potential remedial alternatives, and no remedial action or monitoring would be performed.

4.2.2 Engineering and/or Institutional Controls

Engineering controls (such as capping, fencing, or hydraulic barriers) are physical measures implemented to prevent or minimize exposure or to reduce mobility of contaminants. Institutional controls (such as land, water use, or property access restrictions) are legal or administrative actions implemented to reduce exposure to contaminants.

4.2.3 Treatment

Treatment alternatives include various in-situ or ex-situ technologies to permanently and substantially eliminate or reduce toxicity, mobility, or volume of contaminants. In general terms, treatment may be performed by chemical, thermal, physical, or biological methods and can be completed either on site or off site.

4.2.4 Excavation and Off-Site Disposal Without Treatment

This alternative involves excavation of soil, solid waste, or hazardous waste and subsequent transportation to and management of the material at a permitted off-site facility.

4.2.5 Any Combination of the Aforementioned General Response Actions

One or more of the above general response actions may be combined to achieve the RAOs. For example, engineering and/or institutional controls will not achieve the RAO by themselves, but will be implemented in conjunction with another remedial technology as part of the final remedial action for the site. Sites that permanently incorporate institutional controls into their remedial action will remain on DEQ's "Inventory of Sites Requiring Further Action."

Specific remedial technologies for the applicable general response actions are identified and further evaluated in Section 4.3 of this report.

4.3 IDENTIFICATION AND SCREENING OF REMEDIAL ALTERNATIVES

This section describes the focused remedial action technologies that are aligned with the focused general response actions identified in Section 4.2 of this report. A screening is presented to assess if the technologies warrant further consideration. These potential remedial action technologies are screened based on the RAOs and data obtained during the RI and RA. The remedy selection criteria, or balancing factors (as specified in OAR 340-122-090), used for the initial screening process are presented in Table 16 and summarized as follows:

Effectiveness: Evaluates the overall effectiveness of the remedy in achieving protection considering the magnitude of risk from untreated waste or treatment residuals, adequacy of engineering or institutional controls, extent to which the action restores or protects existing and reasonably likely future beneficial water uses, and time until the RAOs would be achieved.

Long-Term Reliability: Evaluates the reliability of the treatment technology to meet objectives, reliability of engineering and institutional controls to manage risk, and the nature and degree of uncertainty of any necessary long-term management.

Implementability: Evaluates the ease or difficulty of implementing the remedial action considering practical, technical, and legal difficulties, and unknowns associated with the technology; ability to monitor effectiveness; consistency with federal, state, and local requirements; and availability of necessary services, materials, and specialists.

Implementation Risk: Evaluates the potential impacts on the community, workers, and the environment during implementation of the remedial action and estimated completion time for the remedy.

Reasonableness of Cost: Considers the reasonableness of cost considering capital, annual operation, and review costs; the degree to which the cost of the remedial action are proportionate to the benefits to human health and the environment; degree to which the costs are proportionate to the benefits created through restoration or protection of existing and reasonably likely future beneficial uses of water; and the degree of sensitivity and uncertainty of the costs.

4.3.1 Identification of Potential Remedial Alternatives

The following remedial alternatives for the general response actions were identified as potentially suitable for the impacted media that currently pose unacceptable risks or potential unacceptable future risks to human and ecological receptors.

- Removal Actions, including:
  - Excavation/Dredging and Off-Site Disposal/Treatment
  - Excavation/Dredging and On-Site Disposal/Treatment
- Physical Treatment, including:
  - Solidification/Stabilization
  - Neutralization
  - Air Sparging/Chemical Treatment
- MNA
- Institutional Controls
- Engineering Controls, including:
  - Caps
  - Slope Stabilization
  - Hydraulic Containment

Each of the above remedial technologies was screened based on the criteria described in Section 4.3 of this report.

4.3.2 Description and Initial Screening of Potential Remedial Technologies

The results of the technology screening for each impacted media currently posing or potentially posing unacceptable risks to human and/or ecological receptors are presented in Table 16. Table 16 identifies each remedial technology applicable to the specific media, presents a qualitative rating of the balancing factors described in Section 4.3 of this report, briefly describes each technologies advantages and disadvantages, and whether or not the technology was retained and carried forward for detailed analysis. Each remedial alternative screened is briefly described in Sections 4.3.2.1 through 4.3.2.11 of this report.

4.3.2.1 No Action

The "No Action" alternative assumes that no remediation activities occur at the site. The "No Action" alternative is generally carried forward as a baseline for purposes of cost/benefit comparison; however, it has been screened out from further consideration (and not included in Table 16) because it does not achieve any of the RAOs identified in Section 4.1.1 of this report.

4.3.2.2 Excavation/Dredging and Off-Site Disposal/Treatment

The excavation/dredging and off-site disposal/treatment technology is a stand-alone removal technology that could be implemented at the site to prevent exposure to human and ecological receptors. This removal technology involves excavating the surface and subsurface soil or dredging the surface and subsurface sediment containing the contaminants and/or elevated pH and transporting it off site for landfill disposal or treatment in accordance with applicable regulations. Both the soil and sediment can be loaded onto barges and transported to a RCRA Subtitle D landfill (Roosevelt Landfill in Roosevelt, Washington) or trucked to the Hillsboro Landfill in Hillsboro, Oregon. Based on the results of the screening presented in Table 16, excavation/dredging of surface and subsurface soil/sediment and off-site disposal/treatment was retained for consideration in the detailed analysis.

4.3.2.3 Excavation/Dredging and On-Site Disposal/Treatment

The excavation/dredging and on-site disposal/treatment removal technology involves excavating the surface and subsurface soil in the uplands or dredging the surface and subsurface sediment in the lagoon that contain contaminants or elevated pH and transporting the impacted material to a single on-site location for disposal or treatment (such as adjacent to the main settling pond) where the current cap could be extended to cover newly placed material. This technology would be combined with other technologies where appropriate, such as solidification/stabilization, engineering cap and institutional controls to achieve the RAOs. Based on the results of the screening presented in Table 16, excavation/dredging of surface and subsurface soil/sediment and on-site disposal/treatment was retained for consideration in the detailed analysis.

4.3.2.4 Solidification/Stabilization

This technology is a treatment technology that would be combined with another technology (such as excavation) that involves mixing the contaminants with a binder or mixture of binders, which solidify and contain the contaminants. Stabilization makes the contaminants less soluble, immobile, and in a state that is less toxic. Solidification encapsulates the waste. Solidification/stabilization (in combination with another technology) was retained for consideration in the detailed analysis.

4.3.2.5 Neutralization

This treatment technology would also be combined with another technology (such as a removal technology or engineering control) and would neutralize the elevated pH to levels that would not pose unacceptable risk to benthic invertebrates. Sediment, whether imported fill material to be used as a cap or removed from the lagoon, would be amended with another substance (such as sulfur) to lower the pH to levels less than 8.5. Based on our research, this treatment technology is unproven in submerged environments and would require further evaluation. Neutralization, however, is carried forward for further consideration in the detailed analysis.

4.3.2.6 *Air Sparging/Aeration*

This technology is an in-situ treatment technology that involves volatilizing organic compounds absorbed onto soil and dissolved in groundwater via forced air. For a site where groundwater is impacted by organic compounds, air would be injected below the water table via vertical slotted piping, adding oxygen to the aquifer, and facilitating biodegradation. Volatile contaminants could be collected in the vadose zone by vapor extraction. Based on the results of the screening presented in Table 16, air sparging/aeration was not retained for consideration in the detailed analysis.

