FINAL WEST DOANE LAKE
ENGINEERING EVALUATION/COST ANALYSIS
RP - PORTLAND SITE

February 12, 2009

Submitted to:

Oregon Department of Environmental Quality
Northwest Region
2020 S.W. 4th Avenue
Portland, Oregon 97201

Submitted for:

SLLI
55 Corporate Drive
Bridgewater, NJ 08807-0800

Submitted by:

AMEC Earth & Environmental, Inc.
7376 S.W. Durham Road
Portland, Oregon 97224

0-61M-107030/Phase 0700/T4

February 12, 2009

0-61M-107030/Phase 0700/T4

Mr. David Lacey
Oregon Department of Environmental Quality
2020 S.W. 4th Avenue
Portland, Oregon 97201

Dear Dave:

**Re: Final West Doane Lake Engineering Evaluation/Cost Analysis
RP – Portland Site**

AMEC Earth & Environmental, Inc. (AMEC) is submitting this Final West Doane Lake Engineering Evaluation/Cost Analysis (WDL EE/CA) to the Oregon Department of Environmental Quality (DEQ) on behalf of SLLI. The purpose of this EE/CA is to aid in the selection of an appropriate Interim Remedial Action Measure (IRAM) to mitigate direct human and ecological contact with WDL surface water and sediment, and to reduce or eliminate potential leaching of constituents of interest (COIs) from WDL sediment to groundwater. This EE/CA presents a site-specific evaluation of several remedial technologies that were considered for use as part of the IRAM for WDL and, through the EE/CA screening process, evaluates a number of specific remedial alternatives, including in-situ solidification/stabilization (ISS) of WDL sediments, and sediment removal and off-site disposal scenarios.

This Final EE/CA has been submitted to address DEQ comments expressed in two letters dated November 28, 2007 and March 19, 2008. Specifically, DEQ requested additional treatability study (TS) testing to "demonstrate effective treatment and stabilization" in its March 19, 2008 letter. Since then, SLLI has conducted two additional phases of TS testing, in accordance with the WDL Phase 5 TS Work Plan (WP) and WDL Phase 5 TS WP Addendum, as approved by DEQ via a letter on August 8, 2008, and e-mail approvals on August 18 and 20, 2008.

Throughout the completion of the additional TS testing, and preparation of the Revised Draft EE/CA, SLLI has attended technical progress meetings with DEQ on multiple occasions to discuss the scope and results of the TS testing and the EE/CA document. At these meetings, SLLI reached agreement with DEQ on a few topics, including the following:

- Evaluation of excavation as a remedial alternative is narrowed to a single excavation method for the detailed analysis of remedial alternatives. All other methods are eliminated on the basis of implementability or cost. This was discussed at the October 9 and November 4, 2008 meetings.
- DEQ indicated it generally agreed with the conceptual site model for WDL as expressed in the 1D BIOSCREEN model, during the November 4 meeting.

However, a number of other topics remain unresolved. Specifically:

- SLLI has not received any feedback from DEQ on the Revised WDL Geotechnical Investigation Report, submitted on October 3, 2008, beyond the verbal discussions and feedback offered by Ash Creek Associates at the October 9, 2008 meeting;
- SLLI also has not received any specific feedback from DEQ regarding the inputs for the BIOSCREEN model, beyond their general agreement with the WDL CSM, as mentioned above; and
- SLLI has not received any feedback from DEQ regarding the incorporation of an on-site containment facility (OCF) into a remedial alternative, beyond the discussions of the November 4, 2008 meeting. SLLI's position, expressed at this meeting, is that an OCF cannot be evaluated as part of the EE/CA at this time because a number of key assumptions would have to be made, for which DEQ has yet to provide any input regarding the viability of those assumptions. SLLI has addressed an OCF in the EE/CA as one of two disposal options, but has eliminated any on-site options because of the associated uncertainty.

Finally, SLLI has addressed the request in DEQ's December 10, 2008 letter (December 10 letter) regarding updates to the WDL screening criteria. In accordance with the December 10 letter, and follow-up correspondence on January 13, 2009 to clarify SLLI's questions about the December 10 letter, SLLI has updated the screening values used to evaluate the results of the TS. SLLI does not necessarily agree with the application of the all the values, but is willing to use these values to evaluate the TS results. SLLI does not consider these screening values to be cleanup criteria for the WDL IRAM, nor does SLLI believe these values are applicable to other potential IRAMs or final remedies for the RP - Portland Site.

As stated in the conclusions section of this EE/CA, the ISS Alternative 2 was selected on the basis of its protectiveness, including its ability to immediately achieve all remedial action objectives (RAOs) upon completion of implementation. ISS is considered effective based on the TS results because non-aqueous phase liquid (NAPL) is both physically and chemically bound during stabilization, and because leaching to groundwater is minimized to levels that do not present unacceptable risks to either WDL or NDL receptors at their respective exposure points. The TS results also demonstrate that ISS will be reliable over the long term. ISS is the most readily implementable alternative having the lowest implementation risk. Finally, the cost for implementation of ISS is considered to be the most reasonable given its protectiveness, effectiveness, good long-term reliability, implementability, and low implementation risk.

Implementation of the WDL IRAM is currently planned in 2009, based on the assumption that the remedial alternative (Alternative 2) recommended in this EE/CA is approved by DEQ by Spring 2009. Construction of the remedy would take approximately 6 months following 2 months of site preparation, for an estimated completion in Winter 2010. DEQ, in an e-mail dated January 26, 2009, has expressed their opinion that review, approval and public notifications need to commence as quickly as possible. Based on discussions at the January 22, 2009 meeting, SLLI's understanding is that DEQ will consider utilizing a public notice process or press release process to support SLLI in achieving this schedule in order to reduce risk at this Site. SLLI is committed to working with DEQ to achieve this schedule.

Please find enclosed two bound copies and a compact disc containing a Portable Document Format file (PDF) of this Draft Revised WDL EE/CA. If you should have any questions, please call Roger Gresh at 503-639-3400.

Sincerely,

AMEC Earth & Environmental, Inc.

Christopher R. Poulsen, P.E.
Associate Engineer

Michelle L. Peterson, R.G.
Associate Geologist

REGISTERED PROFESSIONAL
OREGON
MICHELLE L. PETERSON
#G1656
GEOLOGIST

Roger T. Gresh, P.G.
Project Manager

Attachments

MLP/lp

c: S. Dearden, sanofi-aventis US, Inc.
R. Ferguson, SLLI
J. Benedict, CHBH&L
K. Koch, EPA

REGISTERED PROFESSIONAL
ENGINEER
77384
OREGON
SEPT. 15, 2005
CHRISTOPHER R. POULSEN
EXPIRATION DATE: 12.31.2010

Table of Contents

Page

List of Tables

List of Figures

List of Attachments

LIST OF ACRONYMS AND ABBREVIATIONS

AMEC	AMEC Earth & Environmental, Inc.
amsl	above mean sea level
ANSI	American National Standards Institute
AOC	area of concern
Alluvium Zone	Alluvium Hydrogeologic Zone
ARAR	Applicable Relevant and Appropriate Requirement
AS	air sparging
Atlas	Atlas Building Wreckers
Basalt	Basalt Geologic Zone
Basalt Zone	Basalt Hydrogeologic Zone
BES	Bureau of Environmental Services
bgs	below ground surface
BMP	Best Management Practice
BNSF	BNSF Railway Company
bmsl	below mean sea level
bwsi	below water sediment interface
CAMU	Corrective Action Management Unit
CDF	controlled density fill
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm/s	centimeters per second
COI	constituent of interest
COP	City of Portland
COPC	constituent of potential concern
CPT	cone penetration test
CSM	conceptual site model
CWA	Clean Water Act

cy	cubic yard
DAG	Deep Alluvial Gravel
DCB	1,2-dichlorobenzene
2,4-D	2,4-Dichlorophenoxyacetic acid
DEQ	Oregon Department of Environmental Quality
DGZ	Deep Gravel Hydrogeologic Zone
DMT	flat plate dilatometer
DSL	Oregon Department of State Lands
DMMP	dredged materials management program
EDL	East Doane Lake
EE/CA	Engineering Evaluation/Cost Analysis
ELT	elutriate leach test
EPA	United States Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
ESCO	ESCO Corporation
FEM	finite element computer modeling
Fill Zone	Fill Hydrogeologic Zone
FS	Feasibility Study
ft	feet or foot
ft/ft	feet per foot
GAC	granular activated carbon
GCL	geosynthetic clay liner
Gould	Gould Electronics
HA	Herbicide Area
HDPE	high-density polyethylene
HHRA	human health risk assessment
IA	Insecticide Area
ID	identification

