RECORD OF DECISION

REMEDIAL ACTION

FOR

ROSS ISLAND SAND AND GRAVEL
PORTLAND, OREGON

Prepared By

OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY
Northwest Region Office

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1. INTRODUCTION

1.1 INTRODUCTION

This document presents the selected remedial action for the Ross Island Sand and Gravel (RISG) site located on Ross and Hardtack Islands in Portland, Oregon which was developed in accordance with Oregon Revised Statutes (ORS) 465.200 et. seq. and Oregon Administrative Rules (OAR) Chapter 340, Division 122, Sections 0010 through 0115.

The selected remedial action is based on the administrative record for this site. A copy of the Administrative Record Index is attached as Section 12. This report summarizes the more detailed information contained in the Remedial Investigation (RI) and Feasibility Study reports completed under Order on Consent No. WMCVC-NWR-99-09 with the Oregon Department of Environmental Quality (DEQ), dated November 9, 1999.

1.2 SCOPE AND ROLE OF THE SELECTED REMEDIAL ACTION

The selected remedial action addresses the presence of hazardous substances in Ross Island Lagoon and upland portions of the island complex resulting from the importation and placement of fill for site reclamation, and industrial activities associated with gravel processing for cement production. Site contaminants of concern include polycyclic aromatic hydrocarbons (PAHs), metals (lead, arsenic, copper, chromium, nickel, and zinc), tributyl tins (TBTs), polychlorinated biphenyls (PCBs), pesticides (including DDT and its breakdown products), and petroleum hydrocarbons (TPH). These contaminants were present in fill brought to the site from local shipyards (e.g., Port of Portland Swan Island and Terminal 4 facilities), other dredged material brought to the site for filling that was impacted by surface runoff from a variety of sources (e.g., urban stormwater), legacy contaminants present in sediment deposited at the site through natural processes, and operation and maintenance of gravel processing equipment. Elevated pH, believed to be associated with cement wastes deposited at the site, has also been detected in shoreline portions of the lagoon.

The selected remedial action consists of the following elements:

- Capping of shallow surface soil in the processing plant area contaminated with arsenic and zinc (Area A1),
- Stabilization of the slope on the southeastern lagoon shoreline where PCB and PAH concentrations pose a potential threat to the lagoon via erosion (Area A2),

- Long-term management of the existing cap over the TBT-contaminated material confined at the location of the former settling pond (Area B),
- Monitoring of groundwater on the southeastern lagoon shoreline where PAH concentrations in groundwater may pose a threat to the lagoon (Area C)
- Capping and long-term monitoring and management of the surface sediment in the southern portion of the lagoon containing elevated concentrations PCBs and PAHs as a result of the breach of a confined disposal cell (Area D),
- Capping and long-term monitoring of shoreline areas where elevated pH has been detected (Area E),
- Long-term monitoring and management of existing confined disposal cells in the southern portion of the lagoon (Area F),
- Institutional controls to prevent disturbance of all capped areas, and
- Regular reporting on the status of remedial elements, effectiveness in preventing release of contaminants to the environment at levels of concern, and any contingency measures implemented as a result of monitoring data.

2. SITE HISTORY AND DESCRIPTION

2.1 SITE LOCATION AND LAND USE

The site is located at approximately river mile 15 of the Willamette River, about 1 mile upstream of downtown Portland (Figure 1). The Ross Island area includes Ross, Hardtack, Toe and East Islands. An earthen dike was constructed between Ross and Hardtack Islands in 1926-27, creating the Ross Island lagoon. The lagoon is connected to the Willamette River through a 500-foot-wide mouth that opens eastward to Holgate Slough. The total area owned by RISG within the Willamette River is 390 acres, about half of which is upland and the other half made up of the lagoon. Toe Island was deeded to the Nature Conservancy in 1979. Upland areas of the islands are partially tree covered, notable exceptions including the RISG material processing plant located at the northern end of Hardtack Island, and areas south of the plant where reclamation is ongoing. Site zoning is Open Space except for the extreme northern tip of Ross Island which is zoned General Commercial.

Land use in the Ross Island vicinity is mixed industrial, commercial, and residential. The Brooklyn and Sellwood-Moreland neighborhoods are located to the east of the island, and the Seymour, Corbett-Terwiliger, and Lair Hill neighborhoods are located to the west. Several riverfront parks are also located nearby. These include the Oaks Bottom Wildlife Refuge and Riverside Park along the Willamette River east bank, as well as Willamette Park along the west bank and slightly upstream of Ross Island, and South Waterfront Park located downstream of Ross Island on the west. Recreational uses of the Willamette River near Ross Island include boating and water sports, wildlife viewing, fishing, and hiking. The islands are posted to prevent trespass for insurance and safety reasons, but RISG does not maintain a policy of asking trespassers to leave unless they are in areas near the processing plant or on-going mining or reclamation activities. Some recreational use of the island does occur, particularly along the shoreline beach areas.

2.2 PHYSICAL SETTING

2.2.1 Climate

Portland receives approximately 39 inches of precipitation annually. The majority of the precipitation falls between October and March, with July being the driest month and December the wettest.

2.2.2 Hydrogeology

In general, regional geology is characterized by fill and unconsolidated river alluvium overlying sedimentary rocks of the Troutdale Formation. Alluvial material typically consists of stream-deposited sand and gravel with minor silt, and varies in thickness to a maximum of about 200 feet in the lower Willamette Basin. The alluvial deposits overlie non-cemented to partially-cemented sandstone and conglomerate of the Troutdale Formation. In the site vicinity, the Troutdale Formation commonly contains black gravel fragments derived from Columbia River Basalt and older, dark green to black volcanic rock. The thickness of the Troutdale Formation varies from about 100 to 350 feet. Sedimentary materials are underlain at depth by Miocene-age basalts of the Columbia River Basalt Group.

Shallow unconfined groundwater occurs within alluvial materials and fill. Deeper groundwater occurs as a regional aquifer in the Troutdale Formation. Groundwater may be continuously present downward through the alluvial system into the Troutdale Formation. Unconfined groundwater typically occurs within about 10 to 30 feet of ground surface; and, depending on local topography, recharge sources are from precipitation and streams. Perched groundwater is also common in shallow water-bearing units throughout much of the Portland Basin. Perching zones are often related to silt/sand/clay lenses and are laterally discontinuous. The unconsolidated nature of alluvial sands and gravels provides for relatively high permeability and hydraulic conductivity.

Data collected from monitoring well clusters and lagoon piezometers as part of the Port and Ross Island investigations indicate that hydraulic gradients are consistently upward from the Troutdale Formation the overlying hydogeolgic units at the site and there is a net upward hydraulic gradient through upland fill and Native Alluvium to the lagoon. During transitional periods of the tidal cycle when the lagoon water level is decreasing rapidly, downward hydraulic gradients are temporarily present from the shallow wells to the deeper alluvium wells. Tidal responses in piezometers placed in the lagoon generally mimic the responses in the upland wells, generally indicating a small, but predominantly upward, gradient which was corroborated by data from flux meters placed in the lagoon.

The average horizontal hydraulic gradient in the deep, regional Troutdale Aquifer, is to the northwest with and average magnitude of 0.0002. This generally follows the course of the Willamette River as it approaches the Columbia River. Along the southern portions of the island, in the area of the disposal cells, Willamette River levels are higher than lagoon levels, causing a horizontal hydraulic gradient across the island from the river to the lagoon. The lagoon water level is controlled by the river elevation at the lagoon opening. Also, hydraulic head in the lagoon is generally lower than heads in upland monitoring wells screened in fill or native alluvium indicating that net horizontal flow is inward toward the lagoon.

2.2.3 Seismicity

The lower Willamette Basin is a seismically active region with documented earthquake hazards. The Portland metropolitan area includes soil units identified by the USGS as having high potential earthquake hazard. A concealed structure known as the Portland Hills fault is believed to trend in a northwest to southeast direction beneath (or in the vicinity of) Ross and Hardtack Islands. This structure is considered part of a major regional fault system.

2.2.4 Surface Water

The lower Willamette River consists of a freshwater tidal section with typical mid-channel depths of up to about 30 feet near Ross Island. Hydraulic characteristics of the Willamette River affect surface water levels and flooding potential near Ross Island. Tidal fluctuations, seasonal flooding, Columbia River water heights, and discharges from upstream reservoirs affect river elevations. Daily tidal variations produce river elevation changes of about 1 to 3 feet near Ross Island. Seasonal variations are between about 1 and 9 feet, with higher water levels during spring freshets or periods of more extreme flooding. Upstream storage reservoirs in the Willamette Basin stabilize flows during flood-prone winter months and dry summer months. Predicted water elevations for the 100-year flood event are between about 27.5 and 30.5 feet, resulting in overtopping much of the upland areas of Ross and Hardtack Islands.

2.3 HISTORICAL FACILITY OPERATIONS

The RISG 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, noncommercial sand/silt material that had been separated from commercial grade material during on-site aggregate processing was placed back in the lagoon as fill. In 1979, the City of Portland issued a Conditional use Permit to RISG requiring the reclamation of uplands and in-water areas that had been mined. To meet these requirements, RISG began importing fill material. Between the early 1980s and 1998, fill material is documented to have come primarily from:

- The noncommercial material generated from on-site processing that had historically been used as fill,
- Material dredged from other local sites as part of maintenance activities, and
- Waste rock from a U.S. Army Corp of Engineers navigation project at Bonneville Locks.