4.3.2.7 *Groundwater Extraction and Treatment*

This technology involves extraction of groundwater from recovery wells or trenches with aboveground treatment using either activated carbon or air stripping methods, or both. Based on the results of the screening presented in Table 16, groundwater extraction and treatment was not retained for consideration in the detailed analysis.

4.3.2.8 *Chemical Treatment*

This technology is a stand-alone treatment technology that involves injecting chemical oxidants or magnesium peroxide to contaminated media in order to destroy the contaminants by converting them to innocuous compounds commonly found in nature. Chemical treatment technologies have been shown to be very effective at treating organic compounds in soil and groundwater. Based on the results of the screening presented in Table 16, chemical treatment was not retained for consideration in the detailed analysis.

4.3.2.9 *MNA and MNR*

These technologies involve the reliance of naturally occurring physical, chemical, or biological processes to reduce the concentration and/or mobility of organic contaminants in soil, sediment or groundwater. Natural attenuation and natural recovery processes include adsorption, dilution, dispersion, and biological transformation of contaminants. These technologies would be combined with a monitoring program to document their effect on the contaminant mass. Based on the results of the screening presented in Table 16, MNA and MNR were retained for consideration in the detailed analysis

4.3.2.10 *Institutional Controls*

Institutional controls (such as land use restrictions) are legal or administrative measures or actions that will be implemented to prevent and/or minimize exposure to the impacted media either currently or potentially posing unacceptable risk to human receptors. Institutional controls will not achieve the RAOs by themselves, but will be implemented in combination with another technology as part of the final remedial action for the specific impacted media. Sites that permanently incorporate institutional controls into their remedial action will remain on DEQ's "Inventory of Sites Requiring Further Action." Based on the results of the screening presented in Table 16, institutional controls will be considered as critical components in combination with other select alternatives (such as capping and MNR), but since they are not stand-alone technologies for a given general response action, they are not included in the detailed analysis.

4.3.2.11 *Engineering Controls*

Engineering controls will not achieve the RAOs by themselves, but would be combined with other alternatives (such as institutional controls) as part of the final remedial action for the site. The engineering control technologies considered and screened are intended to physically prevent exposure of contaminants to human and ecological receptors. Based on the results of the screening presented in Table 16, some engineering controls were retained for consideration in the detailed analysis. The retained engineering controls include caps constructed of soil, concrete, or sediment. To achieve the RAOs outlined in Section 4.1 of this report, we have defined uplands soil and lagoon sediment caps at least 3 feet thick and uplands concrete caps at least 0.5-foot thick. Actual cap thicknesses would be determined during further site-specific analysis .

4.4 *SUMMARY OF RETAINED REMEDIAL TECHNOLOGIES*

Based on the initial screening, certain technologies were retained for further consideration based on the balancing criteria. The retained remedial technologies for the impacted media currently posing or potentially posing unacceptable risk to human and/or ecological receptors are as follows:

- Excavation/Dredging and Off-Site Disposal
- Excavation/Dredging and On-Site Disposal
- Combination Dredging and Sediment Cap
- Solidification/Stabilization
- MNA and MNR as part of monitoring programs
- Institutional Controls
- Engineering Controls

4.5 *ASSEMBLY OF REMEDIAL ALTERNATIVES*

From the initial screening, the retained potential remedial technologies were assembled into viable remedial alternatives for further analysis. For each general response action, at least one stand-alone remedial technology was carried forward from the screening analysis. For those general response actions with only one stand-alone remedial technology, a comparative analysis was not completed.

According to DEQ guidance, sites containing hot spots of contamination must include an evaluation of treatment- or removal-based alternatives. Current hot spots have been identified as Area B, select Areas D, and Areas F, as shown on Figure 6. Partial removal of hot spots combined with other alternatives (such as capping remaining residual contamination) are also evaluated. Fate and transport modeling predicts a potential future hot spot in the surface water along a portion of the lagoon shoreline (Area C) as shown on Figure 6. As shown in Table 16, the removal technologies that include off-site treatment for Areas B, D, and E were retained for quantitative evaluation and are described below. However, since groundwater is identified as only a potential hot spot in the future (should the previously detected concentration at boring LB213 migrate north and discharge to the lagoon in 400 years), none of the treatment technologies identified in Table 16 for this area were retained for quantitative evaluation, based on a combination of all five remedy selection criteria. Area C is identified as a potential concern and will be addressed via monitoring.

5.0 RESULTS OF COMPARATIVE EVALUATION OF RETAINED TECHNOLOGIES

A comparative evaluation of the retained technologies for impacted media that are currently or may potentially present unacceptable risk to human and/or ecological receptors are summarized in Table 17. The comparative evaluations were made by completing direct comparisons of the retained remedial technologies and are based on the ability to meet the RAO for each media and consideration of the criteria for remedial actions as provided in OAR 340-122-0090, specifically effectiveness, long-term reliability, implementability, implementation risk, and reasonableness of cost. As mentioned in Section 1.2.2 of this report, components of the reclamation plan are considered as part of the comparative analysis of remedial alternatives; therefore, for two remedial alternatives that are equally effective and provide equivalent protection, the alternative that more closely conforms with the plans and goals of the reclamation plan is preferentially considered. A maximum of 10 points is awarded to the most favorable technology for each head-to-head ranking; therefore, a maximum of 50 total points may be awarded for the entire evaluation for those areas without identified hot spots. For areas with identified hot spots, a maximum of 60 total points may be awarded for the evaluation.

For each identified hot spot, each of the alternatives was evaluated on overall effectiveness to either:

- treat or remove the identified hot spots to non-hot spot levels by reducing their concentration where exposure is predicted to occur via migration (such as along the lagoon shoreline),
- treat or remove the identified hot spots in the lagoon sediment to non-hot spot levels by reducing their concentration, volume, or mobility, or
- manage and maintain existing containment systems (such as the capped pond material and the CAD cells) where modeling has indicated the contained hot spots will not cause hot spot levels in other media via migration.

In order to evaluate reasonableness of costs, planning level cost estimates were developed for each technology. These planning level cost estimates were based on numerous assumptions because conceptual design has not been completed for each technology. Cost estimates represent a 30-year (or less, when applicable) life cycle. While adequate for decision-making purposes, final cost estimates will depend on the scope of the final remedial design. Note the following regarding the estimated costs for each alternative:

- Cost estimates are considered to be within a margin of plus 50 percent to minus 30 percent.
- Many unit costs are derived from experience.
- Long-term monitoring and maintenance costs are presented as present worth costs using a 30-year period and an interest rate between 5 and 7 percent.

An itemized cost estimate for each developed alternative is provided in Appendix A. The itemized cost estimates include various assumptions and references for the cost estimates (as specified in OAR 340-122-090(e) (A)).

- Capital costs, including both direct and indirect costs
    - Annual operation and maintenance costs
    - Costs of any periodic review requirements
    - Net present value of all of the above

The itemized cost estimates also include reference to specific types of equipment, sampling and analysis, and various other resources that would be required to complete the remedial alternative.

5.1 UPLANDS SURFACE SOIL - AREA A1

Five remedial alternatives were retained for comparison in Table 17 for the uplands surface soil in Areas A1 where benzo(a)pyrene, arsenic, and/or zinc exceed RBCs based on exposure to human and/or ecological receptors. The retained alternatives include the following:

- Alternative 1A: Excavation and On-Site Disposal/Containment
- Alternative 1B: Excavation and Off-Site Disposal/Treatment
- Alternative 2: Solidification and Stabilization
- Alternative 3A: Construct Soil Cap
- Alternative 3B: Construct Concrete Cap

5.1.1 Effectiveness

Each of the alternatives is considered to be equally effective in achieving the RAO.