IHc	Heavy Industrial with environmental conservation overlay
IRAM	Interim Remedial Action Measure
ISCM	Interim Source Control Measure
ISS	in-situ solidification/stabilization
LA	Lake Area
LADD	Lake Area Drainage Ditch
lf	linear feet
LTM	long-term monitoring
MDL	method detection limit
MGP	manufactured gas plant
mm	millimeter
MNA	monitored natural attenuation
NAPL	nonaqueous phase liquid
NAS	National Academy of Sciences
NDL	North Doane Lake
NFA	Northwest Front Avenue
NPDES	National Pollutant Discharge Elimination System
NWN	Northwest Natural
OAR	Oregon Administrative Rule
OCF	on-site containment facility
ODFW	Oregon Department of Fish and Wildlife
ODWR	Oregon Department of Water Resources
O&M	operation and maintenance
OPC	organophilic clay
ORS	Oregon Revised Statutes
OSHA	Occupational Safety and Health Administration
PAH	polynuclear aromatic hydrocarbon
PCBs	polychlorinated biphenyls
PCOPC	potential constituent of potential concern

PEL	permissible exposure limit
1,2,3,7,8-PeCDD	1,2,3,7,8-Pentachlorodibenzo-p-Dioxin
2,3,4,7,8-PeCDF	2,3,4,7,8-Pentachlorodibenzofuran
PPE	personal protective equipment
psi	pounds per square inch
%	percent
QC/QA	Quality Control/Quality Assurance
RAOs	Remedial Action Objectives
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
River	Willamette River
RIWP	Remedial Investigation Work Plan
ROD	Record of Decision
RP	Rhône-Poulenc
RRI	Remaining Remedial Investigation
SBLT	sequential batch leach test
SCE	Source Control Evaluation
Schnitzer	Schnitzer Investment Corporation
Siltronic	Siltronic Corporation
Site	RP Portland Site
SLV	screening level value
sq/ft	square feet
S/S	solidification/stabilization
SVOC	semivolatile organic compound
SVE	soil vapor extraction
2,3,7,8 TCDD	2,3,7,8-Tetrachlorodibenzo-p-Dioxin
TCLP	Toxicity Characterization Leaching Procedure
TPH	total petroleum hydrocarbon

TS	Treatability Study
TSD	treatment, storage, and disposal facility
UCS	unconfined compressive strength
USACE	United States Army Corps of Engineers
UV	ultraviolet
WDL	West Doane Lake
WP	work plan
WTP	water treatment plant
VOCs	volatile organic compounds

EXECUTIVE SUMMARY

AMEC Earth & Environmental, Inc. (AMEC) has prepared this Final West Doane Lake (WDL) Engineering Evaluation/Cost Analysis (EE/CA), on behalf of SLLI for the Rhône-Poulenc (RP) Portland Site (Site), as requested by the Oregon Department of Environmental Quality (DEQ) in its November 28, 2007, and March 19, 2008, comment letters to SLLI regarding the original Draft WDL EE/CA which was dated September 11, 2007. This document incorporates the results of six technical meetings conducted between DEQ and SLLI in 2008 regarding the WDL Interim Remedial Action Measure (IRAM), along with technical documentation associated with follow-ups to those meetings. This EE/CA also includes, as attachments, the Final WDL Treatability Study (TS) Report (Attachment 1) and the Revised WDL Geotechnical Investigation Report (Attachment 2). Each of these attached reports support of the conclusions reached by this EE/CA, and each is summarized below in this Executive Summary, as well as in Sections 3.2.4 and 3.2.5, respectively.

This Executive Summary includes sections relating to the Remedial Action Objectives and Screening Criteria; the WDL TS; the WDL Geotechnical Investigation; the WDL Conceptual Site Model; the Remedial Technology Evaluation, Alternative Development, and Analysis; the Recommended Remedial Alternative; and the Implementation Schedule.

The purpose of the EE/CA is to aid in the selection of an appropriate IRAM to mitigate direct human and ecological contact with WDL surface water and sediment, and to reduce or eliminate potential leaching of constituents of interest (COIs) from WDL sediment to groundwater. This EE/CA presents a site-specific evaluation of several remedial technologies that were considered for use as part of the IRAM for WDL and, through the EE/CA screening process, evaluates a number of specific remedial alternatives, including in-situ solidification/stabilization (ISS) of WDL sediments, and sediment removal and off-site disposal scenarios.

WDL COIs consist of volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), chlorinated herbicides, organochlorine insecticide, metals, dioxins/furans, and polychlorinated biphenyls (PCBs). The WDL IRAM will address impacted sediment within the WDL water body to a depth of 12 feet below the water/sediment interface (bwsi). This implementation depth has been selected to address the zone of impacted soils observed to approximately 11 feet bwsi during multiple WDL investigations, and to address the zone in which the maximum concentrations of COIs have been identified, between approximately 4 to 8 feet below the bwsi. The basis for this configuration is summarized below, under the heading WDL Conceptual Site Model, and is presented in detail in Sections 3 and 4 of this EE/CA.

The WDL IRAM is one interim action which serves as a cornerstone to additional remedial actions at the Site. Following completion of the WDL IRAM, a subsequent step of the Site-wide remedy is containment of the primary source area on RP property to mitigate ongoing constituent migration in groundwater. At this point, a slurry wall is envisioned to meet the remedial action objectives (RAOs) associated with source area containment. The footprint of WDL overlaps the currently delineated primary source area. However, impacted WDL sediments are shallow and occur only to a depth of approximately 11 feet bwsi. Thus, WDL remediation is necessary prior to implementation of the slurry wall for two reasons: 1) to provide a solid working platform for slurry wall installation in the WDL vicinity, and 2) to prevent the pushing/spreading of impacted "liquid-like" WDL sediments deeper into the soil column during slurry wall installation.

The final steps in the Site-wide remedy are intended to eliminate infiltration of stormwater and risk from direct contact with shallow soils by capping the RP property (the RP property cap in the Lake Area [LA] would tie into the WDL cap), and to determine the need for remedy in North Doane Lake (NDL).

Additional remedial actions in the form of Interim Source Control Measures (ISCMs) are also anticipated to be implemented at the RP property and adjacent properties as outlined in the Draft Source Control Evaluation Report (AMEC, 2008a) for the Source Control Program. These include hydraulic control of RP constituents in deep groundwater near NW Front Avenue (NFA) and eliminating discharge of shallow groundwater into the City of Portland (COP) Outfall 22B storm sewer. Preliminary activities for both these measures already are in progress.

Remedial Action Objectives and Screening Criteria

The RAOs identified for the WDL IRAM are:

1. Minimize or eliminate direct human exposure to WDL COIs in surface water/sediment.
2. Minimize or eliminate direct ecological receptor exposure to WDL COIs in surface water/sediment.
3. Reduce the potential for WDL COIs to migrate from sediment to groundwater at concentrations greater than screening or performance criteria (Section 5.2), where human receptors, such as a future excavation worker, may potentially be exposed.
4. Reduce the potential for WDL sediment to serve as a source of COIs that potentially could leach to groundwater above the screening or performance criteria

and discharge to the Willamette River (River), where potential exposures to human and ecological receptors may occur.

5. Reduce the potential for WDL sediment to serve as a source of COIs that potentially could leach to groundwater above the screening or performance criteria and discharge into NDL, where potential exposure to human and ecological receptors may occur.

In order to aid evaluation of the effectiveness of remedial technologies in achieving these RAOs, a set of screening and performance criteria for application to any COIs that might leach from WDL sediments into groundwater after completion of the remedial action was developed. For the WDL IRAM, the post-remedy potential human receptors are:

- An excavation worker contacting groundwater adjacent to or downgradient of the WDL monolith during possible future utility excavation activities;
- Trespassers at NDL or fishermen along the River exposed via the consumption of fish from these water bodies to WDL COIs hypothetically migrating from WDL in groundwater; and
- Ecological receptors residing in NDL or the River or using NDL or the River for feeding or drinking that are exposed to WDL COIs hypothetically migrating from WDL in groundwater.

Screening criteria that are protective of NDL will be protective of water bodies farther downgradient, including the River.

Site-specific risk-based concentrations (RBCs) for an excavation worker in contact with leachate from the solidified WDL monolith were developed in accordance with current DEQ guidance. SLLI initially presented to DEQ a list of ecological screening level values (SLVs) consisting of chronic toxicity values obtained from federal and state guidance, peer-reviewed literature, and regulatory documents and bioaccumulation SLVs consisting of DEQ ambient water quality criteria (AWQC) values for constituents considered bioaccumulative in the Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment (DEQ, 2007). SLVs were not available for all chlorinated herbicides. In order to provide screening criteria for these analytes, AMEC consulted peer-reviewed literature and regulatory documents, including EPA Re-registration Eligibility Decisions (REDs) for current-use herbicides, for available chronic toxicity data. The most conservative available no-observed-effect concentration (NOEC) or lowest observed-effect concentration (LOEC) for algae, aquatic macrophytes, aquatic invertebrates, or fish was selected for use as an ecological SLV.