In five cases, the fill material used to reclaim the lagoon was judged to be unsuitable for unconfined open water disposal due to the presence of contaminants. This material was placed in depressions within the lagoon and covered with clean material creating “confined aquatic disposal” sites (CADs). Concern about the lack of long-term monitoring of the effectiveness of these disposal sites generated the initial requirement for environmental investigation at the site.

3. SUMMARY OF INVESTIGATIONS

Several investigations have been conducted at the site beginning in the late 1990s. The purpose and extent of the primary investigations are summarized below. The overall conclusions regarding environmental issues at the site are described in Sections 3.6 through 3.9.

3.1 PORT OF PORTLAND – CONFINED DREDGE MATERIAL INVESTIGATION

The initial focus of environmental investigation at the site was the evaluation of the five (5) confined disposal cells used to isolate contaminated material brought to the site from Port of Portland (POP) shipping facilities. The five disposal areas, shown in Figure 2, contain material generated from the following sources:

1. Cell 5 – Sediments from maintenance dredging of the Port of Portland Ship Repair Yard Dry Docks 1 and 4, at Swan Island.

2. Cells 1 and 2 – Pencil pitch spill and associated sediments dredged from POP Terminal 4, Slip 3.

3. Cell 1 – Sediments from maintenance dredging of POP Ship Repair Yard, Dry Dock 3, at Swan Island.

4. Cell 3 – Sediments from maintenance dredging of POP Terminal 2, Berths 204, 205, and 206.

5. Cells 3 and 4 – Sediments from maintenance dredging of POP Terminal 4, Berths 410/411.

Between January and November, 2000 the POP conducted an extensive field exploration program to evaluate the effectiveness of the caps in preventing contaminants associated with the dredged material from moving into the lagoon. Groundwater, surface water, and sediment samples were collected. Monitoring wells in the upland areas and piezometers in the lagoon were installed and sampled to assess vertical movement of contaminants. Flux chambers were placed on the sediment surface above capped areas to assess movement of water at the groundwater/surface water interface. Bioassay and bioaccumulation testing was performed to assess impacts of contaminants found in sediments on aquatic organisms.

As a result of this investigation, it was discovered that RISG mining activities had extended into one of the capped areas resulting in a breach of a confined cell. Follow-up investigations associated with this finding are described below. Research of fill records that occurred as part of this study also indicated that other fill used for reclamation might contain contaminants. This finding resulted in DEQ requiring RISG to conduct a broader remedial investigation of the reclamation areas and processing plant portion of the site as is described below.

The overall conclusion of the POP CAD study was that, when undisturbed, sediment caps above the CAD cells are effective in isolating contaminants from the surrounding environment. Some concerns about the stability of the confined cells considering adjacent slopes in the lagoon were raised and the need for long-term monitoring of the cells was identified.

3.2 BREACH INVESTIGATION

As a result of the discovery of the breach of confined disposal Cell 5, RISG conducted an investigation (1999) of the area and constructed a new cap over the breach. Confirmation sampling conducted after placement of the new cap indicated that it covered the majority of the exposed area though some limited residual contamination was identified in surface sediments on the periphery of the cap. DEQ noted that further evaluation of this contamination would be included as part of the broader remedial investigation subsequently completed by RISG.

The breached material included clean cap material, adjacent non-contaminated fill material, and approximately 6,300 cubic yards of contaminated previously confined material. Investigation into the disposition of the approximately 62,250 cubic yards of breached material concluded that, following being run through the on-site processing plant for extraction of usable sand and gravel, the majority was discharged to the main aggregate settling pond located south of the sand and gravel processing facilities. Elevated levels of TBT subsequently discovered in settling pond sediment was believed to be associated with the breach material. RISG closed the eastern portion of the settling pond where the highest concentrations of contaminants associated with the breach were detected and capped the contaminated material with non-contaminated material dredged from the western portion of the pond.

3.3 CLEAR ZONE STUDY

In order to provide baseline characterization data in areas where filling might continue during the remedial investigation, in 1999 RISG sampled a deep portion of the lagoon adjacent to the southern fill area where reclamation filling had not yet taken place and an upland area on the lagoon shoreline of Ross Island where contamination was expected to be unlikely. Some contaminants were detected; however, the concentrations were low enough that they were judged to be unlikely to trigger remedial action. DEQ therefore approved filling of these areas.

3.4 COE PERMIT RELATED STUDIES

In 1999/2000, RISG conducted a Biological Assessment and a Turbidity Study to support their dredge/fill permit renewal process with the Corps of Engineers (COE) and Division of State Lands (DSL). The Biological Assessment included a reconnaissance-level ecological survey of Ross and Hardtack Islands including assessments of: 1) salmonid use, 2) terrestrial habitat, vegetation, and vertebrates, 3) near-shore aquatic habitat, 4) periphyton, 5) macrophytes, 6) benthic communities, and 7) fish. The turbidity study evaluated sources of turbidity and the extent to which mining and filling activities contributed to turbidity observed in the lagoon and Willamette River.

3.5 PHASE I AND II REMEDIAL INVESTIGATIONS

RISG completed a broader investigation of contaminant concentrations within or associated with the fill and processing areas in two phases. Phase I was initiated in 1999 in conjunction with the POP confined disposal site study to take advantage of the equipment and sampling opportunities provided. Phase II was completed between 2000 and 2002 to fill remaining data gaps in the characterization of the site. Both phases included the collection of groundwater, soil, and sediment samples from throughout the lagoon and upland areas as well as areas expected to serve as background sampling locations. In addition to chemical analysis, bioassays and bioaccumulation testing was performed on a number of collected samples.

3.6 NATURE AND EXTENT OF CONTAMINATION

DEQ has concluded that the nature and extent of contamination at the RISG site has been adequately characterized based on the data collected in the above-described investigations. With the exception of the material present in confined cells, site-wide contaminant concentrations were generally low across the site. A number of large maps or "plates" presenting sampling results for various chemical contaminants and site media are presented in the Phase II Remedial Investigation Report. A general overview of the findings is presented below with more specific information provided in Section 3.9.

3.6.1 Upland Soil

The investigation strategy for evaluating upland soil consisted of biased sampling in the processing plant area where potential contamination sources (e.g., oils and cleaners used for equipment maintenance) could be identified and random sampling of the fill placed in the central portion of Hardtack Island and the southern portions of Ross and Hardtack Islands. Surface and subsurface soil samples were collected and analyzed in each area as follows: 84 samples at 43 locations in the processing plant area, 96 samples at 28 locations in the central fill area, and 99 samples at 32 locations in the southern fill area.

Low levels of contaminants including PAHs, metals, and TPH were detected at a number of locations in surface and near-surface upland soil. Few of these detections exceeded risk-based screening levels. Areas of concern identified in the sampling included some surface soil the the vicinity of the lagoon shoreline where erosion into the lagoon was thought to be possible, one location in the processing plant area, and the breach material buried in the former settling pond.

3.6.2 Upland Surface Water

Surface water from the main and north settling ponds on the site was sampled and analyzed for contaminants of concern. Concentrations detected were below risk-based levels (PAHs, PCBs) or generally consistent with background concentrations detected in the Willamette River upstream from the site (metals).

3.6.3 Groundwater

Groundwater was evaluated at the site through construction and sampling of 3 sets of nested wells constructed on eastern (MW-3), southern (MW-2), and western (MW-1) portions of the Hardtack/Ross Island complex. Five (5) individual shallow zone monitoring wells (MW-4 – MW-8) were also installed in the central and southern portions of the island, and one-time sampling of 15 temporary well screens placed in lagoon shoreline areas was also completed. Well locations are shown in Figure 3. Wells at the MW-1 - 3 locations were screened in three zones: shallow groundwater, consisting of recently placed fill material; intermediate groundwater, consisting of native alluvium; and deep groundwater, consisting of the upper portion of the Troutdale Gravel Aquifer. Monitoring wells 4 through 8 and the temporary wells screens sampled shallow groundwater only.

In general, shallow groundwater was found to flow from the longitudinal “centerline” of the upland areas 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.

Fate and transport modeling was used to evaluate the potential for contaminants present in shallow groundwater in upland areas to migrate laterally and discharge to the lagoon, where exposure to human or ecological receptors could occur. This evaluation indicated that, with the exception of potential low level impacts from groundwater contamination detected along the immediate shoreline of the lagoon, groundwater contamination is unlikely to pose a significant risk to lagoon or Willamette River receptors.

3.6.4 Lagoon Sediment

More than 70 surface sediment samples and 75 subsurface sediment samples were collected and analyzed from Ross Island Lagoon during the Phase I and II investigations completed by RISG. Bioassays were conducted on 15 of the surface sediment samples. Bioaccumulation tests were conducted on two samples to evaluate the potential bioavailability of TBT and mercury.

Concentrations of contaminants exceeding conservative risk-based screening levels were detected throughout the lagoon. Many of these detections appear to be attributable to or consistent with "background" levels of contamination in surrounding surface water associated with urban runoff or other pollutants not originating at the site. Site-related contamination was most notable in the vicinity of the CAD cells and in the vicinity of the breach of CAD cell no. 5.

Five of the bioassays conducted exceeded the biological effects interpretive criteria (i.e., mortality of the organisms appeared to be related to the sediment conditions). These samples were collected from the lagoon shoreline and the toxicity appeared to correlate to elevated pH and associated unionized ammonia. Bioaccumulation tests indicated that mercury and TBT did not appear to be bioavailable to benthic organisms.

Elevated concentrations of contaminants in subsurface sediment is generally associated with the CAD cells.