5.1.2 Long-Term Reliability

Alternative 1B ranked the highest for this criterion, primarily because it removes the contaminants from the site. The second most reliable alternative is the concrete cap, due to its durability and strength. The remaining alternatives ranked equally reliable in the long term combined with performance monitoring and/or institutional controls.

5.1.3 Implementability

Alternative 3A ranked the highest for this criterion since, based on 2003 topographic data, between 1 and 3 feet of fill material has already been placed apparently from routine grading operations at the site. The source of the fill material appears to be non-commercial grade material generated from on-site aggregate processing and general grading operations in the vicinity of the processing plant, and no import of fill material has occurred in Area A1. Alternative 3B ranked the second highest for this criterion, since it would not require removal of the fill material that has been placed, but would require subgrade preparation. Alternatives 1A, 1B, and 2 ranked lower than 3A and 3B. Alternatives 1A, 1B, and 2, while implementable, inherently involve greater level of effort in comparison to capping alternatives. Where required, compliance with solid waste disposal rules and regulations would be met (including landfill permitting for off-site disposal, Solid Waste Letter of Authorization requirements) or at a minimum adherence to substantive requirements therein.

5.1.4 Implementation Risk

Alternatives 3A and 3B ranked the highest for this criterion, as there is little or no implementation risk associated with these alternatives other than manageable risks to on-site workers and potential recreational visitors or trespassers. Alternatives 1A, 1B, and 2 ranked lower for this criterion due to overall increased handling and on- and off-site transportation of contaminated media.

5.1.5 Reasonableness of Cost

Alternatives 2 and 3A ranked the highest for this criterion (least expensive), followed by Alternatives 1A, 1B, and 3B.

5.1.6 Extent of Treatment of Hot Spots

There were no hot spots identified in Area A1.

5.2 UPLANDS SURFACE SOIL - AREA A2

Two remedial alternatives were retained for comparison in Table 17 for the uplands surface soil in Area A2 where PCBs (aroclor 1254 and 1260), several PAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(k)fluoranthene, and indeno(1,2,3-cd)pyrene), and two metals (nickel and silver) could result in unacceptable impacts to surface sediment in the lagoon if significant erosion of soil represented by these samples and subsequent transport into the lagoon were to occur. The retained alternatives include the following:

- Alternative 1: Excavation and Off-Site Disposal/Treatment
- Alternative 2: Slope Stabilization and Monitoring

5.2.1 Effectiveness

Alternatives 1 and 2 ranked equally as high for this criterion, since they both are equally as effective at achieving the RAO. Since both are equally as effective, Alternative 2 is more favorable for this criterion, since it more closely conforms with the plans and goals of the reclamation plan.

5.2.2 Long-Term Reliability

Alternative 1 ranked the highest for this criterion, as it removes the contaminants from the surface soil, whereby erosion (if it were to occur) would not impact the lagoon.

5.2.3 Implementability

Alternative 2 ranked the highest for this criterion, as it appears that some fill material has already been placed on some slopes in Area A2. Placing additional fill material at a designed slope in accordance with the reclamation plan could be easily implemented.

5.2.4 Implementation Risk

Alternative 2 ranked the highest for this criterion (less implementation risk), as there are only minor risks (manageable) associated with continued material placement and grading. Excavation and handling of impacted soil (under Alternative 1) would present more risk to on-site workers than Alternative 2.

5.2.5 Reasonableness of Cost

Alternative 2 ranked the highest for this criterion. For the A2 uplands areas in the south portion of the lagoon, the planned reclamation activities (including fill placement and re-vegetation) are considered sufficient to achieve the RAO with no additional cost beyond that associated with the reclamation. On the east side of the lagoon, the steeper sloped areas not affected by the reclamation; therefore, supplemental stabilization using rock may be required.

5.2.6 Extent of Treatment of Hot Spots

There were no hot spots identified in Area A2.

5.3 CAPPED POND MATERIAL - AREA B

Two remedial alternatives were retained in Table 17 for the material in the capped portion of the settling pond where TBT and TPH may cause a risk to human and ecological receptors should the current cap material be compromised. The retained alternatives include the following:

- Alternative 1: Excavation and Off-Site Disposal/Treatment
- Alternative 2: Implement a Management/Maintenance Plan to Maintain the Existing Cap

5.3.1 Effectiveness

Alternatives 1 and 2 ranked equally high for this criterion, since they both effectively achieve the RAO. Since the current cap prevents exposure of the hot spot to current receptors and will continue to prevent exposure to future receptors if properly maintained, it provides equal effectiveness as Alternative 1, which would reduce the hot spot levels by removing the source.

5.3.2 Long-Term Reliability

Alternative 1 ranked the highest for this criterion, primarily because it removes the contaminants from the site, thereby eliminating any chance for future exposure.

5.3.3 Implementability

Alternative 2 ranked the highest for this criterion, as the current cap is effective at achieving the RAO and a plan to maintain the cap could be implemented at any time. Alternative 1 would be difficult to implement due to the significant volume of cap material that would require removal prior to removing the impacted material.

5.3.4 Implementation Risk

Alternative 2 ranked the highest for this criterion, as there is no implementation risk associated with this alternative. Alternative 1 inherently would involve greater risk to workers and ecological receptors during excavation and transportation of contaminated media.

5.3.5 Reasonableness of Cost

Alternative 2 (the non-treatment alternative) ranked the highest for this criterion, followed by Alternative 1 (the treatment alternative).

5.3.6 Extent of Treatment of Hot Spots

Alternatives 1 and 2 would both achieve the RAO; however, Alternative 1 would result in the removal of the hot spot and, therefore, is ranked slightly higher. Alternative 2 is currently reliably containing the hot spot and will continue to do so as long as the existing cap is maintained.

5.4 GROUNDWATER - AREA C

Only one remedial alternative was retained for comparison in Table 17 for groundwater collected from a grab groundwater sample from boring LB213 where benzo(a)pyrene could potentially pose unacceptable risk to human receptors along the lagoon shoreline (via migration through groundwater). The retained alternative is Alternative 1 (MNA).

Since there is only one alternative for this area, a direct comparison was not completed. Groundwater at the location of boring LB213 and along the predicted migration pathway will be re-sampled using direct push drilling methodology to verify that the concentration of benzo(a)pyrene is consistent with the prior results that were used to predict a potential unacceptable risk to human receptors along the lagoon shoreline (via migration through groundwater) approximately 400 years in the future. If similar groundwater conditions are encountered, then a permanent monitoring well will be installed along the migration pathway to verify groundwater quality over time.

Extending the shoreline in this area in accordance with the reclamation plan will increase the distance the groundwater will migrate and thereby increase the attenuation time of the contaminants dissolved in the groundwater. The increased attenuation time will reduce the contaminant concentrations that were predicted via modeling at the lagoon shoreline. The reduced concentrations may not constitute a hot spot at the lagoon shoreline. Additional action would be triggered if monitoring at compliance points indicated unacceptable risk to human or ecological receptors along the lagoon shoreline.

5.5 LAGOON SURFACE SEDIMENT - AREA D

Three remedial alternatives were retained for comparison in Table 17 for the surface sediment in the lagoon where various contaminants (including PAHs, PCBs, pesticides, and metals) exceed RBCs based on exposure to human and ecological receptors. The retained alternatives include the following:

- Alternative 1A: Dredging and Off-Site Disposal/Treatment
- Alternative 1B: Dredging and On-Site Disposal/Containment
- Alternative 2: Construct Sediment Cap and Implement Monitoring Program
- Alternative 3: Hot Spot Removal/Capping Residual Contamination

5.5.1 Effectiveness

Each of the above alternatives ranked equally effective as they would effectively achieve the RAO and each would effectively mitigate contaminant mobility. Should contingency measures be required in support of the capping alternative, neutralization or alternative cap design could be implemented, specifically to address potential for elevated contaminant concentrations at the sediment/surface water interface near shoreline areas.