In a December 10, 2008 letter to SLLI (DEQ, 2008b), DEQ requested that several of the proposed ecological SLVs be updated with values from additional sources and that selected metal SLVs be adjusted for hardness of 25 mg/L, which is the general hardness of the River. On January 13, 2009, DEQ provided a response letter (DEQ, 2009) to clarify some discrepancies SLLI had identified in the values presented in the December 10, 2008 letter. SLLI added the updated and clarified values presented in the December and January letters from DEQ to the WDL TS screening criteria (Table 1), and these values were used to screen TS results.

Per the December 10, 2008 letter (DEQ, 2008b), SLLI prepared a list of constituents detected in the fish tissue evaluated for the Draft North Doane Lake Baseline HHRA (AMEC, 2008c). To obtain applicable bioaccumulation SLVs for the NDL exposure point, SLLI selected DEQ AWQC values that assume a subsistence fish ingestion rate of 175 grams per day (g/day) for the constituents detected in NDL fish tissue. DEQ directed SLLI to use formulas presented in the Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment (DEQ, 2007) to calculate screening levels for the analytes detected in NDL fish tissue. The formulas presented in the guidance are sediment-specific and do not allow for calculation of aqueous SLVs.

SLLI does not agree with the application of all screening criteria, as directed by DEQ, but SLLI is willing to use these values to screen the TS results. SLLI does not consider these screening values to be cleanup criteria for the WDL IRAM, and notes that actual cleanup criteria are typically one to two orders of magnitude greater than conservatively applied screening values.

The exposure point for ecological receptors and a trespasser consuming fish is at the edge of NDL nearest to WDL instead of the WDL monolith. To evaluate potential unacceptable risk at NDL from inorganic COIs that may leach from stabilized sediment, SLLI compared the metals detected in Mix I leachate that exceed SLVs at the monolith to the following three sets of analytical results: (1) untreated sediment leachate, (2) groundwater from wells surrounding WDL, and (3) to current conditions at NDL (Section 13.3.1 of Attachment 1). For organic analytes that exceed their respective SLVs in Mix I leachate, the 1-dimensional transport model described in Section 13.3.2 of Attachment 1 was used to calculate an exposure point concentration at NDL. The calculated exposure point concentration was compared with the ecological and bioaccumulation SLVs to determine if there could be an unacceptable potential exposure from post-stabilization leachate.

WDL Treatability Study

The first step in evaluating an ISS remedy for WDL sediments was performance of a TS to determine baseline conditions and select/optimize various mix designs for solidification and stabilization. The WDL TS was conducted in multiple, progressively refined phases to evaluate whether ISS of WDL sediments represents a feasible IRAM technology for WDL.

The WDL TS was completed in six separate phases of work, consisting of three sediment sampling phases and four bench-scale TS phases (one TS phase included both sampling and TS). The phases were designed to physically and chemically characterize WDL sediment and to determine which additives or combination of additives was best suited for ISS of WDL sediments. Additives tested consisted of Portland cement, fly ash, pozzolans, bentonite clay, granular activated carbon (GAC), and organophilic clay. The additives tested and the compositions of the mixes tested (A through I) are summarized in the table below.

Treatability Study Phase	Mix ID	Additives to Sediment by % Volume					
		Portland cement	Zeolite	Fly Ash	Bentonite	OPC	GAC
Phase 3	A	10	0	0	5	0	0
	B	10	0	10	5	0	0
	C	10	0	0	10	0	0
	D	20	0	10	10	0	0
Phase 4	E (Mix A plus carbon)	10	0	0	5	0	1
Phase 5	E (Same as Phase 4)	10	0	0	5	0	1
	F	5	5	0	0	5	5
	G	5	5	0	5	0	0
	H	2.5	2.5	0	10	0	0
Phase 6	I	20	0	0	5	5	5

Treated Mixes A through I underwent physical testing including unconfined compressive strength (UCS), hydraulic conductivity, wet/dry durability, and moisture content to evaluate whether the mix effectively solidified WDL sediment, including sediments containing non-aqueous phase liquid (NAPL). Additionally, treated Mixes A through I underwent laboratory leaching simulations (Section 8 of TS, Attachment 1), with the leachate subsequently tested by various chemical analyses to evaluate the potential for leaching of COIs from a solidified WDL monolith. Mix I results indicate a substantial reduction in leachability of COIs from all analyte classes when compared to untreated sediments.

Current hydrogeologic conditions do not support groundwater transport of COIs from WDL to NDL, based on water level data. These conditions are not expected to change after stabilization of WDL sediments. Therefore, COIs detected in WDL leachate will not contribute unacceptable risk at NDL post-stabilization. However, as a conservative approach, SLLI evaluated the hypothetical transport of inorganic and organic COIs in Mix I leachate that exceed SLVs to NDL.

Constituent concentrations in leachate prepared using the stabilized WDL sediment were compared to potentially applicable risk-based levels for human and ecological receptors. The exposure scenario considered for site-specific risk-based concentrations protective of human health through direct contact with groundwater is an excavation worker in contact with leachate from the solidified WDL monolith. As discussed in Section 13 and presented in Table 19 of the Final WDL TS Report (Attachment 1), leachate concentrations from sediment stabilized with Mix I were evaluated. This evaluation shows that concentrations of COIs in post-stabilization leachate were less than the applicable human health screening values for direct contact.

The exposure point for evaluation of stabilization performance in terms of bioaccumulation and ecological screening values is inside NDL, and not adjacent to the solidified WDL monolith. Although some constituents were present in leachate from the stabilized sediment at levels that exceed ecological or bioaccumulation-based screening values at the stabilized WDL monolith, further evaluation reveals that;

1. The leachability of inorganics is substantially reduced for all metals not commonly associated with Portland cement. Treatability study results indicate that inorganic material that may leach from stabilized WDL sediment is not likely to contribute to unacceptable risk to human or ecological receptors in NDL. Additionally, the post-stabilization leachate concentrations of most metals are less than or comparable to concentrations detected in groundwater from unimpacted upgradient monitoring well RP-05-47. Therefore, Mix I is considered protective of NDL and should be considered an effective IRAM for stabilizing inorganic constituents in WDL sediments (Section 13.3.1 and Table 19 of Attachment 1); and

2. All organic constituent concentrations exceeding SLVs in Mix I leachate are less than their respective SLVs when input into the BIOSCREEN model under representative conditions for a biodegradation scenario. Therefore, Mix I is considered protective of NDL and should be considered an effective IRAM for stabilizing organic constituents in WDL sediments (Section 13.3.2 and Table 19 of Attachment 1).

The desired outcomes of ISS of WDL sediment include increasing the strength and geotechnical stability of WDL sediments, decreasing permeability, and decreasing leachability for the maximum number of COIs from all WDL sediments, including those bearing NAPL. The TS results demonstrate that ISS using the Mix I design is protective of an excavation worker at the WDL monolith, ecological receptors at NDL, and human receptors consuming fish from NDL or from the River. The final mix design consists of 20% Portland cement to provide strength and stabilize metals and nonionizable organics (e.g., PCBs and dioxin/furans), 5% bentonite to decrease permeability, and 10% adsorbents (OPC and GAC) to stabilize ionizable organics (e.g., herbicides).

ISS of WDL sediments using Mix I represents a substantial improvement over current conditions. ISS of WDL sediments using this treatment mix will be protective of potential receptors for all organic COIs and all inorganic COIs, except potentially for calcium, barium, and aluminum, which are attributable to the Portland cement in the mix. The ISS monolith exceeds the permeability objective to minimize leaching, and the Portland cement and adsorptive additives will immobilize constituents, including those originally present as NAPL prior to treatment.

Post-remedy, the permeability of the stabilized WDL monolith will be two orders of magnitude less than the surrounding fill or embankment material, which will cause groundwater to flow around the monolith. In the long-term, the constituent release from the WDL monolith will be negligible because the monolith’s extremely low permeability essentially eliminates movement of water through the monolith. Therefore, the release of COIs via leaching also will be essentially eliminated. The only remaining release mechanism is diffusion through the solid, and across the solid-liquid interface, rather than active transport. Flux release from diffusion will be insignificant as this process is controlled by the physical characteristics of the monolith, such as its hydraulic conductivity and temperature; physical and chemical properties of each COI, such as size, affinity for sorption to other particles, and other chemical specific properties. All of these properties limit the depth to which diffusive transport is able to penetrate the monolith. The product of ISS, as described by these TS results, is a monolith that has been specifically designed to minimize and/or eliminate the physical and chemical processes that currently allow for COI release from sediments at WDL.

WDL Geotechnical Investigation

A geotechnical investigation was completed to evaluate the effects of various WDL remedy components on the stability of the BNSF Railway Company (BNSF) embankment. The scope of the geotechnical investigation included: literature review of previous reports and historic documentation; site reconnaissance; geophysical investigations; field data collection consisting of the completion of 8 cone penetration test (CPT) soundings, 2 flat plate dilatometer (DMT) soundings, 3 mud-rotary borings, and 1 sonic boring; a laboratory program; and settlement analysis using traditional settlement calculations and finite element computer modeling (FEM).