3.7 RISK ASSESSEMENT

The standards for a protective cleanup are defined in Oregon Revised Statute (ORS) and Oregon Administrative Rule (OAR). ORS 465.315 states in part:

> **Standards for degree of cleanup required; Hazard Index; risk protocol; hot spots of contamination; exemption.** (1)(a) Any removal or remedial action performed under the provisions of ORS 465.200 to 465.510 and 465.900 shall attain a degree of cleanup of the hazardous substance and control of further release of the hazardous substance that assures protection of present and future public health, safety and welfare and of the environment.
>
> (b) The Director of the Department of Environmental Quality shall select or approve remedial actions that are protective of human health and the environment. The protectiveness of a remedial action shall be determined based on application of both of the following:
>
> (A) The acceptable risk level for exposures. For protection of humans, the acceptable risk level for exposure to individual carcinogens shall be a lifetime excess cancer risk of one per one million people exposed, and the acceptable risk level for exposure to noncarcinogens shall be the exposure that results in a Hazard Index number equal to or less than one. "Hazard Index number" means a number equal to the sum of the noncarcinogenic risks (hazard quotient) attributable to systemic toxicants with similar toxic endpoints. For protection of ecological receptors, if a release of hazardous substances causes or is reasonably likely to cause significant adverse impacts to the health or viability of a species listed as threatened or endangered pursuant to 16 U.S.C. 1531 et seq. or ORS 496.172, or a population of plants or animals in the locality of the facility, the acceptable risk level shall be the point before such significant adverse impacts occur.
>
> (B) A risk assessment undertaken in accordance with the risk protocol established by the Environmental Quality Commission in accordance with subsection (2)(a) of this section.

OAR 340-122-0115 provides additional definition of protectiveness:

> (1) "Acceptable risk level" with respect to the toxicity of hazardous substances has the meaning set forth in ORS 465.315 (1)(b)(A) and (B) and is comprised of the acceptable risk level definitions provided for carcinogenic exposures, noncarcinogenic exposures, and ecological receptors in sections (2) through (6) of this rule.
>
> (2) "Acceptable risk level for human exposure to individual carcinogens" means:

(a) For deterministic risk assessments, a lifetime excess cancer risk of less than or equal to one per one million for an individual at an upper-bound exposure; or

(b) For probabilistic risk assessments, a lifetime excess cancer risk for each carcinogen of less than or equal to one per one million at the 90th percentile, and less than or equal to one per one hundred thousand at the 95th percentile, each based upon the same distribution of lifetime excess cancer risks for an exposed individual.

(3) "Acceptable risk level for human exposure to multiple carcinogens" means the acceptable risk level for human exposure to individual carcinogens and:

(a) For deterministic risk assessments, a cumulative lifetime excess cancer risk for multiple carcinogens and multiple exposure pathways of less than or equal to one per one hundred thousand at an upper-bound exposure; or

(b) For probabilistic risk assessments, a cumulative lifetime excess cancer risk for multiple carcinogens and multiple exposure pathways of less than or equal to one per one hundred thousand at the 90th percentile and less than or equal to one per ten thousand at the 95th percentile, each based upon the same distribution of cumulative lifetime excess cancer risks for an exposed individual.

(4) "Acceptable risk level for human exposure to noncarcinogens" means:

(a) For deterministic risk assessments, a hazard index less than or equal to one for an individual at an upper-bound exposure; or

(b) For probabilistic risk assessments, a hazard index less than or equal to one at the 90th percentile, and less than or equal to ten at the 95th percentile, each based upon the same distribution of hazard index numbers for an exposed individual.

(5) "Acceptable risk level for individual ecological receptors" applies only to species listed as threatened or endangered pursuant to 16 USC 1531 et seq. or ORS 465.172, and means:

(a) For deterministic risk assessments, a toxicity index less than or equal to one for an individual ecological receptor at an upper-bound exposure, where the toxicity index is the sum of the toxicity quotients attributable to systemic toxicants with similar endpoints for similarly-responding species and the toxicity quotient is the ratio of the exposure point value to the ecological benchmark value; or

(b) For probabilistic risk assessments, a toxicity index less than or equal to one at the 90th percentile and less than or equal to 10 at the 95th percentile, each based on the same distribution of toxicity index numbers for an exposed individual ecological receptor; or

(c) The probability of important changes in such factors as growth, survival, fecundity, or reproduction related to the health and viability of an individual ecological receptor that are reasonably likely to occur as a consequence of exposure to hazardous substances is de minimis.

(6) "Acceptable risk level for populations of ecological receptors" means a 10 percent chance, or less, that no more than 20 percent of the total local population will be exposed to an exposure point value greater than the ecological benchmark value for each contaminant of concern and no other observed significant adverse effects on the health or viability of the local population.

OAR 340-122-0084 describes the requirements for risk assessments including the process for determining concentrations corresponding to acceptable risk levels. These concentrations were developed for Ross Island and the areas warranting remediation identified based on exceedance of these concentrations.

3.7.1 Conceptual Site Model

A conceptual site model for a contaminated site identifies all relevant sources of cotnamiatnion, potential or known pathways via which said cotnamiantns can migrate, and all potential receptor populations (human or ecological). Based on the current and potential future site land and water uses determined for the site in the Beneficial Land and Water Use Determinations, potential human receptors at Ross Island include the following: on-site occupational workers, including those who excavate subsurface soil, recreational visitors to the site, and recreational anglers. Potential ecological receptors at Ross Island include: benthic organisms (aquatic organisms that live on or in the sediment), fish (including endangered salmon), birds (including the threatened bald eagle), and mammals.

3.7.2 Risk-Based Concentrations - Human Health

In order to evaluate the data collected at Ross Island and determine areas where remedial action may be warranted, risk-based concentrations reflecting a 1×10^{-6} excess cancer risk or hazard index greater than 1, were calculated for each media considering the pertinent exposure pathways of concern. For the human health, the risk based concentrations addressed the following scenarios:

a) Soil concentrations reflecting protective levels for site worker direct contact,

b) Soil concentrations derived from protective levels in sediment (see item d below) for soil that may erode into the lagoon,

c) Groundwater concentrations derived from protective levels in surface water (generally EPA Ambient Water Quality Criteria or AWQC) should migration to surface water occur,

d) Sediment concentrations reflecting protective concentrations considering movement of contaminants up the food chain to fish and subsequent ingestion of fish by recreational anglers.

A summary of the risk-based concentrations developed for the site based on these exposure scenarios is provided in Table 1.

3.7.3 Risk-Based Concentrations – Ecological Receptors

Risk-based concentrations (RBCs) were also developed for the potential ecological exposure pathways identified in Section 3.7.1. For the most part, RBCs corresponding to protection of recreational fishers were the most stringent (lowest) protective concentrations developed for Ross Island. However, impacts to benthic organisms were identified as the primary exposure pathway of concern for the elevated pH measured in shoreline sediment. A summary of the ecological risk-based concentrations developed for the site is provided in Table 2. In addition, a pH level exceeding 8.5 was used to define areas of excess risk, consistent with EPA ambient water quality standards.

3.8 HOT SPOT CRITERIA

Characterization of a site also includes whether a "hot spot" is present.

OAR 340-122-115(32) defines hot spot of contamination for groundwater and surface water and for other media such as sediments:

> (a) For groundwater or surface water, hazardous substances having a significant adverse effect on beneficial uses of water or waters to which the hazardous substances would be reasonably likely to migrate and for which treatment is reasonably likely to restore or protect such beneficial uses within a reasonable time, as determined in the feasibility study; and
>
> (b) For media other than groundwater or surface water, (*e.g.*, contaminated soil, debris, sediments, and sludges; drummed wastes; "pools" of dense, non-aqueous phase liquids submerged beneath groundwater or in fractured bedrock; and non-aqueous phase liquids floating on groundwater), if hazardous substances present a risk to human health or the environment exceeding the acceptable risk level, the extent to which the hazardous substances:
>
> (A) Are present in concentrations exceeding risk-based concentrations corresponding to:
>
> (i) 100 times the acceptable risk level for human exposure to each individual carcinogen;
>
> (ii) 10 times the acceptable risk level for human exposure to each individual noncarcinogen; or
>
> (iii) 10 times the acceptable risk level for exposure of individual ecological receptors or populations of ecological receptors to each individual hazardous substance.
>
> (B) Are reasonably likely to migrate to such an extent that the conditions specified in subsection (a) or paragraphs (b)(A) or (b)(C) would be created; or
>
> (C) Are not reliably containable, as determined in the feasibility study.

3.8.1 Surface Water Beneficial Use Determination

OAR 3401-122-115(9) defines beneficial uses of water as: "…any current or reasonable likely future beneficial use of groundwater or surface water by humans or ecological receptors."

Beneficial uses for surface waters of the Willamette River and Ross Island Lagoon include recreation (*e.g.*, fishing, swimming) wildlife habitat and food source, and salmonid rearing. Beneficial uses of surface water are pertinent in that contamination may be considered a hot spot if it migrates to surface water and causes a significant adverse impact to the surface water beneficial uses. Buried waste materials that are the source of elevated pH detected in shoreline areas are also interpreted by DEQ to meet these criteria. Also, a relationship between sediment concentrations and fish tissue concentrations can be estimated using biota sediment accumulation factors (BSAFs). This type of evaluation indicates that elevated sediment concentrations in Ross Island lagoon may result in unacceptable concentrations of contaminants in fish tissue (considering potential impacts to humans and wildlife that consume the fish).