5.5.2 Long-Term Reliability

Alternative 1A ranked highest for this criterion primarily since it removes all of the contaminants from the site and would reduce the hot spots to non-hot spot levels by removing the source of the contaminants. Alternative 1B ranked second due to potential long-term impacts associated with contaminated media placement in uplands areas. Alternatives 2 and 3 ranked lower given reliance on management and institutional controls to ensure the integrity of the cap over time.

For Alternatives 2 and 3, seismicity has been identified as a potential concern that would reduce long-term reliability given the proximity of the lagoon to the Portland Hills Fault. The Portland Hills Fault is a structurally complex zone of faults. Maps published by DOGAMI have mapped the Portland Hills Fault Zone in the vicinity of Ross Island and show a line representing the fault running directly beneath Ross Island. The fault location on the map is inferred from geophysical testing and geologic expression in the area and may be up to 1 kilometer north or south of the mapped location. The seismic history of the Portland area indicates the potential that the Portland Hills Fault and/or other faults in the region are seismogenic; however, there is no direct evidence that the Portland Hills Fault is seismogenic. While the presence of the Portland Hills Fault in the general vicinity of Ross Island has been considered in ranking the long-term reliability of Alternatives 2 and 3, the potential for significant detrimental effect to capping alternatives is considered to be very low. In the event of seismic activity of the Portland Hills Fault Zone, potential concern related to the capping would be associated with localized in-water failure or, very remotely, surface rupture and offset of the cap material. The CAD cells, and ultimately the impacted surface sediments, are covered by significant overburden and slope failures, if any, would be surficial in nature as opposed to deep seated. Similarly, the potential for surface rupture is considered to be extremely remote and if were to occur would require significant offset to result in exposure of capped media. Therefore, significant adverse impact to the capped contaminated media would not be anticipated to be a concern as a result of seismicity. Surveys would be conducted in the event of a significant seismic event to verify cap integrity.

5.5.3 Implementability

Alternative 2 ranked the highest for this criterion (most implementable), since some of Area D has already received fill in accordance with the approved reclamation plan and provisions set forth in the DSL Removal/Fill permit. The widespread and dispersed nature of the likely source material for the elevated pH in the lagoon poses an implementation challenge for Alternatives 1A and 1B, as well as potentially exacerbating existing contamination confined in the CAD cells.

5.5.4 Implementation Risk

Alternative 2 ranked the highest for this criterion, primarily due to its conformance with typical on-going filling activities. This alternative only poses minor risks to on-site workers and potential recreational visitors. Alternatives 1A and 1B rank lowest for this criterion, since significant implementation risks associated with dredging and transportation of contaminated media exist near the CAD cells.

5.5.5 Reasonableness of Cost

Alternative 2 ranked the highest for this criterion (least expensive), followed by Alternative 1B, 3, and 1A (most expensive). Alternative 2 (a non-treatment alternative) is more easily implemented, has low implementation risk, and significantly lower cost than Alternative 1A (treatment technology) to achieve the RAOs.

5.5.6 Extent of Treatment of Hot Spots

Each of the alternatives would achieve the RAO; however, Alternatives 1A and 3 would result in the removal of the hot spots and, therefore, are ranked slightly higher. Although Alternative 1B would result in the removal of the hot spot from Area D, it could potentially create a hot spot at the on-site disposal location. Alternative 2 would reliably contain the hot spot and would continue to do so as long as the cap is maintained.

5.6 LAGOON SURFACE SEDIMENT - AREA E

Three remedial alternatives were retained for comparison in Table 17 for the surface sediment in the lagoon where elevated levels of pH are toxic to benthic organisms. The retained alternatives include the following:

- Alternative 1A: Dredging and Off-Site Disposal/Treatment
- Alternative 1B: Dredging and On-Site Disposal/Containment
- Alternative 2: Construct Sediment Cap and Implement Monitoring Program

5.6.1 Effectiveness

Each of the above alternatives ranked equally effective as they would effectively achieve the RAO and each would effectively mitigate contaminant mobility. Further evaluation on the effectiveness of cap material currently in place within the lagoon at reducing elevated pH concentrations is ongoing. Should contingency measures be required in support of the capping alternative, neutralization or alternative cap design could be implemented, specifically to address potential for elevated pH conditions at the sediment/surface water interface near shoreline areas.

5.6.2 Long-Term Reliability

Alternative 1A ranked highest for this criterion, primarily since it removes the contaminants from the site and would reduce the hot spots to non-hot spot levels by removing the source of the PAHs, PCBs, and elevated pH. Alternative 1B ranked second due to potential long-term impacts associated with contaminated media placement in uplands areas. Alternative 2 ranked lower given reliance on management and institutional controls to ensure the integrity of the cap over time.

As with Alternative 2 for Area D, seismicity has been identified as a potential concern for Alternative 2 for Area E that would reduce long-term reliability given the proximity of the lagoon to the Portland Hills Fault. Significant adverse impact to the capped contaminated media would not be anticipated to be a concern as a result of seismicity. Surveys would be conducted in the event of a significant seismic event to verify cap integrity.

5.6.3 Implementability

Alternative 2 ranked the highest for this criterion (most implementable), since some of Area D has already received fill in accordance with the approved reclamation plan and provisions set forth in the DSL Removal/Fill permit. The widespread and dispersed nature of the likely source material for the elevated pH in the lagoon poses an implementation challenge for Alternatives 1A and 1B, as well as potentially exacerbating existing contamination confined in the CAD cells.

5.6.4 Implementation Risk

Alternative 2 ranked the highest for this criterion, primarily due to its conformance with typical on-going filling activities. This alternative only poses minor risks to on-site workers and potential recreational visitors. Alternatives 1A and 1B rank lowest for this criterion, since significant implementation risks associated with dredging and transportation of contaminated media exist near the CAD cells.

5.6.5 Reasonableness of Cost

Alternative 2 ranked the highest for this criterion (least expensive), followed by Alternative 1B, and Alternative 1A (most expensive). Alternative 2 (a non-treatment alternative) is more easily implemented, has low implementation risk, and significantly lower cost than Alternative 1A (treatment technology) to achieve the RAOs.

5.6.6 Extent of Treatment of Hot Spots

There were no hot spots identified in Area E.

5.7 LAGOON SUBSURFACE SEDIMENT - AREA F

Two remedial alternatives were retained for comparison in Table 17 for the material in the existing CAD cells in the southern portion of the lagoon where TBT, heavy metals, and SVOCs (including PAHs, VOCs, and PCBs) may cause an unacceptable risk to human and ecological receptors should the current cap material be compromised. The retained alternatives include the following:

- Alternative 1: Dredging and Off-Site Disposal
- Alternative 2: Implement a Management/Maintenance Plan to Maintain the Existing Cap and monitor the cap

5.7.1 Effectiveness

Each alternative ranked equally high (equally as effective) for this criterion. Currently, the CAD cells are considered reliably contained hot spots, as modeling and site data have demonstrated.

5.7.2 Long-Term Reliability

Alternative 1 ranked the highest for this criterion primarily since it removes the contaminants from the site and would reduce the hot spots to non-hot spot levels by removing the source of the contaminants. Alternative 2 ranked only slightly lower than Alternative 1 because it would require an institutional control.