The conclusions reached as a result of the geotechnical investigation indicate that the proposed fill at WDL will cause relatively insignificant settlements beneath the crest of the BNSF embankment, with somewhat greater settlements at the toe of the BNSF embankment and the center of WDL. Settlements at the crest of the BNSF embankment are expected to range from 2.9 to 4.9 inches following the final remedy, with most of the settlement occurring over a period of 15 days to 21 months. Settlements at the toe of the BNSF embankment are expected to range from 10 to 21 inches. The potential settlement differential between the crest and the toe of the BNSF embankment may cause additional embankment cracking or may exacerbate the existing cracks in the embankment.

In contrast, finite FEM and slope stability analysis indicate that dewatering of the embankment and/or excavation of unsolidified lake sediments at the toe of the railroad embankment would create unacceptable risks to the railroad embankment. Dewatering alone, which would be necessary to affect any successful unsupported excavation and replacement operation, would result in slope stability factors of safety below 1, imposing unallowable risk to property and public safety (e.g., Amtrak trains on the embankment). Removal of sediments further increases the risk via three significant pathways: 1) additional slope failures; 2) differential settlements; and 3) heaving of lake sediments, most likely undermining the embankment. Additional information on this topic can be found in Section 4.2.2 and Attachment 2.

It is expected that any potential settlement of the railway at the crest of the embankment associated with an ISS remedy for WDL can be mitigated through the implementation of a settlement monitoring program and through routine railway maintenance prior to, during, and following construction. Overall, FEM calculations indicate that the proposed ISS remedy will help stabilize the embankment slope, though some minor sloughing of the slope may occur following construction.

WDL Conceptual Site Model

The findings of all the investigations completed at WDL indicate its sediments are primarily comprised of very soft to soft, black to gray, silts and silty sands. Permeability test results indicate a range from 10^{-7} to 10^{-8} cm/sec for particle sizes ranging from clayey sands to high plasticity silts. Coarse materials, believed to have sloughed off the railroad embankment, were often encountered on the northern edge of WDL where borings were advanced very close to the BNSF embankment. Black and gray sands, believed to be foundry sands from the ESCO Corporation (ESCO) property, are generally only encountered in borings completed in the northern half of WDL which is adjacent to ESCO property. The maximum depth beneath the sediment/water interface in WDL where impacted sediment was visually observed is approximately 11 feet. The total depth explored beneath WDL is 20 feet bwsi.

Most impacted sediments are located at the southern end of the lake. Discontinuous NAPL inclusions (“blebs”) were observed in multiple borings completed within the southern 75 feet of WDL. NAPL was observed between approximately 3 and 11 feet bwsi in three locations.

The highest concentrations of most COIs were detected in bulk sediment samples collected in the southern portion of WDL. Selected metals exhibit maximum concentrations in sediments collected from the northern half of WDL, consistent with the presence of foundry sands in this portion of WDL. Maximum constituent concentrations are typically found in samples collected from depths of 4 to 8 feet bwsi.

Debris is observed on the eastern edge of WDL in the LA from historical filling activities conducted within the former Doane Lake. Debris types observed to date includes brick, gravel, wire, concrete, and battery casings. Similar debris may be present within WDL sediments and is believed to be the cause of periodic drilling refusals during WDL subsurface investigations.

The most relevant geologic zone associated with the WDL IRAM is the Alluvium, which includes unconsolidated fill materials and debris. Beneath WDL, the Alluvium is interpreted to be approximately 60 to 90 feet thick. All explorations to date at WDL have occurred within the Alluvium, and visually impacted sediment is known to be present only in the upper 11 feet of the Alluvium beneath WDL.

There exist two primary limiting physical conditions that are relevant to an evaluation of removal technologies. These limiting conditions are as follows:

- Saturated Sediments – WDL sediment is fairly uniform in density and water content. Sampling and testing conducted for both the TS and the geotechnical investigation have indicated that a large portion of the sediment is in the "liquid state". Physical test results from these studies are presented in Attachment 1 (Final WDL TS Report) and Attachment 2 (Revised WDL Geotechnical Investigation Report), respectively. This physical condition constrains what removal technologies would potentially be effective for sediment removal at WDL.

- Slope Stability – Both finite element modeling (FEM) and slope stability calculations/modeling indicate an unacceptable risk to embankment stability as a result of scenarios including dewatering and/or excavating sediment from the toe of the existing embankment.

The most relevant hydrogeologic zones to the WDL IRAM are the Fill and Alluvium Zones. Water in the southern portion of WDL is the surface expression of the water table, with water levels at the monitoring wells closest to WDL [RP-04-16, RP-15-25, W-08-26, W-09-D(38), RP-18-30, RP-06-30, and MW-03-S(27)] typically at 10 to 15 feet bgs. Based on the shallow occurrence of groundwater at these monitoring wells, and their location within the former Doane Lake footprint, they are considered Fill Zone wells. Groundwater elevations in nearby monitoring wells track closely with the water elevation in WDL, suggesting a connection between WDL and the Fill Zone. Prior water balance evaluations completed for the RP Site indicate that water is lost through evaporation and discharge to groundwater in the northern portion of WDL, and that water is gained from stormwater runoff from the Lake Area Drainage Ditch (LADD) and groundwater recharge in the southern portion of the lake (AMEC, 2005b).

A downward vertical hydraulic gradient is present in the Fill Zone, indicating that it is connected to the underlying Alluvium Zone. The Fill Zone is not directly hydraulically connected to the River, based on water level measurements near the River collected by the Lower Willamette Group (LWG) and an ongoing RP groundwater level-elevation monitoring program; but, it is indirectly connected via the Alluvium Zone. The hydraulic conductivities of both the Fill and Alluvium zones (estimated through performance of instantaneous discharge tests) are generally less than 1 foot/day (AMEC, 2008a).

Water levels measured in NDL are lower than those measured in WDL, suggesting that there is currently no direct hydraulic connection between these two surface water bodies via the Fill Zone. Historically, a connection may have existed between the two water bodies when the configurations of the former Doane Lake and NDL were significantly different.

Given what is known about the hydrogeologic characteristics of the Fill and Alluvium Zones (e.g., low hydraulic conductivities, and the results of the 1-dimensional transport evaluation), COIs in WDL leachate would not reach receptors at either NDL or the River at concentrations that pose an unacceptable ecological or human health risk.

Remedial Technology Evaluation, Alternative Development, and Analysis

As previously stated, this EE/CA presents a site-specific evaluation of several remedial technologies that were considered for use as part of the IRAM for WDL and, through the EE/CA screening process, evaluates a number of specific remedial alternatives, including in-situ solidification/stabilization (ISS) of WDL sediments, and sediment removal and off-site disposal scenarios. These remedial alternatives were evaluated and compared in accordance with Oregon's environmental cleanup requirements (described in Oregon Revised Statutes (ORS) 465.315) and Oregon Administrative Rules (OAR 340-122-0085), using five balancing factors: effectiveness, long term reliability, implementability, implementation risk, and reasonableness of cost. In addition, SLLI performed an evaluation of the various remedial alternatives from a sustainability perspective, in which the magnitude of the greenhouse gas emissions for each alternative was considered as part of the evaluation of individual alternatives, as well as part of the comparison of alternatives.

A total of 27 remedial technologies were evaluated, including 10 removal methods. Seven technologies, including two removal methods, were retained for evaluation as part of the development of remedial alternatives. Retained technologies include capping, natural attenuation, ISS, excavation (both post-ISS and using cofferdam technologies), as well as both on-site and off-site disposal options, including incineration. Some sediments in WDL may be classified as dioxin-bearing wastes and could carry the Resource Conservation and Recovery Act (RCRA) F027 hazardous waste code. There are currently no incinerator facilities in the United States that will accept wastes bearing the F027 code. Thus, incinerating the sediments is, therefore, not permissible due to the waste code(s) associated with the sediments.

From these retained technologies, three remedial alternatives (numbered 2, 3, and 4) were developed for formal evaluation, in addition to including the "No Action" alternative (Alternative 1). These developed remedial alternatives were:

- Alternative 2 – In-Situ Stabilization: This alternative treats the impacted sediment in place to meet the RAOs. The components of this alternative include: (1) ISS of the sediment; (2) installation of an impermeable cap over the stabilized mass to prevent direct contact with the stabilized monolith and to prevent infiltration of storm water; (3) monitored natural attenuation as part of a long-term monitoring program; and (4) stormwater controls.
- Alternative 3 – In-Situ Stabilization with NAPL-Affected Sediment Removal and Offsite Disposal: This alternative is based on removing NAPL-affected sediment,

and has the same components as Alternative 2, plus the removal and off-site disposal of the NAPL-affected sediment. This alternative assumes that NAPL-affected sediment, once stabilized, would be considered CAMU-eligible. The excavated volume of the NAPL-affected sediment would be backfilled with controlled density fill material.

As part of the development of this alternative, further evaluation of the two retained removal methods was performed. ISS followed by excavation with a track hoe is the retained removal method. Use of a cofferdam and excavation of wet, unstabilized sediment was eliminated because it would have a higher implementation risk, a longer duration, and added cost without offering any additional benefit to the project or the environment.