3.8.2 Sediment Hot Spots

Sediment hot spots were identified in Ross Island lagoon based on exceedance of the risk-based criteria as described in Section 3.8 as well as considering "ambient" concentrations in the Willamette River in the vicinity of the site. Many of the contaminants that were detected in Ross Island lagoon are also detected throughout river sediments in this area. The source of this contamination is presumed by DEQ to be a combination of historical releases from hazardous substance sties around and up-river of the area, and non-point source releases of stormwater to the river (urban runoff). Consequently, lagoon sediment data were compared to sediment data collected in areas upstream of the Ross Island site as part of the evaluation of areas where active cleanup would be effective. Surface sediment hot spots, shown in Figure 2, generally lie in the vicinity of the CAD cells, particularly in the area of the breach and along the shoreline where pH is elevated. In addition, the material that is confined within the CAD cells would meet the criteria for hot spots if exposure pathways were complete (i.e., if the existing capping material was either not present or properly maintained).

3.8.3 Upland Hot Spots

Upland hot spots may exist in areas where there is potential for contaminants to migrate to the lagoon and accumulate in sediments at concentrations that exceed hot spot criteria for sediments. In general, upland hot spot areas are limited to the breach material that was capped in the former settling pond and shoreline areas where overland erosion of contaminated surface soils to the lagoon was determined to be possible.

3.9 ESTIMATE OF VOLUMES/AREAS OF CONTAMINATED MEDIA

Areas warranting remedial evaluation are identified below. Locations are shown in Figure 4.

3.9.1 Surface Soil – Processing Plant Area

Elevated concentrations of zinc and arsenic were detected in surface soil samples collected in the vicinity of MW-03. The source of these contaminants is not known and the full extent of contamination has not been defined but is expected to be limited based on other vicinity sampling results. Assuming contamination is limited to 1 foot in depth and extends no more than 100 feet from the sample location, the volume of impacted soil is estimated to be 3,000 cubic yards.

3.9.2 Surface Soil – Adjacent to Southern Lagoon

PAHs were detected in surface soil immediately adjacent to the southern portion of the lagoon at concentrations that could pose a threat to the lagoon if the soil migrated to the lagoon by erosion. Assuming this contamination is limited to 1.5 feet deep and extends no more than 100 feet from the sample locations, the volume of impacted soil is estimated to be no more than 8,000 cubic yards.

3.9.3 Capped Breach Material

As discussed in Section 3.2, the former eastern portion of the main process settling pond was capped to cut off exposure to material removed from lagoon disposal Cell 5 during mining activities. The estimated volume of TBT-contaminated material buried at this location is 6,300 cubic yards.

3.9.4 Groundwater – Adjacent to Lagoon

PAHs were detected at levels slightly exceeding EPA AWQC in a grab groundwater sample collected adjacent to the southern portion of the lagoon. Because of the proximity to the lagoon there is some potential that this groundwater could discharge to the lagoon at levels that would be of concern for sediment-dwelling organisms.

3.9.5 Surface Sediment - Lagoon

Elevated concentrations of PAHs, metals, and/or PCBs were detected in a limited number of surface sediment samples collected from the southern portion of the lagoon where reclamation filling has occurred and in the vicinity of the recapped breach area. Assuming contamination associated with each sampling point that exceeded RBCs extends laterally no more than 100 feet from that point and vertically to no more than 0.3 feet below the surface, the volume of impacted sediment is estimated at 4,500 cubic yards. Of this volume, approximately 3,800 cubic yards are above hot spot levels.

3.9.6 Lagoon Shoreline

Several areas along the southern shoreline of the lagoon had elevated pH assumed to result from the placement of cement wastes as fill. It is difficult, if not impossible to estimate the volume of material present in the fill areas that is causing the elevated pH as there are no accurate records on where this material was placed, and it was likely mixed in a heterogenous fashion with other fill during placement. The impacted shoreline extends approximately 2,500 feet along the southern lagoon from the processing plan area to eastern shore of Ross Island.

3.9.7 Lagoon Confined Disposal Cells

As discussed in Section 3.1, highly contaminated material is present in the five confined disposal cells used for management of material dredged from POP facilities. Disposal records indicate that approximately 162,000 cubic yards of material are confined in these cells.

4. PEER REVIEW SUMMARY

Reports and work plans documents produced during the investigation of the Ross Island site have been reviewed by a technical team at DEQ. Over the years during which the investigation was conducted team members changed but the team consistently included a project manager, hydrogeologist, engineer, modeler, and toxicologist. In addition, DEQ sought input from the engineering staff at Oregon State University on slope stability questions. The DEQ team raised many issues during the investigation which were subsequently resolved by follow-up field work and/or evaluations. One issue that continues to be evaluated is the effectiveness of capping in reducing the elevated pH detected in shoreline areas. Ross Island continues to conduct field work to evaluate this aspect of the proposed remediation with DEQ oversight. Results of this evaluation will be used to modify, as appropriate, the parameters of the proposed remedy for elevated pH at the site. The team supports the proposed remedial action.

In addition to the DEQ technical team described above, input on the investigation was provided by an outside group of experts referred to as the Ross Island Technical Assistance Panel (TAP). The TAP included the following members: Jim Grimes, Oregon Department of Fish and Wildlife; Mike Houck, Portland Audubon Society; Jeremy Buck, U.S. Fish and Wildlife; John Malek, U.S. EPA Region X; Mike Palermo, U.S. ACOE – Waterways Experiment Station; Jim Reese, U.S. Army Corps of Engineers; Don Stephens, Brooklyn Neighborhood Association; Chris Prescott, City of Portland – Bureau of Environmental Services; and Deke Gundersen, Pacific University. The TAP received copies of investigation reports and met at least three times to provide input on the findings and discuss evaluation strategies.

5. DESCRIPTION OF REMEDIAL ACTION OPTIONS

5.1 REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) for this site are focused on preventing potential human and ecological receptor exposures to contaminants that exceed RBCs. The risk-based concentrations are based on achieving the standards for protectiveness established in OAR 340-122-0040 and OAR340-122-0115. Selected remedial actions are expected to prevent or minimize future releases and migration of hazardous substances in the environment. RAOs for each remedial area at the site are described below.

5.1.1 Upland Soil

The RAO for upland surface soil in the processing plant area is to reduce risk to occupational workers, recreational visitors, and ecological receptors from exposure to concentrations of arsenic and zinc exceeding protective levels. The RAO for upland surface soil in the lagoon shoreline area is to prevent the erosion of surface soil contaminated at levels that exceed protective levels for aquatic receptors into the lagoon. The RAO for the material impacted with TBT and TPH that is currently capped in the former lagoon settling pond area is to prevent exposure to occupational and potential future recreational visitors and prevent migration of the contaminants from the capped areas to the lagoon or river.

5.1.2 Lagoon

The RAO for lagoon surface sediments with contaminant concentrations that exceed RBCs is to reduce risk to human health and ecological receptors (via consumption of fish) to protective levels. The RAO for lagoon surface sediment with elevated pH is to prevent exposure of benthic organisms to pH levels that exceed 8.5. The RAO for contaminated subsurface sediments in the CAD cells is to prevent human and ecological receptor exposure to contaminant concentrations that exceed protective levels based on toxicity to benthic organisms and bioaccumulation in fish based on protective concentrations for wildlife and human consumers of fish; and to prevent migration of contamination away from the capped areas. Consideration was also give to the feasibility of remediating sediment hot spots to protective or non-hot spot levels by treatment or removal.

5.2 REMEDIAL ACTION OPTIONS

A limited number of general response actions and associated remedial technologies were considered in the FS. The general response actions include: no action, excavation of impacted material, solidification of impacted soil/sediment, capping and associated long-term maintenance and monitoring, neutralization of elevated pH, monitored natural attenuation/recovery, institutional controls, and on and off-site disposal of excavated material. Because applicable response actions varied for the individual remedial action areas identified at the site, alternatives were identified and evaluated for each area separately and are summarized in Sections 5.2.2 – 5.2.8 below.

5.2.1 Reclamation Plan

As discussed in Section 2.3, RISG was required to reclaim the mined areas of the lagoon under a Conditional Use Permit with the City of Portland, and subsequently in a removal/fill permit with the Oregon Division of State Lands (DSL) beginning in 1979. In 2002 the Reclamation Plan was updated under a process provided through the DSL permit. 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 fill. The plan specifies where the fill will be placed to create emergent wetlands and shallow water habitat within the lagoon. This area includes the southern portion of the lagoon where contaminated sediment is located and portions of the nearshore upland areas where potential erosion of contaminated surface soil was identified. The impact of the anticipated reclamation has been considered in the evaluation of remedial options for the site in an effort to provide a consistent, integrated plan for improving environmental conditions.

5.2.2 Upland Surface Soil – Processing Plant Area

Alternative 1A: Excavation and On-Site Disposal

This option would consist of excavating soil contaminated with arsenic and zinc in the processing plant area and transporting the excavated material to an on-site cell for confinement. Sampling to assess the extent of required contamination and backfilling of areas where the excavation was deeper than 1 foot would be required. It is estimated that approximately 2,300 cubic yards of soil would need to be removed. This alternative could be implemented in less than a year, is readily implementable with available equipment, and would cost approximately $243,000.

Alternative 1B: Excavation and Off-Site Disposal

This option would consist of excavating soil contaminated with arsenic and zinc in the processing plant area and transporting the excavated material off-site by barge to a permitted disposal site. Sampling to assess the extent of required contamination and backfilling of areas where the excavation was deeper than 1 foot would be required. It is estimated that approximately 2,300 cubic yards of soil would need to be removed. This alternative could be implemented in less than a year, is readily implementable with available equipment, and would cost approximately $406,000. The long-term reliability of this option is high given that contamination would be removed from the site.