5.7.3 Implementability

Alternative 2 ranked the highest for this criterion, primarily because a cap is already in place and a maintenance/management program could be prepared and implemented any time. On-going reclamation fill adjacent to the capped areas will be placed in a manner that ensures cap stability. The depth of the CAD cells beneath the fill material in the lagoon adds a significant implementation challenge to Alternative 1.

5.7.4 Implementation Risk

Alternative 2 ranked the highest for this criterion, as there is no anticipated implementation risk associated with this alternative. There is a significant implementation risk associated with Alternative 1, and implementing this alternative may potentially exacerbate contamination in the lagoon and would inherently include increased risks associated with the excavation and transportation of contaminated media.

5.7.5 Reasonableness of Cost

Alternative 2 (the non-treatment alternative) ranked the highest for this criterion, followed by Alternative 1 (the treatment alternative). Alternative 2 results in equal effectiveness, is more easily implemented, and has less implementation risk, yet at a significantly lower cost.

5.7.6 Extent of Treatment of Hot Spots

Alternatives 1 and 2 would both achieve the RAO; however, Alternative 1 would result in the removal of the hot spot and, therefore, is ranked slightly higher. Alternative 2 is currently reliably containing the hot spot and will continue to do so as long as the existing cap is maintained.

6.0 RECOMMENDED REMEDIAL ALTERNATIVES

Recommended alternatives for each remedial area identified in Section 3.0 of this report are presented below and are based on the results of the comparative evaluation of each alternative summarized in Table 17 and discussed in Section 5.0 of this report.

6.1 UPLANDS SURFACE SOIL - AREA A1

On the basis of the detailed analysis of each of the alternatives presented in Section 5.0 and Table 17 of this report, Alternative 3A received the highest total rankings (46 points). Considering a combination of all five remedy selection criteria, Alternative 3A is recommended for implementation at the site to achieve the RAO. Implementation of the recommended remedy would include soil import and placement over the affected area at a thickness of approximately 3 feet. Prior to implementing the remedy, supplemental sampling and analysis would be conducted to more accurately define the extent of benzo(a)pyrene, arsenic, and zinc in surface soil requiring a soil cap. Estimated costs for the soil cap have been initially developed on the conservative assumption that all surface soils within the 100-foot radius would require capping. The capping alternative for Area A1 is consistent with the overall reclamation plan goals for the facility.

6.2 UPLANDS SURFACE SOIL - AREA A2

On the basis of the detailed analysis of each of the alternatives presented in Section 5.2 and Table 17 of this report, Alternative 2 (Slope Stabilization) received the highest total ranking (48 points) and is consistent with the overall reclamation plan for the facility. For those areas of Area A2 that will receive fill in accordance with the reclamation plan and will be re-vegetated, slope stabilization will occur as a result of the reclamation plan. For those areas of Area A2 that will not receive fill in accordance with the reclamation plan (east side), enhancement of established slopes may be required, potentially including placement of additional rip-rap or equivalent or reworking of existing slopes in the upland area only. Alternative 2 (Slope Stabilization) is recommended for implementation for those areas of Area A2 that will not receive fill in accordance with the reclamation plan (east side).

6.3 CAPPED POND MATERIAL - AREA B

On the basis of the detailed analysis of each of the alternatives presented in Section 5.3 and Table 17 of this report, Alternative 2 (Maintain Existing Cap) received the highest total rankings (58 points) followed by Alternative 1 (54 points). Therefore, Alternative 2 is recommended for implementation at the site to achieve the RAO and is consistent with the reclamation plan for the facility.

Implementation of Alternative 2 would entail development of management or institutional controls identifying periodic maintenance inspections and restrictions on future earthwork or excavation activities at Area B.

6.4 GROUNDWATER MIGRATION TO SHORELINE - AREA C

Only one alternative for this area (Alternative 1) was carried forward, based on the screening presented in Table 16. Since there is only one alternative for this area, a direct comparison was not completed in Table 17. Therefore, Alternative 1 (MNA) is recommended for implementation at the site to achieve the RAO established in Section 4.1.2.1 of this report.

Given that the potential risk associated with discharge of impacted water at boring LB213 is modeled to occur 400 years in the future, and considering the uncertainty in the data quality, Alternative 1 is recommended to: 1) provide verification of groundwater quality near boring LB213 and 2) establish contingency for permanent monitoring well(s) to assess MNA between boring LB213 and the final groundwater to surface discharge point considering the reclamation fill activities planned for the area. The planned reclamation filling north of boring LB213 provides overall benefit in mitigating the modeled potential future exceedance by extending the shoreline considered in prior modeling efforts, which conservatively identified a potential exposure via this pathway.

6.5 LAGOON SURFACE SEDIMENT - AREA D

On the basis of the detailed analysis of each of the alternatives presented in Section 5.5 and Table 17 of this report, Alternative 2 (Construct Sediment Cap and Implement Monitoring Program) received the highest ranking (56 points), followed by Alternative 1A (44 points) and Alternatives 1B and 3 (42 points). Therefore, Alternative 2 is recommended for implementation at the site to achieve the RAO established in Section 4.1.3.1 of this report.

Alternative 2 would include the import and placement of clean fill over Area D surface sediment to physically prevent human and ecological exposure to various contaminants exceeding RBCs. Fill placement activities would be conducted in accordance with and to fulfill the DSL Removal/Fill permit requirements, and placement of the cap material would be implemented over time to reach the ultimate goals set forth in the reclamation plan. At this time, we anticipate a minimum cap thickness of 3 feet to achieve the RAOs; however, the final minimal design thickness would be based on supplemental investigation results to confirm adequate mitigation of risk to benthic organisms.

6.6 LAGOON SURFACE SEDIMENT - AREA E

On the basis of the detailed analysis of each of the alternatives presented in Section 5.5 and Table 17 of this report, Alternative 2 (Construct Sediment Cap and Implement Monitoring Program) received the highest ranking (46 points), followed by Alternative 1A (44 points) and Alternative 1B (42 points). Therefore, Alternative 2 is recommended for implementation at the site to achieve the RAO established in Section 4.1.3.1 of this report.

Alternative 2 would include the import and placement of clean fill over Area E surface sediment to physically prevent exposure of benthic organisms to elevated levels of pH. Fill placement activities would be conducted in accordance with and to fulfill the DSL Removal/Fill permit requirements, and placement of the cap material would be implemented over time to reach the ultimate goals set forth in the reclamation plan. At this time, we anticipate a minimum cap thickness of 3 feet to achieve the RAOs; however, the final minimal design thickness would be based on supplemental investigation results to confirm adequate mitigation of risk to benthic organisms from elevated pH.

Various supplemental sampling programs have been completed to further evaluate pH in surface sediment at Area E. Final field investigations are planned by May 2005 to install semi-permanent, multi-port wells to further characterize the attenuation of pH vertically through cap material in accordance with the DEQ-approved work plan. The results of the supplemental investigations will be presented to DEQ (including conclusions on the effectiveness of capping to prevent pH risk to benthic organisms, recommendations for alternative cap material specification or design if warranted, and final recommendations for appropriate monitoring programs to verify cap protectiveness).

6.7 LAGOON SUBSURFACE SEDIMENT - AREA F

On the basis of the detailed analysis of each of the alternatives presented in Section 5.8 and Table 17 of this report, Alternative 2 (Implement a Management/Maintenance Plan to maintain the existing cap) received the highest ranking (58 points), followed by Alternative 1 (42 points). Therefore, Alternative 2 is recommended for implementation at the site to achieve the RAO established in Section 4.1.3.2 of this report.