Also as part of the development of this alternative, further evaluation of disposal options was performed. Off-site disposal of sediment is the retained disposal method. On-site disposal cannot be fully evaluated in this EE/CA because there are several unknown factors regarding the construction and approval of an on-site containment facility (OCF) at this time. Construction of an OCF is under consideration as a potential component of the final site remedy, and also may be considered in conjunction with other possible IRAMs that might be completed prior to the issuance of the RP Site Record of Decision (ROD).

- Alternative 4 – In-Situ Stabilization, Sediment Removal, and Offsite Disposal: This alternative is based on removal of all of the stabilized sediment and backfill with imported material. The components of this alternative are the same as Alternative 3, except that all of the stabilized WDL sediment would be removed and disposed of offsite. The excavated WDL would be backfilled with clean, imported material, and then covered with an engineered cap.

Each of these three alternatives, including a “No Action” alternative (Alternative 1), was evaluated based on its protectiveness and the five balancing factors previously referenced. A summary of each of these factors for Alternatives 1-4 is as follows:

- Protectiveness – Alternative 1 was not considered protective, because it would not achieve any of the RAOs, and was consequently eliminated from further consideration. While Alternatives 2 through 4 are each considered protective because each would immediately achieve all RAOs, Alternatives 3 and 4 are considered less protective than Alternative 2 due to the increased exposure to elevated risk via truck traffic, dust, noise, potential traffic accidents in transit, and potential spills or releases in transit to an off-site disposal facility, and the amount of greenhouse gas emissions associated with the transportation.
- Effectiveness - For the same reasons described above under protectiveness, Alternatives 2, 3, and 4 were each considered to be effective in achieving

protection, because the residual risk to potential future receptors is acceptable and all RAOs are immediately achieved following implementation of these alternatives.

- Long-Term Reliability - Alternative 2 is considered to have good long-term reliability based on the leachate test method used during the WDL TS. The sequential batch leach test (SBLT) leachate method provides what SLLI considers to be the most representative laboratory test of how stabilized sediment may perform over the long term. Site groundwater was used as the leachant, as recommended by USACE guidance, for each of the four required cycles of leachate testing, with each cycle demonstrating approximately 10 years of time. As stated previously, the analytical results of the leachate samples indicated that screening criteria and performance criteria would not be exceeded at the applicable exposure points. Additionally, the physical test results from the WDL TS indicated that a stabilized monolith would have the necessary physical characteristics required to maintain its integrity over the long term.

  Alternative 3 is considered slightly more reliable over the long term than Alternative 2 because the NAPL-affected sediments are permanently removed from WDL and, therefore, are not available to contribute to leaching. The results of the WDL TS have demonstrated the ability of ISS to contain NAPL; therefore, removing NAPL-affected sediment provides only a slight improvement in long-term reliability. Furthermore, the area of NAPL-impacted sediment will be included within the slurry wall.

  Alternative 4 is considered the most reliable over the long term because the impacted sediments are permanently removed from WDL and, therefore, cannot leach to groundwater.

- Implementability - Alternative 2 is the most readily implementable of the alternatives, because it uses conventional methods and readily available equipment and material. Specialty contractors, where required, use techniques and procedures that are well established and proven in the field. There are no known permitting limitations for this alternative, and permitting has been completed.

  Alternatives 3 and 4 incorporate additional components, including excavation, transportation and disposal, as well as backfill of excavated portions of stabilized WDL sediment. Implementation of the additional components uses readily available equipment and standard techniques, but both alternatives would require approval to dispose of the excavated sediment as CAMU-eligible waste, for which no determination has been made to date.

- Implementation Risk - Alternative 2 has the lowest implementation risk as compared to Alternatives 3 and 4, which require excavation, handling, and transportation of stabilized sediment offsite. Additionally, excavation of the stabilized sediment would increase the risk of slope failure and/or bottom heave, directly affecting embankment stability, which is not a factor under Alternative 2. Alternatives 3 and 4 would also have higher emissions of greenhouse gases than Alternative 2, which represents an adverse impact that is considered to represent a higher implementation risk. Alternative 4 will have the highest implementation risk due to the higher quantities of waste handling and greenhouse gas generation.
- Reasonableness of Cost - Alternative 2 has the lowest overall cost to implement. Alternative 3 costs are approximately $2 million higher, a greater than 10% premium over Alternative 2, with little or no increase in protectiveness to human health and the environment. It is important to remember that the area of NAPL-affected sediment is planned to be enclosed within a slurry wall, along with other source areas on the RP property, as part of the site-wide remedy. Therefore, the added cost to remove the NAPL-affected sediment, as compared to the relative reduction of releases of COIs to the environment, is not deemed a reasonable tradeoff. Alternative 4 is the most expensive alternative, at more than twice the overall cost when compared to Alternative 2. The added cost to remove the sediment is considered to be unreasonable, considering that Alternative 2 meets the RAOs.

Recommended Remedial Alternative

Based on the evaluation contained in this EE/CA, including the results presented in the Final WDL TS Report (Attachment 1) and the Revised WDL Geotechnical Investigation report (Attachment 2), Alternative 2 (ISS) was selected as the recommended remedial alternative for the WDL IRAM.

Alternative 2, ISS, was selected on the basis of its protectiveness, including its ability to immediately achieve all RAOs upon completion of implementation. ISS is considered effective based on the TS results because NAPL is both physically and chemically bound during stabilization, and because leaching to groundwater is minimized to levels that do not present unacceptable risks to either WDL or NDL receptors at their respective exposure points. The TS physical testing results demonstrate that ISS will be reliable over the long term. ISS is the most readily implementable alternative having the lowest implementation risk. Finally, the cost for implementation of ISS is considered to be the most reasonable given its protectiveness, effectiveness, good long-term reliability, implementability, and low implementation risk.

Alternative 3 (ISS with NAPL-Affected Sediment Removal and Off-site Disposal) was not selected because the slight increases in effectiveness and long-term reliability are not commensurate with its greater than 10% premium in cost, or nearly $2 million, over Alternative 2, resulting from its increased complexity of implementation and increased implementation risks associated with handling of the sediment and transportation to an off-site disposal facility, including substantial emissions of greenhouse gasses and the resulting reduction in air quality along the transportation route, which transverses the Columbia River Gorge National Scenic Area.

Alternative 4 (ISS, Sediment Removal, and Off-site Disposal) was not selected for the same reasons as Alternative 3. The relative increases in effectiveness and long-term reliability are not commensurate with a cost of 2.5 times that compared to Alternative 2, or greater than $20 million more, especially given the increased complexity of implementation and a significantly greater implementation risk.

Implementation Schedule

The implementation of the WDL IRAM is currently planned in 2009, based on the assumption that the remedial alternative recommended in this EE/CA (Alternative 2) is approved by DEQ by spring 2009. Construction of the remedy, including stabilization and capping, would take approximately 6 months following 2 months of site preparation, for an estimated completion in winter 2010.

1.0 INTRODUCTION

AMEC Earth & Environmental, Inc. (AMEC) has prepared this Final West Doane Lake (WDL) Engineering Evaluation/Cost Analysis (EE/CA), hereinafter referred to as the EE/CA, on behalf of SLLI for the Rhône-Poulenc (RP) Portland Site, as requested by the Oregon Department of Environmental Quality (DEQ) in its comment letters to SLLI regarding the original Draft WDL EE/CA, which was dated September 11, 2007. The first DEQ comment letter was dated November 28, 2007, and SLLI responded on December 21, 2007 (DEQ, 2007; AMEC, 2007b). The second DEQ comment letter was dated March 19, 2008, and followed a meeting between DEQ, SLLI, and AMEC on January 9, 2008 (DEQ, 2008a). SLLI responded to the second DEQ comment letter on April 18, 2008 (AMEC, 2008b).

This EE/CA was prepared in general accordance with current Oregon environmental cleanup statutes (Oregon Revised Statutes [ORS] 465.200 through 465.545 and 465.900) and rules (Oregon Administrative Rules [OAR] 340-122). Additionally, the EE/CA is generally consistent with United States Environmental Protection Agency (EPA) guidelines for preparing feasibility studies (FSs) and EE/CAs under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

The remedial alternatives presented in this EE/CA are considered Interim Remedial Action Measures (IRAMs) because implementing the WDL remedy is proposed to occur before the remedial investigation/feasibility study (RI/FS) is completed and the Record of Decision (ROD) is issued for the RP Site. However, the remedial technology recommended for this IRAM is intended to be final, and as such, screening and performance criteria are proposed in this EE/CA as performance standards.

The WDL IRAM will address impacted sediment within the WDL water body to a depth of 12 feet below the water/sediment interface (bwsi). This implementation depth was selected to address the zone of visually impacted soils observed to approximately 11 feet bwsi during multiple WDL investigations and to address the zone in which the maximum concentrations of constituents of interest (COIs) have been identified, between approximately 4 to 8 feet bwsi. The basis for this implementation depth is presented in detail in Section 3 (WDL Background) and Section 4 (WDL Conceptual Site Model) of this EE/CA.