Alternative 2: Excavation and Solidification

This option would consist of excavating the contaminated soil, mixing it with a binding agent to solidify and contain the contaminants and placing the material in an on-site (upland) cell with a cap. The estimated cost of this alternative is $295,000 and it is readily implemented with available equipment.

Alternative 3A: Soil Cap

This option would consist of placing a minimum of 3 feet of clean soil over the contaminated area to prevent exposure to current and future site workers, recreational visitors and ecological receptors. Sampling to assess the extent of contamination in this area would be required. It is estimated that approximately 7,000 cubic yards of clean material would be required for the cap. Long-term maintenance of the cap and institutional controls would be required to prevent disturbance of the cap. The estimated cost of this alternative is $191,000.

Alternative 3B: Concrete Cap

This option would consist of placing a minimum 0.5 foot thick concrete cap over the contaminated soil to prevent exposure to current and future site workers, recreational visitors and ecological receptors. Sampling would be required to assess the extent of contamination in this area. It is estimated that the area to be addressed would be approximately 10,000 square feet. Long-term maintenance of the cap and institutional controls would be required to prevent disturbance of the cap. The estimated cost of this alternative is $411,000.

5.2.3 Upland Surface Soil – Adjacent to Lagoon

Alternative 1: Excavation and Off-Site Disposal

This option would consist of excavating approximately 8,700 cubic yards of soil adjacent to the southern portion of the lagoon that is contaminated with PAHs at concentrations that may pose a threat to the lagoon via erosion. Soil would be excavated to a depth of 1.5 feet and transported by barge to an off-site permitted disposal facility. The excavated are would be backfilled with clean soil consistent with the Reclamation Plan. This option is readily implementable with available equipment. The estimated cost $815,000. The capping can be completed with standard equipment but the action would need to be timed to occur when tides are low to limit generation of turbidity in the lagoon or controls on turbidity would need to be put into place.

Alternative 2: Stabilize and Cap

This option would consist of stabilizing the slopes in this area to prevent future erosion of surface soil into the lagoon. The contaminated area would be capped with approximately 3,500 cubic yards of clean soil consistent with the Reclamation Plan. Long-term maintenance of the cap and institutional controls would be required to prevent disturbance of the cap. This alternative is readily implementable with available equipment and would have a total cost of approximately $251,000.

5.2.4 Breach Material Contained in Former Settling Pond

Alternative 1: Excavation and Off-site Disposal

This option would consist of excavating approximately 6,300 cubic yards of TBT-contaminated material that is currently confined in the former process settling pond south of the processing plant on Hard Tack Island. Approximately 60,000 cubic yards of clean cap material would need to be removed to access the contaminated soil, after which TBT-contaminated material could be removed and transported off-site by barge for disposal at a permitted facility. This option is easily implemented with available equipment. The estimated cost of this alternative is $947,000.

Alternative 2: Maintain Existing Cap

This option would consist of preparing and implementing a long-term maintenance plan to ensure the integrity of the existing cap is maintained. Institutional controls would be required to ensure the capped area is not disturbed. The estimated cost of this alternative is $54,000.

5.2.5 Groundwater – Adjacent to the Lagoon

Alternative 1: Monitoring

Only one option was considered for this remedial area due to the high uncertainty as to whether a potential threat actually exists (identified risk was based on a single detection of contamination at an upland groundwater sampling location, and a modeling effort which showed that contamination could migrate to the lagoon after many years). It was also noted in the FS that the reclamation plan includes extending the shoreline approximately 200 feet in this area which will allow for significant attenuation of any groundwater contamination detected, prior to discharge to the lagoon. Proposed monitoring would require the installation of up to three monitoring wells to ensure that PAH concentrations do not exceed those detected during the investigation and that concentrations attenuate to protective levels prior to discharge to the lagoon. The estimated cost of this option is $131,000.

5.2.6 Lagoon Surface Sediment – CAD/Breach Areas

Alternative 1A: Dredging and Off-Site Disposal

This option would consist of dredging surface sediments with elevated concentrations of PAHs, metals, and PCBs and transporting the excavated sediment off-site for disposal at a permitted facility. Approximately 4,500 cubic yards of sediment would need to be dredged and transported off-site by barge, and an equivalent amount of clean soil imported to backfill the excavated area. This option is readily implemented with available equipment but would require permitting associated with in-water work. The estimated cost of this alternative is $1,044,000.

Alternative 1B: Dredging and On-Site Disposal

This option would consist of dredging surface sediments with elevated concentrations of PAHs, metals, and PCBs and transporting the excavated sediment to an onsite upland cell where it would be capped. Approximately 4,500 cubic yards of sediment would need to be dredged and transported off-site by barge, and an equivalent amount of clean soil imported to backfill the excavated area. Approximately 14,000 cubic yards of clean soil would be required for the upland cap. This option is readily implemented with available equipment but would require permitting associated with in-water work. Long-term maintenance of the cap and institutional controls would be required to prevent disturbance of the cap. The estimated cost of this alternative is $798,000.

Alternative 2: Capping

This option would consist of constructing a minimum 3-foot thick cap over areas where contaminant concentrations in surface sediment are elevated to prevent exposure to benthic invertebrates inhabiting the sediment and fish in the lagoon. Approximately 47,000 cubic yards of soil would be required for the cap, 35,000 cubic yards of which would be placed to meet reclamation plan requirements. This option is readily implemented with available equipment. Long-term maintenance of the cap, institutional controls to prevent disturbance of the cap, and monitoring to ensure the effectiveness of the cap would be required. The estimated cost of this alternative is $430,000.

Alternative 3: Hot Spot Dredging and Capping

This option would consist of the dredging and off-site transportation to a permitted facility of approximately 3,800 cubic yards of hot-spot level surface sediment and the capping of remaining areas of non-hot-spot (but elevated) surface sediment. Approximately 10,000 cubic yards of soil would be required for the in-water cap. This option is readily implemented with available equipment. Long term maintenance of the cap, institutional controls to prevent disturbance of the cap, and monitoring to ensure the effectiveness of the cap would be required. The estimated cost of this alternative is $939,000.

5.2.7 Lagoon Surface Sediment – Shoreline Areas

Alternative 1A: Dredging and Off-Site Disposal

This option would consist of dredging surface sediments in lagoon shoreline areas where pH is elevated and bioassays indicated benthic toxicity, and transporting the excavated sediment off-site for disposal at a permitted facility. Approximately 3,500 cubic yards of sediment would need to be dredged and transported by barge off-site and an equivalent amount of clean soil brought in to backfill the excavated area. Approximately 2,000 cubic yards of clean overburden material would need to be excavated to access the presumed source of the elevated pH. The effectiveness of this option is somewhat uncertain as the source of the elevated pH may remain in fill material that is not removed from the site and evaluation of the effectiveness of capping at attenuating elevated pH is on-going. This option is readily implemented with available equipment but would require permitting associated with in-water work. The estimated cost of this alternative is $804,000.

Alternative 1B: Dredging and On-Site Disposal

This option would consist of dredging surface sediments with elevated concentrations of PAHs, metals, and PCBs and transporting the excavated sediment to an onsite (upland) cell where it would be capped. Approximately 3,500 cubic yards of sediment would need to be dredged and transported by barge to the upland area and an equivalent amount of clean soil brought in to backfill the excavated area. Approximately 2,000 cubic yards of clean overburden material would need to be excavated to access the presumed source of the elevated pH. Approximately 14,000 cubic yards of clean soil would be required for the upland cap. Effectiveness of this option is somewhat uncertain as the source of the elevated pH may remain in fill material that is not removed from the site and evaluation of the effectiveness of capping at attenuating elevated pH is on-going. This option is readily implemented with available equipment but would require permitting associated with in-water work. The estimated cost of this alternative is $720,000.

Alternative 2: Capping

This option would consist of constructing a minimum 3-foot thick cap over areas where contaminant concentrations in surface sediment are elevated to prevent exposure to benthic invertebrates inhabiting the sediment and fish in the lagoon. Approximately 35,000 cubic yards of soil would be required for the cap, 35,000 cubic yards of which would be required to meet reclamation specifications. Effectiveness of this option is somewhat uncertain as evaluation of the effectiveness of capping at attenuating elevated pH is on-going. This option is readily implemented with available equipment. Long-term maintenance of the cap, institutional controls to prevent disturbance of the cap, and monitoring to ensure the effectiveness of the cap would be required. The estimated cost of this alternative is $320,000.

5.2.8 Lagoon Confined Disposal Cells

Alternative 1: Dredging and Off-Site Disposal

This option would consist of dredging subsurface sediments contaminated with PCBs, PAHs, metals, and TBT that are currently confined in aquatic disposal cells within the lagoon, and transporting the excavated material off-site for disposal at a permitted facility. Approximately 162,000 cubic yards of contaminated sediment would need to be dredged and transported by barge off-site and an equivalent amount of clean soil brought in to backfill the excavated area. Approximately 250,000 cubic yards of clean overburden material would need to be excavated to access the CAD material. This option is readily implemented with available equipment but would require permitting associated with in-water excavation work. The estimated cost of this alternative is $32,800,000.

Alternative 2: Maintain Existing CADs

This option would consist of placing clean fill material in areas adjacent to the CADs where slope stability may be an issue. A long-term maintenance and monitoring plan would be prepared and implemented to ensure the integrity of the existing cap is maintained and remains effective in isolating contaminated material. Institutional controls would be required to ensure the capped area is not disturbed. The estimated cost of this alternative is $205,000.