Alternative 2 would include implementation of formal management and maintenance plans to ensure proper future maintenance of the existing cap at Area E where TBT, heavy metals, SVOCs, VOCs, and PCBs may cause an unacceptable risk to human and ecological receptors should the cap material be compromised. Monitoring would also be a critical component of Alternative 2.

The monitoring would include ensuring the stability of the cap and adjacent slopes. Alternative 2 would be combined with institutional controls restricting future dredging or other activities in these areas that could compromise the capped materials.

6.8 INSTITUTIONAL CONTROLS

As stated in Section 4.3.2.10 of this report, institutional controls were not carried forward for detailed analysis as a potential primary remedial alternative. However, institutional controls in the form of administrative measures will be implemented in conjunction with the following recommended alternatives to enhance overall protectiveness and to further ensure the achievement of the RAOs:

- Uplands Surface Soil - Area A1, Soil Cap: Institutional controls would be implemented to restrict future excavation or earthwork activities that may disturb the cap.
- Uplands Surface Soil - Area A2, Slope Stabilization: Institutional controls would be implemented to restrict disturbance of designed slopes and vegetation that, if disturbed, could result in erosion of surface soil to the lagoon surface water. Maintenance requirements would also be established to verify adequacy of the slopes in mitigating potential erosion to surface water.
- Capped Pond Material - Area B, Maintain Existing Cap: Institutional controls would be implemented to restrict future excavation or earthwork activities that could disturb the current cap. Maintenance requirements would also be established to verify integrity of the cap over time.
- Groundwater Migration to Shoreline - Area C, MNA: Institutional controls do not appear warranted as part of the recommended remedy. However, monitoring of potential contaminant migration to the lagoon in this area will be incorporated into the monitoring/management plan.
- Lagoon Surface Sediment - Areas D and E, Sediment Cap: Institutional controls would be implemented to restrict future dredging or other physical activities that could disturb the sediment cap. Maintenance and management plans would also be developed to monitor cap conditions and integrity over time using periodic bathymetric surveys. Additionally, sediment and/or pore water sampling may be required periodically as part of the monitoring/management plan to assess the effectiveness of the cap.
- Lagoon Subsurface Sediment - Area F, Maintain Existing Caps: Institutional controls would be implemented to restrict future dredging or other physical activities that could disturb the sediment cap. Maintenance and management plans would also be developed to monitor cap conditions and integrity over time, using periodic bathymetric surveys. Additionally, sediment and/or pore water sampling may be required periodically as part of the monitoring/management plan to assess the effectiveness of the cap.

The institutional controls will be documented in the form of a restrictive covenant that will be recorded in the real property records of Multnomah County.

6.9 MONITORING AND SAMPLING PROGRAMS

Various monitoring and/or sampling programs would be conducted as part of the remedial action program to:

- further evaluate and refine areas of uplands surface soil requiring capping (i.e., Areas A1 and A2) prior to cap placement (discrete soil sampling).
- verify current groundwater quality conditions at boring LB213 and along the migration pathway in support of the MNA alternative recommended for potential impacted groundwater migration to surface water (direct push and potentially groundwater monitoring well sampling). Monitoring will also address potential migration of aroclor 1254 from subsurface sediment to the groundwater/surface water interface.
- verify adequacy of cap materials in mitigating pH risk to benthic organisms and for use in evaluating cap design or amendment alternatives (multi-channel monitoring wells and surface sediment sampling).
- verify adequacy of the cap materials in mitigating human health and ecological risk associated with surface and subsurface sediment impacts (surface sediment sampling). Subsurface sediment and potentially pore water sampling will be incorporated into the long-term monitoring plan to assess the effectiveness of the cap.
- monitor cap placement efforts and performance and stability of cap materials and slopes through bathymetric and topographic surveys and interpretation/reporting.

A detailed comprehensive monitoring and sampling plan addressing each of the above required elements would be submitted to DEQ for approval and comment as part of the RAP after selection of the final remedy by DEQ. It is anticipated that, for those monitoring or sampling requirements requiring evaluation and/or verification (i.e., sediment cap performance and groundwater monitoring), monitoring and sampling would be conducted on a quarterly or semi-annual basis for 1 year following implementation of the remedy or placement of the minimum sediment cap thickness, semi-annually for years 1 through 5, and then annually thereafter until such time that long-term reliability can be demonstrated .

6.10 CONTINGENCY MEASURES

Recommended remedial alternatives for six of the seven impacted areas (Areas A1, A2, B, D, E, and F) include engineering controls to mitigate exposure risk. Area C (Groundwater Migration to Surface Water [LB213]) is recommended to include verification and, if warranted, monitoring in support of natural attenuation. For those areas requiring engineering controls, which are physical barriers to prevent the human or ecological exposure, the engineering controls must include adequate and appropriate performance monitoring to verify that the controls are operating as intended and management and inspections to ensure that that the controls are not damaged or otherwise rendered ineffective.

The RAP will include an O&M Plan for all engineering controls selected by DEQ for implementation and a detailed contingency plan to address potential failure or required design modifications to engineering controls. The contingency plan will include, but not be limited to, requirements for notification, identification of response team and responsibilities, a decision matrix, summary of alternative responses to meet RAOs, and reporting requirements. For uplands areas where capping alternatives or bank stabilization methods are recommended, contingency responses would be anticipated to include alternatives such as placement of additional fill if damaged or eroded, or removal of contaminants.

For in-water sediment capping areas, the ultimate goal of the cap will be to maintain isolation of the CAD cells and to mitigate potential exposure to current surface sediment. Final design of the sediment caps would be presented in the RAP and would be integrated with the reclamation plan requirements that incorporate a much greater volume of sediment cap than that which is anticipated to meet the RAOs for subsurface and surface sediment. Additional monitoring and sampling is currently being planned to further evaluate the required sediment cap thickness to mitigate potential future risk, particularly related to elevated pH. Results of the supplemental investigations will be presented to DEQ with recommendations for cap thickness and design considerations. If, based on additional investigation, contingency response is required beyond installation of a standard sediment cap, viable alternatives will be evaluated and presented to DEQ, potentially including cap amendment material to buffer pH or utilization of lower permeability media for construction of the uppermost portions of the final cap. Results of compliance and performance monitoring will be evaluated over time to determine the overall effectiveness of the cap and if additional response is necessary at areas of concern within the lagoon.

Regarding Area C, the potential for discharge of adverse groundwater impacts to surface water 400 years into the future is considered to be very low, given natural degradation processes and planned extensions of the shoreline that will inherently alter the modeled assumptions developed in the RI. The recommended remedial alternative includes tasks to verify groundwater conditions near boring LB213, and if warranted, install compliance monitoring well(s) to assess the fate and transport of impacted groundwater and quantify natural attenuation processes. In the event that the results of the additional sampling and analysis determines that groundwater may indeed pose a risk via discharge to surface water, contingency measures that could be considered for implementation would include alternatives such as enhanced bioremediation or installation of physical barriers to prevent surface water discharge in the future. Results of additional sampling and analysis as recommended herein would be presented to DEQ for concurrence on the adequacy of MNA to achieve the RAO.

The recommended engineering controls, particularly sediment caps in the lagoon, could be susceptible to damage or alternation as a result of significant earthshaking during a seismic event. Given the likely thickness of the cap material, it is anticipated that overall potential exposure risk (if damage is caused by a seismic event) is considered to be very low. However, in the event of such an occurrence in the vicinity of the facility, inspection of the engineered caps via bathymetric survey would be conducted to verify the integrity of the caps and document that significant alteration of capped areas, particularly slopes, has not occurred.