Finally, it is important to recognize that while the proposed WDL IRAM is intended to be fully protective of potential exposures to COIs contained in WDL sediment and surface water, the WDL IRAM is not envisioned to represent a stand-alone remedy for the entire RP Site. Consideration of the adequacy and protectiveness of the WDL IRAM must recognize that it represents only the first of multiple remedial actions anticipated as part of the site-wide remedy plan for the RP Site. Each of these anticipated future remedial actions will address one or more additional potential exposure or transport pathways at the RP property and adjacent properties and will be designed to integrate with the other remedial components as part of a final site-wide remedy. The preliminary site-wide remedy plan for the RP Site was presented to DEQ in an August 21, 2007, letter titled “Site-Wide Conceptual Remedy Plan” (AMEC, 2007a).

1.1 Purpose of the WDL EE/CA

The purpose of the EE/CA is to aid in selecting an appropriate IRAM to mitigate direct human and ecological contact with WDL surface water and sediment, and to reduce or eliminate potential leaching of COIs from WDL sediment to groundwater.

This EE/CA presents a site-specific evaluation of several remedial technologies that were considered for use as part of the WDL IRAM and, through the EE/CA screening process, evaluates a number of specific remedial alternatives, including in-situ solidification/stabilization (ISS) of WDL sediments, and sediment removal and off-site disposal scenarios. These remedial alternatives were evaluated and compared in accordance with Oregon’s environmental cleanup requirements described in ORS 465.315 and OAR 340-122-0085, using the five balancing factors: effectiveness, long-term reliability, implementability, implementation risk, and reasonableness of cost. In addition, SLLI evaluated the various remedial alternatives from a sustainability perspective, in which the amount of greenhouse gas emissions for each alternative was considered as part of the evaluation of individual alternatives, as well as part of the comparison of alternatives.

1.2 Report Organization

To provide the reader with a comprehensible view of both current conditions in WDL and the potential outcomes of the proposed remedial alternatives, this EE/CA presents the history of WDL including prior investigations, the remedial action objectives (RAOs) and performance criteria for WDL, and the screening and selection of the remedial alternative for WDL. Individual sections of the report are as follows:

- Section 2 – RP Background
- Section 3 – WDL Background
- Section 4 – WDL Conceptual Site Model
- Section 5 – WDL Remedial Action Objectives and Criteria
- Section 6 – Identification, Screening, and Selection of Remedial Technologies for WDL

- Section 7 – Description of Remedial Alternatives
- Section 8 – Evaluation of Remedial Alternatives
- Section 9 – Recommended Remedial Alternative
- Section 10 – Schedule

This EE/CA also includes, as attachments, the Final WDL Treatability Study Report (Attachment 1) and the Revised WDL Geotechnical Investigation Report (Attachment 2). The content of these attached reports are summarized in Sections 3.4.4 and 3.4.5, respectively.

2.0 RP BACKGROUND

This section describes the RP property and vicinity, summarizes the geologic and hydrogeologic conceptual site models (CSMs), and summarizes the site-wide remedy strategy to provide the larger context within which the WDL IRAM is located. A summary of the ownership and operational history of the RP property and a complete description of the geologic and hydrogeologic CSMs can be found in the Draft Source Control Evaluation Report (Draft SCE Report), dated February 13, 2008. (AMEC, 2008a)

2.1 Site Description

The RP property comprises approximately 17 acres and is located in Section 13 of Range 1 West, Township 1 North of the Willamette Meridian (Figure 1). The RP property is located within the Guild's Lake Industrial Area (City of Portland, 2001), a heavily industrialized area northwest of Portland and southwest of the Lower Willamette River.

The property is a former pesticide formulation and manufacturing facility and is currently vacant except for limited operations related to water treatment, environmental investigations, and remedial actions. The former manufacturing facility operated from 1943 to 1990. Historically, the RP property has been separated for investigation purposes into three areas identified as the Insecticide Area (IA), the Herbicide Area (HA), and the Lake Area (LA) (Figure 2).

The IA is located at the southern portion of the RP property and was used for the formulation and storage of insecticides and their components. The HA is located adjacent to and northwest of the IA, and was used for the manufacturing, formulation, storage, and handling of herbicides and their components. The administrative buildings and maintenance facility were in the HA. The IA and HA are collectively referred to as the "plant area".

The LA is located north of the plant area. A portion of the LA was once part of former Doane Lake, which has since been filled with the exception of WDL. WDL is located on property owned by the BNSF Railway Company (BNSF), between the eastern side of the BNSF embankment and the LA.

The RP property and vicinity are currently undergoing an RI under a 1999 Consent Order with DEQ. Extensive soil and groundwater sampling have been conducted at and around the RP property. Remedial actions implemented to date include a currently operating groundwater extraction system, soil capping in the former plant area, former piping abandonment, and mitigation of groundwater infiltration into a City of Portland (COP) storm sewer (AMEC, 2004a; AMEC, 2005a; AMEC, 2008a). Neighboring parcels are shown on Figure 2.

2.2 RP Site Geology

The RP property is located approximately 7 river miles south (upriver) of the confluence of the Willamette and Columbia Rivers, on the left bank (looking downstream) of the Willamette River (River). The RP property sits on a bench lying between the River on the northeast and the Tualatin Mountains on the southwest (Figure 1). The RP property is located approximately 2,000 feet away from the River at an elevation of approximately 35 to 45 feet above mean sea level (amsl).

Three geologic zones have been defined and are distinguished by soil and rock lithology. The geologic CSM is composed of the Alluvium, Deep Alluvial Gravel, and Basalt Geologic Zones. The most relevant zone to the WDL IRAM is the Alluvium, which is described in detail below. Complete descriptions of the Deep Alluvial Gravel and Basalt Geologic Zones can be found in the Draft SCE Report (AMEC, 2008a).

<u>Alluvium Geologic Zone</u>

The Alluvium Geologic Zone (Alluvium) consists of unconsolidated fill and naturally deposited lake and stream sediment deposited by the River. The fill component of the Alluvium extends to depths of approximately 4 to 30 feet below ground surface (bgs), equivalent to elevations of approximately 35 feet amsl to 3 feet below mean sea level (bmsl), across the RP property and surrounding properties. Materials comprising the fill include variable amounts of clay, silt, and sand from River dredge spoils, plant organic material, and miscellaneous debris such as brick, gravel, foundry sands, wire, concrete, and battery casings. These materials were placed in former Doane Lake and along the western bank of the River during industrial development throughout the latter half of the 20th century. The fill materials are difficult to distinguish from alluvial materials in the absence of debris because both fill and alluvial material are texturally similar to River sediments.

The alluvial material underlying the fill comprises sediments deposited by the River. The Alluvium is broadly characterized as silty sand and sandy silt extending to depths ranging from as shallow as approximately 40 feet bgs (10 feet bmsl) on the RP property, to more than 200 feet bgs (165 feet bmsl) on Siltronic Corporation (Siltronic) property. An upper layer of clay and silty clay is distinguishable beneath former Doane Lake, extending to a depth of approximately 25 feet bgs (10 feet amsl) and having an average thickness of 15 feet. A silty layer is observed on the north side of the railroad tracks at approximately the same depth/elevation and thickness.

2.3 RP Site Hydrogeology

The hydrogeologic CSM for the RP property and surrounding properties consists of four hydrogeologic zones and was developed to evaluate groundwater fate and transport at the RP property. The four hydrogeologic zones are distinguished by relative location, groundwater elevation, aquifer permeability, and constituent concentrations in groundwater. The hydrogeologic CSM is composed of the Fill Hydrogeologic Zone (Fill Zone), Alluvium Hydrogeologic Zone (Alluvium Zone), Deep Gravel Hydrogeologic Zone (DGZ), and Basalt Hydrogeologic Zone (Basalt Zone). The most relevant hydrogeologic zones to the WDL IRAM are the Fill and Alluvium Zones, which are described in detail below. Complete descriptions of the DGZ and Basalt Zone can be found in the Draft SCE Report (AMEC, 2008a).

Fill Hydrogeologic Zone

The Fill Zone corresponds with the saturated portion of the fill within the Alluvium Geologic Zone. The Fill Zone is discontinuous and is distinguished from the Alluvium, Deep Gravel, and Basalt Hydrogeologic Zones by the following characteristics:

- Relatively high groundwater elevations, and
- Groundwater flow direction toward WDL south of the BNSF railroad tracks, toward North Doane Lake (NDL) north of the BNSF railroad tracks, and toward the River near the riverbank north and south of the BNSF railroad tracks.