6. EVALUATION OF REMEDIAL ACTION OPTIONS

6.1 EVALUATION CRITERIA

Based on the results of the Remedial Investigation (RI), a Feasibility Study (FS) was performed to evaluate the remedial alternatives. The FS evaluated:

- The protectiveness of the alternatives based on the standards set forth in OAR 340-122-040;
- The extent to which the remedial action alternatives treat hot spots: and
- The feasibility of the alternatives based on a balancing of the remedy selection factors including effectiveness, long-term reliability, implementability, implementation risk, and cost reasonableness.

6.2 REMEDIAL FACTORS

The remedial action alternatives are evaluated against the following remedial factors set forth in OAR 340-122-090(3):

- **Effectiveness in achieving protection.** The evaluation of this factor includes the following components:

  – Magnitude of the residual risk from untreated waste or treatment residuals, without considering risk reduction achieved through on-site management of exposure pathways (e.g., engineering and institutional controls). The characteristics of the residuals are considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, propensity to bio-accumulate, and propensity to degrade.

  – Adequacy of any engineering and institutional controls necessary to manage residual risks.

  – The extent to which the remedial action restores or protects existing or reasonably likely future beneficial uses of water.

  – Adequacy of treatment technologies in meeting treatment objectives.

- The time until remedial action objectives are achieved.

- **Long-term reliability.** The following components are considered when evaluating this factor, as appropriate:

  - The reliability of treatment technologies in meeting treatment objectives.

  - The reliability of engineering and institutional controls needed to manage residual risks, taking into consideration the characteristics of the hazardous substances being managed, the ability to prevent migration and manage risk, and the effectiveness and enforceability over time of the controls.

  - The nature and degree of uncertainties associated with any necessary long-term management (e.g., operations, maintenance, monitoring).

- **Implementability.** This factor includes the following components:

  - Practical, technical, legal difficulties and unknowns associated with the construction and implementation of the technologies, engineering controls, and/or institutional controls, including the potential for scheduling delays.

  - The ability to monitor the effectiveness of the remedy.

  - Consistency with regulatory requirements, activities needed to coordinate with and obtain necessary approvals and permits from other governmental bodies.

  - Availability of necessary services, materials, equipment, and specialists, including the availability of adequate treatment and disposal services.

- **Implementation Risk.** This factor includes evaluation of the potential risks and the effectiveness and reliability of protective measures related to implementation of the remedial action, including the following receptors: the community, workers involved in implementing the remedial action, and the environment; and the time until the remedial action is complete.

- **Reasonableness of Cost.** This factor assesses the reasonableness of the capital, O&M, and periodic review costs for each remedial alternative; the net present value of the preceding; and if a hot spot has been identified at this site, the degree to which the cost is proportionate to the benefits to human health and the environment created through treatment of the hot spot.

  In general, the least expensive remedial action is preferred unless the additional cost of a more expensive action is justified by proportionately greater benefits under one or more of the other remedial factors. For sites with hot spots, the costs of remedial actions must be evaluated to determine the degree to which they are proportionate to the benefits created through restoration or protection of beneficial uses of water. A higher threshold will be used for evaluating the reasonableness of costs for treatment of hot spots than for remediation of areas other than hot spots. The sensitivity and uncertainty of the costs are also considered.

6.3 EVALUATION AND COMPARATIVE ANALYSIS OF ALTERNATIVES

This section evaluates and compares each of the remedial action alternatives carried forward for detailed analysis using the factors described in Sections 6.1 and 6.2.

6.4 EFFECTIVENESS

6.4.1 Upland Surface Soil – Process Plant Area

All alternatives evaluated will be effective in meeting remedial action objectives for the site. Excavation with off-site disposal has greater long-term effectiveness as contaminated material is permanently removed from the site and placed in a facility designed to contain wastes. Excavation with solidification is expected to be more effective than excavation without treatment as solidification will reduce mobility of the metal contaminants of concern.

6.4.2 Upland Surface Soil – Adjacent to Lagoon

Both alternatives are effective in achieving remedial action objectives for the site. Excavation and off-site disposal is more effective in that contaminated material is removed from the site and placed in a facility designed to contain wastes.

6.4.3 Breach Material Contained in Former Settling Pond Area

Both alternatives are effective in achieving remedial action objectives for the site. Excavation and off-site disposal is more effective in that contaminated material is removed from the site and placed in a facility designed to contain wastes.

6.4.4 Groundwater – Adjacent to the Lagoon

Assuming contaminant levels in groundwater attenuate with proximity to the lagoon, monitoring should be effective in addressing contaminated groundwater in this area.

6.4.5 Lagoon Surface Sediment – CAD/Breach Areas

All alternatives evaluated will be effective in meeting remedial action objectives for the site. Excavation with off-site disposal is more effective in that contaminated material is removed from the site and placed in a facility designed to contain wastes. Complete excavation is more effective than hot spot excavation as residual contamination of concern will not remain after the action is completed. Containment of material in upland areas is more effective than containment in place as the contaminated material is further removed from receptors in the lagoon.

6.4.6 Lagoon Surface Sediment – Shoreline Areas

All alternatives evaluated should be effective in meeting remedial action objectives for the site though evaluation of capping effectiveness for pH is still underway. Excavation with off-site disposal should be more effective in that contaminated material is removed from the site and placed in a facility designed to contain wastes assuming that the source material for the elevated pH can be identified and removed.

6.4.7 Lagoon Confined Disposal Cells

Both alternatives evaluated will be effective in meeting remedial action objectives for the site. Excavation with off-site disposal is more effective in that contaminated material is removed from the site and placed in a facility designed to contain wastes.

6.5 LONG-TERM RELIABILITY

6.5.1 Upland Surface Soil – Process Plant Area

Excavation with off-site disposal has greater long-term reliability than on-site containment options as contaminated material is removed from the site and placed in a facility designed to contain wastes. Excavation with solidification has greater long-term reliability than excavation without treatment as solidification will reduce the mobility of the metal contaminants of concern.

6.5.2 Upland Surface Soil – Adjacent to Lagoon

Excavation and disposal off site has greater long-term reliability than capping as contaminated material is removed from the site and placed in a facility designed to contain wastes.

6.5.3 Breach Material Contained in Former Settling Pond Area

Excavation and off-site disposal has greater long-term reliability than on-site containment options as contaminated material is removed from the site and placed in a facility designed to contain wastes.

6.5.4 Groundwater – Adjacent to the Lagoon

Assuming that contaminant levels in groundwater attenuate to below RBCs before reaching the lagoon (as expected and to be confirmed by groundwater sampling), the long-term reliability of this option is expected to be high.

6.5.5 Lagoon Surface Sediment – CAD/Breach Areas

Excavation with off-site disposal has greater long-term reliability than on-site capping as contaminated material is removed from the site and placed in a facility designed to contain wastes. Complete excavation has higher long-term reliability than hot spot excavation as there will be no continued reliance on engineering and institutional controls to provide protection.

6.5.6 Lagoon Surface Sediment – Shoreline Areas

Excavation with off-site disposal has greater long-term reliability than on-site containment options as contaminated material is removed from the site and placed in a facility designed to contain wastes.

6.5.7 Lagoon Confined Disposal Cells

Excavation with off-site disposal has greater long-term reliability than on-site containment options as contaminated material is removed from the site and placed in a facility designed to contain wastes.

6.6 IMPLEMENTABILITY

6.6.1 Upland Surface Soil – Process Plant Area

In-place Capping is the most easily implemented option for this area as it appears some capping has already taken place and this option would require the least movement of material. Excavation and on-site containment is somewhat easier to implement than off-site disposal as movement by barge would not be required. On-site disposal without treatment is easier to implement than on-site disposal with treatment as less equipment, material handling, and site set up would be required.

6.6.2 Upland Surface Soil – Adjacent to Lagoon

Stabilization and in-place capping would be the easiest option to implement for this material as it requires the least amount of material movement and long-term monitoring associated with the cap will be straightforward.

6.6.3 Breach Material Contained in Former Settling Pond Area

Excavation and off-site disposal would be very difficult for this area due to the large volume of material that would have to be removed. Maintaining the existing cap would be straightforward.

6.6.4 Groundwater – Adjacent to the Lagoon

Long-term groundwater monitoring is easily implemented in this area following required reclamation.

6.6.5 Lagoon Surface Sediment – CAD/Breach Areas

Excavation options are more difficult to implement than capping options in this area due to the additional material that would need to be removed and associated permitting required for in-water dredging.

6.6.6 Lagoon Surface Sediment – Shoreline Areas

The excavation option is more difficult to implement than the capping option in this area due to the additional material that would need to be moved and associated permitting required for in-water dredging.

6.6.7 Lagoon Confined Disposal Cells

Excavation with off-site disposal would be very difficult to implement considering the large volume of sediment that would need to be moved, the potential for the release of contamination to adjacent areas during removal and consequent expansion of the removal area, and the need for permitting associated with in-water dredging. Also, it may be difficult to implement this option as the source for elevated pH is expected to be widely dispersed throughout the fill material.

6.7 IMPLEMENTATION RISK

6.7.1 Upland Surface Soil – Process Plant Area

In-place capping has the least implementation risk since contaminated material will not be disturbed. Excavation and on-site containment has somewhat lower implementation risk than off-site disposal as the distances that contaminated material would be transported would be lower. On-site disposal without treatment has somewhat lower implementation risk than on-site disposal with treatment as less time is spent working with the contaminated material.

6.7.2 Upland Surface Soil – Adjacent to Lagoon

Stabilization and in-place capping would have a lower implementation risk than excavation as contaminated material would not be disturbed.