6.11 DESIGNATION OF POINTS OF COMPLIANCE

RAOs have been established for six areas of the facility where unacceptable or potentially unacceptable risk has been identified in the RI. Remedial alternatives have been evaluated, the results of which have culminated in a recommended remedial approach to address each of these six areas. The following potential exposure pathways have been identified:

- Uplands surface soil in Area A1: Exposure to occupational workers, recreational visitors, and/or ecological receptors to uplands surface soils impacted with the PAH benzo(a)pyrene and the metals arsenic and zinc.
- Uplands surface soil in Area A2: Exposure to potential human receptors (consumers of fish) and ecological receptors (aquatic life) in the lagoon by erosion of soil impacted with concentrations of PAHs, PCBs, and metals into the lagoon.
- Subsurface Area B (capped pond material): Exposure of the capped material impacted with TBT and TPH to occupational and potential future recreational visitors and migration to the lagoon.
- Groundwater migration to surface water (Area C): Potential future risk to human health (beginning in 400 years based on modeling) as a result of groundwater represented by a sample collected from Geoprobe® boring LB213 migrating to surface water in the lagoon.
- Lagoon surface sediment (Areas D and E): Risk to human health via consumption of fish and to benthic invertebrates from exposure to PAHs, PCBs, pesticides, metals, and elevated pH in the surface sediments in the lagoon.
- Capped subsurface material in Area F (CAD Cells No. 1 through 5): Potential risk to human and ecological exposure to material impacted with TBT, heavy metals, SVOCs, VOCs, and PCBs.

6.11.1 Uplands Surface Soil - Area A1

For potential exposure to uplands surface soil in Area A1, soil capping is recommended as the preferred alternative to mitigate future potential for exposure to occupational workers, recreational visitors, and ecological receptors. Institutional controls would be implemented to ensure that the soil caps remain in place. Construction of the soil cap and proper maintenance of the cap is expected to effectively mitigate exposure risk. There are no anticipated requirements for on-going compliance monitoring points or sampling beyond documentation that the soil caps have been installed in accordance with final design criteria and are maintained.

6.11.2 Uplands Surface Soil - Area A2

Slope stabilization has been recommended to address potential exposure related to erosion of surface soil and migration of contaminants to the lagoon at Area A2. Institutional controls would be implemented to ensure that existing soil caps remain in place and that slope stabilization measures remain undisturbed and effective in the future. The slope stabilization procedures are expected to effectively mitigate exposure risk via the erosion to surface water pathway and migration of contaminants to the lagoon. There are no anticipated requirements for on-going compliance monitoring points or sampling beyond documentation that the stabilization measures have been completed in accordance with final design criteria.

6.11.3 Capped Pond Material - Area B

Maintenance of the existing soil cap in Area B is recommended as the preferred alternative to mitigate future potential for exposure to occupational workers and recreational visitors. Institutional controls would be implemented to ensure that the soil caps remain in place. Proper maintenance of the cap is expected to effectively mitigate exposure risk. There are no anticipated requirements for on-going compliance monitoring points or sampling beyond documentation that the soil cap remain in place and undisturbed.

6.11.4 Groundwater Migration to Surface Water - Area C

Given that the potential risk associated with migration of groundwater to surface water in the lagoon is based on a modeled exceedance beginning 400 years into the future, the intent of recommended remedial alternatives for this pathway is to verify and (as warranted) conduct appropriate monitoring and sampling to re-evaluate the pathway exceedances considering planned reclamation activities that will extend the shoreline area. Compliance monitoring wells (as warranted based on the verification sampling tasks) would be installed between boring LB213 and the shoreline area to monitor the potential for discharge to surface water. Results of groundwater monitoring and sampling would be evaluated over time, and (as warranted) additional groundwater modeling would be conducted to validate earlier modeling efforts considering current and anticipated future shoreline configuration.

6.11.5 Lagoon Surface Sediment - Areas D and E

Human and ecological risks for lagoon surface sediment are related to ingestion of fish and benthic invertebrates in contact with PAHs, PCBs, pesticides, metals, and elevated pH in the surface sediment. The impacted media are those sediments that represented surface conditions at the time of conducting the RI, and some of those areas have been covered since 2003 with soil generated from the CSO project and placed in the southwest area of the lagoon. With proper construction and verification monitoring over time, the sediment cap is anticipated to effectively mitigate exposure risk to contaminants and elevated pH. Additional investigations are currently planned to further evaluate vertical pH flux through the cap material to assess effectiveness in mitigating elevated pH in shallow sediments at the design elevation. Monitoring wells that are to be placed at selected areas will be maintained, if warranted, to allow periodic verification monitoring of pH flux through the cap. In addition, surface sediment sampling at prescribed areas may be conducted periodically to further quantify pH conditions at the new surface sediment/surface water interface.

6.11.6 Capped Subsurface Material - Area F (CAD Cells No. 1 through 5)

Based on the results of the RI, the existing caps over CAD cells No. 1 through No. 5 are effective in mitigating potential risk to human and ecological exposure to material impacted with TBT, heavy metals, SVOCs, VOCs, and PCBs, as long as the cap material is not breached in the future. Periodic monitoring of cap stability through bathymetric surveys is anticipated for the foreseeable future to provide documentation that the cap remains in place and is effective. Periodic confirmation sampling may be required to verify cap effectiveness. With these exceptions, there are no further compliance sampling points anticipated in support of the recommended remedy for Area E.

6.12 RESIDUAL RISK

6.12.1 Introduction

The residual risk assessment is a necessary component in the consideration of remedial action alternatives. Unlike the risk assessment, which is required as part of the RI, the focus of the residual risk assessment is on the risk remaining on site after remedial action has taken place. This residual risk assessment is being presented in support of recommended remedial alternatives identified in Sections 6.1 through 6.7 of this report.

6.12.2 Conceptual Site Model

A conceptual site model delineates the potential pathways by which identified receptors may come in contact with site-related contaminants. Based on the results of the RI, which included investigation and risk assessment for both the uplands and in-water areas, unacceptable or potentially unacceptable risk was identified at the following six areas of the facility:

Surface Soil - Area A1: Risk to occupational workers, recreational visitors, and/or ecological receptors to exposure of uplands surface soils impacted with the PAH benzo(a)pyrene and the metals arsenic and zinc

Surface Soil - Area A2: Risk to potential human receptors (consumers of fish) and ecological receptors (aquatic life) in the lagoon as a result of soil impacted with concentrations of PAHs, PCBs, and metals from eroding into the lagoon

Subsurface Soil - Area B – Capped Pond Material: Risk to occupational and potential future recreational visitors from exposure to currently capped material impacted with TBT and TPH

Groundwater Migration to Surface Water - Area C: Potential risk to human health as a result of the modeled exceedance of benzo(a)pyrene in groundwater discharging to surface water in the lagoon after 400 years

Surface Sediment - Areas D and E: Potential risk to human health via consumption of fish (based on the assumption that a certain level of chemical uptake will occur from the contaminated sediments in the lagoon [primarily endrin aldehyde] to fish tissue) and to benthic invertebrates from exposure to PAHs, PCBs, pesticides, metals, and elevated pH in the surface sediments of the lagoon

Subsurface Material Capped in Area F (CAD Cells No. 1 through 5): Potential risk of human and ecological exposure to materials in CAD cells impacted with TBT, heavy metals, SVOCs, VOCs, and PCBs

Based on the individual and comparative analysis of various remedial alternatives in this FS, a combination of engineering controls, monitoring and maintenance, and institutional controls have been recommended to mitigate the potential for exposure at each of the six areas described above. The recommended engineering controls provide physical barriers or other means (i.e., slope stabilization) to reliably isolate the impacted media from potential receptors; therefore, rendering the pathway(s) incomplete. If properly designed and constructed, the recommended engineering controls for uplands exposure pathways would effectively isolate localized areas of impacted surface soils from exposure to both human and ecological receptors. Although prior studies have concluded that erosion of uplands surface soil to lagoon surface water is not likely, proper slope stabilization and enhancements are conservative measures to eliminate potential for risk. Similarly, properly constructed sediment caps would effectively mitigate exposure of human or ecological receptors to impacted surface and subsurface media.