Water enters the Fill Zone on the south side of the BNSF tracks by precipitation and leakage from the northern portion of WDL. Water leaves the Fill Zone by discharge to the southern portion of WDL and to the underlying Alluvium Zone which flows toward the River (AMEC, 2008a). Water enters the Fill Zone on the north side of the BNSF tracks by precipitation and leakage from the northern portion of NDL. Water leaves the Fill Zone on the north side of the BNSF tracks by groundwater discharge to the southern and western portions of NDL and to the underlying Alluvium Zone which flows toward the River (AMEC, 2008a).

RP property and vicinity groundwater flow in the Fill Zone consists of a lateral component toward WDL and NDL, and a vertical component toward the underlying Alluvium Zone caused by downward vertical hydraulic gradients (e.g., greater than 0.1 feet/feet [ft/ft]) between the Fill and Alluvium Zones.

Alluvium Hydrogeologic Zone

The Alluvium Zone consists of saturated native silty sand and sandy silt. The Alluvium Zone is distinguished from the Deep Gravel and Basalt Hydrogeologic Zones by its lithology and low permeability. The Alluvium Zone lies within the Alluvium Geologic Zone.

Groundwater in the Alluvium Zone exists under both unconfined and semi-confined conditions. Unconfined conditions occur in the upper portion of the Alluvium Zone, where the overlying fill is absent and the upper boundary of the Alluvium Zone is the water table (Freeze and Cherry, 1979). The Alluvium Zone exhibits semi-confined conditions when the overlying fill is present or when shallow portions of the Alluvium Zone (which contain a higher percentage of silt) confine deeper portions of the Alluvium Zone (which contain a higher percentage of sand).

Water enters the Alluvium Zone by infiltration from precipitation (where the fill is not present), leakage from the overlying Fill Zone (where present), leakage from the underlying DGZ (where present) and Basalt Zone (where the DGZ is not present), and lateral inflow from the Tualatin Mountains. Groundwater elevations in the Alluvium Zone are similar to groundwater elevations in the DGZ and Basalt Zone, and are lower than groundwater elevations in the Fill Zone.

2.4 RP Site-Wide Remedy Strategy

The WDL IRAM is one interim action that serves as a cornerstone to additional remedial actions at the Site. Once the WDL IRAM is completed, a subsequent step of the Site-wide remedy will be containment of the primary source area on RP property to mitigate ongoing constituent migration in groundwater. At this point, a slurry wall is envisioned to meet the RAOs associated with source area containment. The WDL footprint, which is limited to shallow/surface soils in relation to the entire soil column, overlaps the currently delineated source area. Because of the overlap in areal extent, remediating WDL is necessary prior to implementation of the slurry wall for two reasons: 1) to provide a solid working platform for slurry wall installation in the WDL vicinity; and 2) to prevent the pushing/spreading of impacted “liquid-like” sediments deeper in soil column during slurry wall installation. Any disturbance to the WDL IRAM cap as a result of the slurry wall installation would be corrected following completion of the slurry wall.

The final steps in the site-wide remedy are intended to eliminate stormwater infiltration and risk from direct contact to shallow soils by capping the RP property (the RP property cap in the LA would tie into the WDL cap), and to determine the need for remedy in NDL.

Additional remedial actions in the form of Interim Source Control Measures (ISCMs) are also anticipated to be implemented at the RP property and adjacent properties, as outlined in the Draft SCE Report (AMEC, 2008a) for the Source Control Program. These include hydraulic control of RP constituents in the DGZ near NW Front Avenue (NFA) and eliminating discharge of shallow groundwater into the COP Outfall 22B storm sewer. Preliminary activities for both these measures already are in progress.

3.0 WDL BACKGROUND

This section presents the filling history of Doane Lake, including WDL which is the focus of this EE/CA, as well as a summary of ecological considerations pertinent to WDL, and a summary of the investigations conducted to date at WDL and their findings.

3.1 WDL Physical Setting

WDL is a long slender lake, approximately 1,000 feet long, that is oriented north-south, adjacent and parallel to the BNSF embankment (Figure 2). The southern portion of the lake is approximately 60 feet wide, and the northern portion of the lake is approximately 40 feet wide. The southern portion of the lake is deeper than the northern portion, with typical water depths of 1 to 2 feet. The northern portion of the lake is often dry during the summer months.

3.2 WDL History

Prior to development of the area around the RP property, a majority of the area to the north of and adjacent to the RP property was occupied by Doane Lake, with Kittridge Lake a few miles southeast of Doane Lake. Both of these lakes were historically oxbow lakes, at one time connected to one another by a slough associated with the River. Currently, only remnants (NDL and WDL) of the original Doane Lake remain. Until completion of the soil remedy at the Gould Superfund Site in 2000, a third remnant, East Doane Lake (EDL) existed on Gould Electronics (Gould) and Schnitzer Investment Corporation (Schnitzer) properties.

From the mid-1950s through the mid-1970s, Doane Lake was filled with soil and various fill materials from industrial activities on all sides by RP and adjacent property owners, including ESCO Corporation (ESCO), NL Industries, Gould Electronics

(Gould), and Schnitzer Investment Corporation (Schnitzer). WDL assumed its present-day configuration at this time. The LA portion of Doane Lake was primarily filled during the 1960s and early 1970s. No RP operations were conducted in the LA, with the exception of operation of a water treatment plant. Atlas Building Wreckers (Atlas) leased a portion of the LA from approximately 1977 to 1990. Atlas' operations included stockpiling and sorting of building materials, and operation of an equipment maintenance and fueling facility (Geraghty and Miller, 1991).

An additional remnant of former Doane Lake, NDL, is located in a triangular-shaped property northwest of the LA. Both WDL and NDL are located on BNSF property. The shallow body now known as NDL was destroyed and re-created several times over the years as part of historical placement of manufactured gas plant (MGP) wastes from Northwest Natural (NWN)/Gasco and dredge spoils from the River on what are now Siltronic and BNSF properties, prior to installation of the northern railroad segment in approximately 1970.

3.3 WDL Ecological Considerations

WDL is considered an attractive nuisance. Both DEQ and the Oregon Department of Fish and Wildlife (ODFW) have in the past agreed that filling and "sealing" WDL would be a reasonable approach to eliminating complete direct exposure pathways to area wildlife (DEQ, 1996). As documented in the Remedial Investigation Work Plan (RIWP) prepared by Ecology & Environment for the DEQ (DEQ, 1999), WDL provides marginal habitat that attracts potential ecological receptors, including deer, nutria, rabbits, mice, voles, and a variety of birds, which have historically been observed at and in the vicinity of WDL (DEQ, 1999). SLLI has placed a series of wildlife deterrents at WDL to reduce its attractiveness while planning to implement the WDL IRAM. Wildlife deterrents at WDL were installed in January 2009, in accordance with the DEQ-approved "Interim Measures for Wildlife Deterrence at West Doane Lake" proposal, dated October 27, 2008 (AMEC, 2008h).

DEQ also has expressed concern historically about the potential for WDL to be a continuing source of COIs to potential human and ecological receptors at NDL (DEQ, 1999). Both DEQ and ODFW consider NDL to be an important resource for migratory birds and water fowl, and the RIWP identifies "maintenance of a healthy aquatic ecosystem to support migratory birds and waterfowl" as an endpoint for evaluating NDL.

The implementation of an IRAM at WDL, as described in this EE/CA, will effectively eliminate the water body known as WDL and its associated habitat. Additionally, a WDL IRAM will significantly reduce the potential contribution of COIs via groundwater, if any, to the NDL habitat.

3.4 WDL Studies

Characterization activities completed to date at WDL are briefly discussed in the following subsections. For clarification, the abbreviation COI(s) is carried forward throughout this document. During previous investigations, other acronyms (e.g., potential constituent of potential concern [PCOPC], constituent of potential concern [COPC]) more appropriate to those phases of work might have been used. For this EE/CA, the term COIs applies to those constituents detected in the sediments of WDL during the investigations described within this section of the document that will be addressed by the proposed WDL IRAM.

3.4.1 Remaining Remedial Investigation (2002)

As part of the ongoing soil and groundwater RI characterization, RI activities were conducted at WDL in 2002. These activities were completed as part of a group of RI tasks identified as “Remaining RI” (RRI) activities. The scope of work completed at WDL during the RRI included a site reconnaissance, and sampling and analysis of sediment and surface water (AMEC, 2003b).

The site reconnaissance was conducted to gather qualitative information for the following purposes:

- To support both the human health (HHRA) and ecological (ERA) risk assessments;
- To support nature and extent characterization;
- To evaluate the accessibility of WDL with respect to future sampling activities; and
- To enhance understanding of surface water and groundwater systems for the groundwater transport evaluation at the RP property and adjacent properties.

Sediment samples were collected from four locations in WDL (Figure 3): WDL-101-S, WDL-102-S, WDL-103-S, and WDL-104-S. Sediment samples were collected at four depth intervals at sediment sampling locations WDL-101-S and WDL-104-S and at five depth intervals at sediment sampling locations WDL-102-S and WDL-103-S. Depth intervals at each boring location included 0 to 0.5 feet and 0.5 to 4 feet, as well as intervals selected based on the presence of sheen, odor, or presence of organic residual, typically between 4 and 9 feet bswi. To provide vertical characterization, an additional sample was collected at any location with observed sheen, odor, or organic residual.