6.7.3 Breach Material Contained in Former Settling Pond Area

Excavation and off-site disposal would have a very high implementation risk relative to maintaining the existing cap due to the large volumes of material that would need to be moved and associated potential exposures that could occur.

6.7.4 Groundwater – Adjacent to the Lagoon

There are no significant implementation risks associated with long-term monitoring of groundwater in this area as contaminant levels do not exceed levels that would be of concern for human exposures that might occur during monitoring activities.

6.7.5 Lagoon Surface Sediment – CAD/Breach Areas

Excavation options would have higher implementation risks than capping options in this area due to the potential for releasing contaminated sediments during removal and general risks associated with additional material handling that would be required.

6.7.6 Lagoon Surface Sediment – Shoreline Areas

The excavation option would have higher implementation risks than the capping option in this area due to the potential for spreading contaminated sediments during removal and general risks associated with additional material handling that would be required.

6.7.7 Lagoon Confined Disposal Cells

Excavation with off-site disposal would have high implementation risks due to the large volume of sediment that would need to be removed and associated potential for spreading of contamination to adjacent areas during removal. It would be very difficult (if not technically impracticable) to remove the material without some release of contaminants to the lagoon.

6.8 REASONABLENESS OF COST

6.8.1 Upland Surface Soil – Process Plant Area

In-place capping is the lowest cost option for this area. Excavation and on-site containment is less costly than excavation and off-site disposal. The addition of treatment slightly increases the cost of the on-site containment option with a slight increase in long-term reliability.

6.8.2 Upland Surface Soil – Adjacent to Lagoon

Stabilization and in-place capping is significantly less costly than excavation with minimal increase in overall effectiveness considering the low levels and low mobility of contaminants present.

6.8.3 Breach Material Contained in Former Settling Pond Area

Excavation and off-site disposal would be significantly more costly than maintenance of the existing cap.

6.8.4 Groundwater – Adjacent to the Lagoon

Groundwater monitoring costs are relatively low, and considered by DEQ to be reasonable and consistent with the need to assess environmental conditions at the site.

6.8.5 Lagoon Surface Sediment – CAD/Breach Areas

Excavation options are significantly more costly than capping options. Excavation with off-site disposal is more costly than excavation with on-site disposal. Hot spot excavation is slightly more costly than complete excavation due to the need to cap residual contamination in the lagoon.

6.8.6 Lagoon Surface Sediment – Shoreline Areas

The excavation option is significantly more costly than capping options and the increased effectiveness over capping is uncertain due to the likely widely dispersed nature of material that is thought to be the source of the elevated pH.

6.8.7 Lagoon Confined Disposal Cells

Excavation with off-site disposal is extremely costly compared to maintenance of the existing caps.

6.9 HOT SPOTS

The definition of hot spots (OAR 340-122-0115(31)) is provided in Section 3.8. Hot spots at Ross Island result from the potential for contaminants to adversely impact the aquatic environment and potentially move up the food chain into fish that may be consumed by humans or wildlife. With the exception of contaminant levels present within the CAD cells, concentrations do not exceed levels that would be considered a hot spot for direct contact exposures for humans. The following areas met the criteria for hot spots: TBT-contaminated material confined in the former settling pond located south of the RISG processing plant, some of the contaminated surface sediments located in the vicinity of the CAD cells and breach areas of the lagoon, and the material confined within the CAD cells in the lagoon. The large volumes of material involved, the wide variety of contaminants present (which may require different types of treatment technologies), the accessibility of the material, and the high potential for releasing contamination during removal generally make treatment and removal options technically challenging and expensive for these areas. Given the high costs, implementation concerns, and risk of contaminant release associated with potential excavation in these areas, and the fact that protective and easily-implemented remedial options are available, DEQ has determined that hot spot removal is not warranted.

7. SELECTED REMEDIAL ACTION ALTERNATIVE

7.1 Selected Actions

Considering the evaluation of the alternatives provided in Section 6, the following remedial actions have been selected:

(1) Upland Surface Soil – Process Plant Area: Capping of contaminated soil.

Capping is the most straightforward and least costly option for this area, is easy to implement, has low implementation costs, and has high long-term reliability and effectiveness considering the low mobility of the contaminants present.

(2) Upland Surface Soil – Adjacent to Lagoon: Stabilization and capping.

Stabilization and in-place capping will be effective and is expected to have long-term reliability considering the low mobility of contaminants involved and the likely greater distance from the lagoon that will result from reclamation activities. This option has relatively low costs, is straightforward to implement, and has low implementation risks.

(3) Breach Material Contained in Former Settling Pond Area: Maintain existing cap.

Maintenance of the cap in this area will be effective and have long-term reliability considering the low mobility of TBT. This option has relatively low costs, is straightforward to implement and has no implementation risks.

(4) Groundwater – Adjacent to the Lagoon: Monitoring

Groundwater monitoring is straightforward to implement and has low implementation risks. Since the distance between the impacted groundwater and the discharge point in the lagoon is expected to increase, it is anticipated that any contamination confirmed to be present in groundwater in this area will attenuate to levels protective of receptors in the lagoon prior to discharge. This option has generally low costs and should effectively address potential risk.

(5) Lagoon Surface Sediment – CAD/Breach Areas: Capping

Capping elevated contamination detected in the surface sediments located in the vicinity of CAD cells and the breach will effectively achieve remedial action objectives by cutting off exposure pathways. This option is expected to be reliable over the long term considering the low mobility of the contaminants involved. It has low implementation risks and is the least costly option considered for this area.

(6) Lagoon Surface Sediment – Shoreline Areas: Capping

Capping shoreline areas where pH is elevated is expected to be effective in preventing exposures to benthic organisms. A final evaluation of the potential effectiveness of this option will be performed following evaluation of pilot studies that are now in progress. Removal of the sources of elevated pH may not be possible given the likely highly dispersed nature of those sources. Capping is easy to implement, has low implementation risks, and is the least costly of the options considered.

(7) Lagoon Confined Disposal Cells: Maintenance of existing caps

Based on the 1999/2000 study completed by the POP, the existing CAD cells are effectively isolating the contaminated material from the surrounding aquatic environment. Their study further indicated that the cells will likely be reliable over the long term. Maintaining and monitoring the effectiveness of the CADs is relatively straightforward to implement, has low implementation risk, and is much less costly than a removal option. Removal of the contaminated material would be highly risky considering the large volume of material that would need to be removed and the potential for spreading contaminated material during removal. Concerns over the potential for CAD material to be released as the result of a seismic event do not appear to outweigh the advantages of capping.

7.2 Description of Selected Options

The following sections describe the remedial actions that have been selected by DEQ for each of the Ross Island site areas where exceedances of RBCs have been identified.

(1) Upland Surface Soil – Process Plant Area: Capping of contaminated soil.

Additional sampling will be conducted to accurately define the extent of arsenic and zinc contamination in this area. Clean soil will be brought to the site and placed over the impacted area to a thickness of at least 3 feet. Institutional controls will be established to restrict future excavation or earthwork activities in this area. The maintenance and monitoring plan for the site will include periodic inspection and documentation of conditions of the cap. Assessment of the adequacy of the depth and nature of the capping material in isolating the contaminated material considering potential erosion that may occur as a result of precipitation and potential flooding events will be included as part of the long-term management. Annual reports on the monitoring results will be submitted to DEQ for review.

(2) Upland Surface Soil – Adjacent to Lagoon: Stabilization and capping.

An evaluation will be completed to determine the extent to which the Reclamation Plan will result in stabilization of this area. Additional stabilization requirements beyond those specified in the Reclamation Plan will be developed during remedial design and may include addition of stabilizing materials and reworking and vegetating upland slopes. Institutional controls will be established to restrict future excavation or earthwork activities in this area. The maintenance and monitoring plan for the site will include periodic inspection and documentation of conditions of the slope and cap, and require repair of the cap as necessary. Annual reports on the monitoring results will be submitted to DEQ for review.

(3) Breach Material Contained in Former Settling Pond Area: Maintain existing cap.

Institutional controls will be established to restrict future excavation or earthwork activities in this area. The maintenance and monitoring plan for the site will include periodic inspection and documentation of conditions of the cap. Annual reports on the monitoring results will be submitted to DEQ for review.

(4) Groundwater – Adjacent to the Lagoon: Monitoring

Up to three monitoring wells will be installed in the vicinity of or downgradient of investigation boring LB213. The maintenance and monitoring plan for the site will include periodic sampling and analysis of groundwater from these wells to assess whether PAH concentrations are attenuating to protective levels prior to discharge to the lagoon. Annual reports on the monitoring results will be submitted to DEQ for review.

(5) Lagoon Surface Sediment – CAD/Breach Areas: Capping

Clean soil will be imported to the site and placed over the sediment containing elevated concentrations of PAHs, metals, and PCBs in the southern portion of the lagoon. A minimum of three feet of clean soil will be placed in these areas. Institutional controls will be established to restrict activities that might disturb the cap. The maintenance and monitoring plan for the site will include periodic monitoring to evaluate the effectiveness of the cap and the adequacy of cap design (thickness and type of material used) in preventing migration of contaminants to the lagoon and eliminating exposure pathways to contaminants. Annual reports on the monitoring results will be submitted to DEQ for review.