Exposure risk can be effectively mitigated by engineering controls, and administrative requirements to maintain and periodically verify integrity over time are recommended to ensure that the controls remain in place and are functioning as designed. With proper implementation of management and maintenance verification programs, the engineering controls would be expected to continue to provide effective means of risk mitigation.

Institutional controls, similar to maintenance verification programs, are implemented to ensure that the engineering controls remain in place and function as designed in the future by preventing certain activities that could damage or otherwise render the controls ineffective (such as excavation, grading, or dredging).

Lastly, periodic monitoring and/or sampling would be performed to verify that the engineering controls are functioning as designed once constructed. In the event that the results of performance or compliance monitoring programs indicate that exposure potential remains after construction, contingency measures would need to be implemented to address those aspects of the remedial components requiring additional action. Once performance is verified and it is demonstrated that RAOs have been effectively achieved, it is anticipated that the frequency of monitoring and sampling programs could be decreased with appropriate regulatory approvals.

6.12.3 Residual Risk Characterization

With proper implementation of the recommended engineering and institutional controls, the potential for receptor exposure and/or unacceptable risk is considered to be very low. The uplands areas identified to have potential risk represent only a small percentage of the overall area available to ecological or potential future recreational receptors, and it is unlikely that exposure could occur with proper construction of the soil caps. The thickness of in-water caps needed to meet the given RAOs, although subject to final analysis and design, is anticipated to be significantly less than the overall volume planned as part of the lagoon reclamation program through DSL. Sediment capping has been implemented effectively at numerous other sites and given the anticipated greater thicknesses required by the reclamation plan, periodic maintenance inspections, and contingency responses, potential future risk associated with the capping alternatives is considered to be very low.

Based on the data quality and the potential modeled exceedance in 400 years, there appears to be no significant risk for potential migration of groundwater to surface water in the vicinity of boring LB213. In addition, the modeling assumptions are likely considerably conservative, since the shoreline in the southern portion of the lagoon will be extended northward under the reclamation plan, further reducing what is already considered to be a very low risk. In the event that verification monitoring and sampling identifies conditions requiring a greater level of response, potential contingency responses are easily implementable to further reduce any potential risk.

6.13 PERIODIC REVIEWS

Performance- and compliance-based monitoring programs will be performed routinely during the risk assessment program, details for which will be summarized in the RAP. As part of the monitoring program, summary reports will be submitted to DEQ and will include the results and findings of monitoring events; appropriate maps, tables, and updates on activities conducted in support of the selected remedy; discussion of the remedial action progress; and difficulties encountered and actions to resolve them. In addition, DEQ will be notified in advance of any routine monitoring events or other site activities so DEQ representatives may be on site to observe current conditions and activities.

Annual reports will be submitted to DSL and DEQ summarizing the results of all activities during the prior 12-month period and will be in compliance with the DSL Removal/Fill permit. The annual report will include a summary of all of the requirements set forth in the removal/fill permit, discussion of the RAOs, overall progress to meet the objectives, and recommendations for any changes or alterations to the remedial action or monitoring programs.

As part of the remedial action program, RIS&G and its representatives will routinely review the current status and direction of the project to ensure that conditions are not changing, which may necessitate more immediate action or response. If conditions are discovered that would require additional action or warrant further discussion or evaluation, DEQ will be notified to discuss an appropriate course of action. Similarly, overall site conditions, monitoring results, and progress will be evaluated every 5 years in accordance with DEQ procedures, and recommendations for modification of required monitoring and sampling programs will be provided to DEQ for consideration if warranted.

6.14 PERMIT EXEMPTIONS FOR ON-SITE ACTIVITIES

Oregon's environmental cleanup law requires that for any remedial action the responsible party must: 1) identify the extent to which remedial action would be conducted on site, 2) identify all state and local permits or licenses that would be exempted pursuant to ORS 465.315(3), 3) describe any consultation with affected state or local government bodies, and 4) identify applicable substantive requirements of the affected state or local laws and how they would be addressed. This information is used by DEQ to document that applicable or relevant and appropriate requirements of other laws have been met.

RIS&G is conducting facility reclamation, including uplands and lagoon areas, in accordance with requirements set forth in a revised DSL Removal/Fill permit (RF-26), an associated USACE dredge fill permit, and relevant local land use requirements. The reclamation plan consists of the placement of approximately 4.5 million cubic yards of reclamation fill at the island over a 10-year period, grading to create more diversity in upland areas, and the creation a more irregular shoreline, and providing for gradual transition from upland to surface water to support emergent wetland vegetation. The existing permits establish the final design criteria for permanent restoration of the facility (including operating, compliance, and reporting standards). Major components of the recommended remedial action conform to the overall reclamation plan and would be conducted under the existing DSL Removal/Fill permit, including placement of in-water and upland fill that also addresses certain cleanup RAOs by capping impacted media.

The combined recommended remedial alternatives conform to the provisions set forth in existing permits and additional permits are not anticipated. However, given the scope and duration of the reclamation and remedial actions, compliance with substantive requirements of other rules and regulations will be required to successfully implement the recommended remedy. Surface soil impacts constituting a solid waste have been documented at several upland areas that potentially pose a risk via contact or erosion to surface water. DEQ's solid waste rules are included in OAR Chapter 340, Divisions 93 through 97, which describe the requirements, limitations, and procedures for the storage, collection, transportation, treatment, and disposal of solid waste in Oregon. While these administrative rules pertain largely to solid waste landfilling operations that are not applicable to the Ross Island facility, general conformance to the substantive requirements of the solid waste rules is warranted to ensure that soils constituting a solid waste that are to be capped in the upland areas are properly managed and maintained to achieve the RAOs. Specifically, procedures and protocols for placement of soil caps, periodic maintenance and monitoring, and documentation are applicable to verify that the proposed engineering controls are not damaged via erosion or flooding such that the underlying materials are exposed to contact or eroded to surface water.

RIS&G operates a gravel crushing and washing facility on Hardtack Island, whereby gravel product mined in Avery, Washington, and transported via barge is processed. RIS&G maintains a WPCF permit through DEQ, which regulates the use of process water for irrigation use on reclaimed portions of Hardtack Island. Permit requirements require sampling and analysis from two monitoring wells on a quarterly basis to demonstrate compliance in accordance with a previously approved WPCF Permit Groundwater Monitoring Plan. The recommended remedial alternatives are not anticipated to interfere with or otherwise cause RIS&G to be unable to conform to the requirements set forth in the WPCF permit.

It is possible that ownership of some portions of the site will be transferred to the City of Portland in the future. Consultation and coordination between RIS&G, the City of Portland, and DDQ regarding remedial responsibilities at the facility will ensure that any ownership transfer in no manner impedes the implementation, completion, and reliability of the remedial actions supported herein.

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Please call if you have any questions regarding this FS or any aspect of the project.

Sincerely,

GeoDesign, Inc.

Kyle Sattler
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