(6) Lagoon Surface Sediment – Shoreline Areas: Capping

Clean soil will be imported to the site and placed in shoreline areas where elevated pH has been detected. The thickness and type of the cap material will be determined following completion of on-going pilot studies at the site but cap thickness is expected to be a minimum of three feet. The pilot studies will consider the need for soil amendments to buffer the pH. Institutional controls will be established to restrict activities that might disturb the cap in those areas. The maintenance and monitoring plan for the site will include periodic monitoring to evaluate the effectiveness of the cap in preventing exposure of benthic organisms to elevated pH. Annual reports on the monitoring results will be submitted to DEQ for review.

(7) Lagoon Confined Disposal Cells: Maintenance of existing caps

Clean fill material will be brought to the site and placed adjacent to the CADs to improve slope stability in this area. Institutional controls will be established to restrict future excavation or earthwork activities. The maintenance and monitoring plan for the site will include periodic monitoring to confirm that the cells remain effective in isolating contaminants from the surrounding aquatic environment. Annual reports on the monitoring results will be submitted to DEQ for review.

7.3 Periodic Reviews

A major component of the proposed remedial action for this site is the long-term monitoring and maintenance plan that will be developed and implemented. Because highly contaminated material will remain at the site under the selected option, long-term monitoring will be required for the foreseeable future to confirm that remedial action objectives continue to be met. The plan will include contingency measures should data indicate that implemented measures may be compromised and not as effective as expected. As more data is collected it is anticipated that a reduction in the frequency and intensity of effectiveness monitoring may be justified; however, some level of long-term monitoring will be required as long as contaminated material remains at the site. The long-term monitoring plan will be referenced and locations of contaminated material management areas will be identified in an Easement and Equitable Servitude document that will be filed with the property records.

DEQ will perform periodic reviews of the remedy to ensure that the remedial action remains protective of present and future public health, safety, and welfare, and the environment. Periodic reviews will be performed at least every 5 years from the date of the ROD and will include the evaluation of site monitoring data, progress reports, inspection and maintenance reports, land and beneficial water uses for the site and site vicinity, compliance with institutional controls, and any other relevant information. Monitoring data will be evaluated on an annual basis to confirm that the established remedial action objectives for the site are being attained and that the monitoring program is adequate. Once the selected remedial action has been implemented, DEQ will prepare a Consent Order for RISG to cover DEQ oversight of long-term monitoring and 5-year reviews.

8. PUBLIC NOTICE AND COMMENT

DEQ's notice of the proposed remedial action was published on October 1, 2005 in the Secretary of State's Bulletin and The Oregonian. Copies of the Staff Report for Proposed Remedial Action, and other documents that make up the Administrative Record were made available for public review at DEQ's Northwest Region office in Portland, Portland's Main and Sellwood public libraries, and DEQ's web page. DEQ presented an overview of the proposed remedial action at a "brown bag" public forum sponsored by the City of Portland's River Renaissance Program on October 11, 2005 and at a regular meeting of the Brooklyn Neighborhood Action Corps on November 16, 2005. The public comment period began October 1 and ended October 31, 2005; however, DEQ postponed finalizing the decision on remedial action until after November 16 to allow consideration of any input received during the Brooklyn neighborhood meeting.

No written comments on the proposed remedial action were received. During the River Renaissance presentation and discussion, one member of the public expressed concern that contaminated material would be managed in or near a water body due to the instability generated by the actively flowing river and sensitive environment that would be impacted should the cap fail. For several reasons listed below, DEQ believes that capping contaminated sediments is a viable option at Ross Island and, in fact reflects the best option for dealing with the existing contamination.

1. The types of contaminants present at Ross Island are not highly mobile. The contaminants consist of metals, PCBs, PAHs, and TBT, which tend to adhere to sediment particles and not dissolve and move in the water column to the degree that would present a concern. There are no reservoirs of "free product" which could be mobilized in a significant seismic or erosional event. The Port of Portland investigation of the CADs confirmed this by sampling groundwater within the confined material and monitoring the water that moved through the caps and into the lagoon.

2. Excavation of contaminated material present at Ross Island presents significant risks of spreading contamination that is currently stable as a result of invasive excavation techniques and the need to transport contaminated material up through, in some cases, up to 80 feet of water column.

3. The reclamation required at the site is bringing large volumes of suitable capping material to the site. Removing large volumes of material would set back the time frame for achieving reclamation goals.

4. The most contaminated material present at the site, the contaminated material within the CADs, is already capped by up to 20 feet of sediment. The need to remove this material to access the contaminated material would have short term impacts on turbidity in addition to potentially spreading contamination as the confined material was removed.

5. Finally, the Ross Island Lagoon is a relatively calm environment hydraulically due to the fact that it is surrounded by Ross and Hardtack Islands and the dike that was constructed between them. It is not directly subjected to the river flow and associated erosion of cap material that this could cause.

DEQ has also considered data on other capping projects completed throughout the country that have demonstrated long term effectiveness of caps in aquatic environments for contamination similar to that present at Ross Island. DEQ recognizes however the heightened importance of long term management of the confined material at this location and will ensure adequate long-term monitoring be conducted to evaluate the effectiveness of the caps in isolating the contaminants from the aquatic environment.

No other comments were received on the proposal.

9. DOCUMENTATION OF SIGNIFICANT CHANGE

No substantive changes were made in the descriptions of the selected remedies from the descriptions that appeared in the staff report. However, further clarification on volumes of cap material that would be required to meet reclamation specifications and the volume of additional cap material required to ensure adequate containment has been provided. This effects the documentation of cap volumes and associated costs for the selected remedial actions for upland soil in shoreline areas, surface sediment in the vicinity of the CADs, and surface sediment in the shoreline areas. The staff report presented volumes and costs for material required in excess of the material that would be required for reclamation. This document indicates the total capping volume required along with the volume that would be required for reclamation. Costs reflect estimated total costs of the material required to provide an adequate cap regardless of whether it is also required for reclamation.

These changes are considered significant but reflect more of a clarification rather than a substantive change to the options presented in the Staff Report. Additional public review and comment was determined to be unnecessary.

10. STATUTORY DETERMINATIONS

The selected remedial actions for the Ross Island site are protective, and reflect the best balance of trade-offs considering treatment of hot spots, effectiveness, long-term reliability, implementability, implementation risk and reasonableness of cost. Performance monitoring will provide the basis for DEQ's final determination of whether additional cleanup action is necessary. The selected action, therefore satisfies the requirements of ORS 465.314 and OAR 340-122-0090.

11. SIGNATURE

Dick Pedersen, Administrator Date
Northwest Region, Department of Environmental Quality

12. ADMINISTRATIVE RECORD INDEX

ROSS ISLAND SAND AND GRAVEL
Portland, Oregon

The Administrative Record consists of the documents on which the proposed remedial action for the site is based. The primary documents used in evaluating remedial action alternatives for the Ross Island site are listed below. Additional background and supporting information can be found in the Ross Island project file located at DEQ Northwest Region Office, 2020 SW 4th Ave., Portland, Oregon.

SITE-SPECIFIC DOCUMENTS

Baseline Sediment Characterization, In-Water Clear Zone Sampling Results, Ross Island Lagoon, Prepared by Landau Associates, January 2000.

Beneficial Water Use Determination, Ross Island Sand and Gravel Co. – Technical Memorandum prepared by Landau Associates, May 2000.

Biological Assessment, Ross Isalnd Sand and Gravel Company Removal/Fill Permit Renewal. Prepared by CH2M Hill, November 1999.

Consent Order between DEQ and Ross Island Sand and Gravel, WMCVC-NWR-99-09, dated November 9, 1999.

Ecological Survey, Fall 1999 and Spring 2000, Ross Island Sand and Gravel, Prepared by Landau Associates, November 2000.

Feasibility Study – Ross Island Sand and Gravel Co., Portland, OR. Prepared by GeoDesign, August 2005.

Feasibility Study Addendum – Ross Island Sand and Gravel Co., Portland, OR. Prepared by GeoDesign, October 2005.

Quarterly Groundwater Monitoring Progress Reports, Water Pollution Control Facilities Permit No. 101782, Ross Island Sand and Gravel Co., Hardtack Island Facility, Prepared by Landau Associates, 2000-2002, prepared by GeoDesign 2002 – 2005.

Remedial Investigation- Phase I, Ross Island Sand and Gravel Co., Prepared by Landau

Associates, September 2000.

Remedial Investigation/Risk Assessment – Ross Island Sand and Gravel Co. Portland, OR. Prepared by Landau Associates, October 2002.

Ross Island Reclamation Plan. Prepared by Landau Associates, Pacific Habitat Services, Inc., Pam Wiley, September 2002.

Sediment Cap Breach Repair Completion, Ross Island Sand and Gravel Co., Prepared by Landau Associates, October 1999.

Settling Pond Dredge Material and Land Farm Area Sampling – Technical Memorandum prepared by Landau Associates, October 2001.

Settling Pond Investigation, Ross Island Sand and Gravel Co., Prepared by Landau Associates, December 2001.

Site Investigation Report - Final, Port of Portland Confined Dredged Material Disposal, Ross Island Facility, Portland, OR. Prepared by HartCrowser, November 2000.

STATE OF OREGON

Oregon's Environmental Cleanup Laws, Oregon Revised Statutes 465.200-.900, as amended by the Oregon Legislature in 1995.

Oregon's Hazardous Substance Remedial Action Rules, Oregon Administrative Rules, Chapter 340, Division 122, adopted by the Environmental Quality Commission in 1997.

GUIDANCE AND TECHNICAL INFORMATION

DEQ. Guidance for Conducting Feasibility Studies. July 1998.

DEQ. Guidance for Identification of Hot Spots. April 1998.

USEPA. Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA. Office of Emergency and Remedial Response. OSWER Directive 9355.3-01. October 1988.