Surface water samples were collected from three locations in WDL: WDL-101-W, WDL-102-W, and WDL-103-W. These surface water sampling locations were in proximity to sediment sample locations WDL-101-S, WDL-102-S, and WDL-103-S.

The sediment and surface water samples were analyzed by a variety of methods for the six classes of RP COIs, including volatile organic compounds (VOCs), semivolatile organic compound (SVOCs) (including phenolics), chlorinated herbicides, organochlorine insecticide, metals, and dioxins/furans.

The results of the WDL RRI activities are briefly discussed below, and presented in detail in the RRI Technical Memorandum, dated February 4, 2003 (AMEC, 2003a).

- Site Reconnaissance - Bank to bank, WDL is approximately 40 to 60 feet wide, with water depths up to 2 feet at its deepest point. The Lake Area Drainage Ditch (LADD), extending from just north of the RP Water Treatment Plant, enters the south end of WDL. The LADD at one time directed storm and wastewater flow from the plant area to WDL; it currently directs stormwater from the BNSF tracks and portions of the LA to WDL. Sheens were not observed on the water surface of WDL unless the lake sediments were disturbed, which caused a sheen to appear on the water surface accompanied by a sulfur-like odor. Overall, the sediment in the lake was dark grey to black in color, except near the WDL-101 sampling location, where reddish-brown water and sediments were observed. Fill material, consisting of brick, concrete, and cinder, was noted on the bank adjacent to the ESCO property, although most of the WDL banks were covered with blackberry brambles and brush. Easy access to WDL was possible either from trails at the south end of WDL or from a stairway near the WDL staff gauge.
- Sediment Lithology – Lake sediments at the three southern boring locations consisted of very soft to soft black to gray organic silt, displaying black and gray lamination, and including plant and wood debris at the most shallow depths. The organic silt grades to clayey silt between approximately 6 and 9 feet bswi. At the fourth and northernmost boring location, a thin layer of dark brown clayey silt overlies approximately 4 feet of loose, black silty sand that might be foundry sands that sloughed into the lake from the ESCO property. Poorly graded sand that might be foundry sands was also encountered at the bottom of this boring at 7 to 7.5 feet bswi. The maximum depths explored range from 7.5 to 11 feet bswi due to refusal on gravelly materials interpreted to be railroad ballast.
- Sediment Results – Concentrations of 1,2-dichlorobenzene (DCB), 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), and various metals were present in excess of preliminary screening values for human health and/or ecological receptors. Several COIs, particularly 1,2-DCB, 2,4-dichlorophenol, 2,4-dichlorophenoxyacetic acid (2,4-D), and Silvex, were detected at their greatest concentrations at the southern end of WDL, within the deeper sediment intervals. Free-phase non-aqueous phase liquid (NAPL) was not observed, but an organic residual was identified within WDL sediment using an ultraviolet (UV) light in samples from WDL-101-S, WDL-103-S, and WDL-104-S. NAPL blebs were observed in surface

water collected near the WDL-101 boring location, so the positive UV light test results are interpreted to represent potential NAPL between 4 and 6 feet bswi at this location.

- Surface Water Results – VOCs and insecticides were not detected above the method detection limits (MDLs) at any of the surface water sampling locations. Herbicides and SVOCs were not detected at concentrations greater than the preliminary human health or ecological screening values. Arsenic, chromium, and 2,3,7,8-TCDD were detected above the preliminary screening values for human health.

3.4.2 Leachability Analysis (2004)

The objective for conducting a leachability analysis in 2004 was to evaluate which COIs detected during the 2002 RRI WDL sampling event had the potential to leach from WDL sediment. The scope of work included sediment sampling and analysis, and leachability analyses for WDL sediment by two leaching methods: (1) Toxicity Characterization Leaching Procedure (TCLP) and (2) a modified Elutriate Leach Test (ELT). The purpose of these tests was to assess potential leachability of COIs as well as to compare the TCLP and ELT leaching test methods.

Sediment samples were collected from four locations in WDL (Figure 3): WDL-201-S, WDL-202-S, WDL-203-S, and WDL-204-S. Sediment samples were collected at two depth intervals (0 to 0.5 and 5 to 7 feet bswi) at sediment sampling location WDL-201-S and at one depth interval at each of the remaining sediment sampling locations (between approximately 3 and 6 feet bswi).

The findings of the leachability analysis are summarized below, and presented in detail in the Leachability Analysis, dated August 6, 2004 (AMEC, 2004b).

- Field lithology descriptions for WDL sediments were consistent with previous descriptions, with the exception of foundry sand identified at sediment sample locations WDL-203-S (5 to 6.5 feet bwsi) and WDL-204-S (4 to 6-feet bwsi). These sample locations are near the southwest and northwest corners, respectively, of the adjacent ESCO property, where foundry sands were disposed. Field soil descriptions were confirmed with laboratory results.
- Residual NAPL was identified at sediment sampling location WDL-201-S (5 to 7 feet bwsi), and sheens were noted at sediment sampling locations WDL-203--S and WDL-204-S. These observations are consistent with proximity of these samples at the south end of WDL and known locations of NAPL in the subsurface, and represent the worst-case samples for organic constituents in WDL.

- In general, the TCLP and ELT leachate concentrations were greater at sediment sampling location WDL-201-S (5 to 7 feet bwsi) at the south end of WDL where a trace amount of residual NAPL was observed. However, higher concentrations of some metals (aluminum, arsenic, barium, and iron) were observed in the northern portion of the lake.
- In general, the concentrations of COIs detected in the TCLP leachate were greater than those in the ELT leachate analysis. In addition, a greater number of COIs were detected above the laboratory MDL during the TCLP procedure, consistent with the fact that the TCLP is a more aggressive and less representative laboratory test method for evaluating the potential for COIs to leach from WDL sediments.

The relative concentrations of COIs detected during the TCLP and ELT leachate analysis procedures indicate that COIs do not leach easily from the WDL sediments, when compared to the total sediment results. However, several dioxin/furan congeners (2,3,7,8-TCDD, 1,2,3,7,8-pentachlorodibenzo-p-dioxin [1,2,3,7,8-PeCDD], and 2,3,4,7,8-pentachlorodibenzofuran [2,3,4,7,8-PeCDF]), one SVOC (2,4,6-trichlorophenol), and one VOC (isobutyl alcohol) were determined to exceed human health screening criteria in the leachate, indicating that a remedial action would likely be required. The leachability results were reviewed to prepare a Treatability Study (TS) to evaluate the use of ISS as a possibly remedy. The TS is discussed in more detail in Section 3.4.4.

3.4.3 Wetland Delineation (2005)

In anticipation of a future remedial action to mitigate COIs in WDL sediment, a wetland delineation was completed at WDL to determine the type and size of wetland present, and to identify the resulting permitting requirements. In November 2005, AMEC classified WDL as a palustrine unconsolidated bottom wetland (AMEC, 2006) using conventional wetland identification methods. The Oregon Department of State Lands (DSL), which has jurisdiction over this type of wetland, concurred with the wetland delineation on October 6, 2006 (DSL, 2006).

A summary of the applicable permitting requirements for implementation of the WDL IRAM is provided at the end of this document in Section 10 (Schedule).

3.4.4 Solidification and Stabilization Treatability Study (2005-2008)

As stated in Section 1.1, the primary purpose of the WDL IRAM is to mitigate direct exposure to surface water and sediment by human and ecological receptors, and additionally, to reduce or eliminate potential COI leaching from WDL sediment to groundwater.

Despite demonstrating that most COIs do not readily leach from WDL sediments, the 2004 leachability study did not adequately address direct exposure of human and ecological receptors. In response to the findings of the 2004 leachability study, ISS was identified as a potential method to remediate impacted sediments, eliminate the physical exposure point, and mitigate leaching potential for dioxins/furans, SVOCs, and VOCs.

The first step in evaluating an ISS remedy for WDL sediments was to characterize WDL in order to determine the baseline conditions, and to perform a TS to select and optimize various mix designs for solidification and stabilization and to evaluate whether ISS of WDL sediments is an effective IRAM technology for WDL (Attachment 1). The WDL TS was completed in six separate phases of work, consisting of three sediment sampling phases and four TS phases (Phase 5 included both sediment sampling and TS activities).

Each phase of the WDL TS was conducted in accordance with the approved WDL TS Work Plans (WPs) (AMEC, 2005c; AMEC, 2008d; AMEC, 2008e). DEQ approved the original TS WP on July 18, 2005 (DEQ, 2005), and the Phase 5 TS WP and its Addendum on August 8, 2008 (DEQ, 2008b). The first three phases of the TS evaluated the nature and extent of WDL sediment impacts as well as the effectiveness of ISS technology to reduce COI leachability of WDL sediment. Phases 4 and 5 of the TS were conducted as optimizations of the original mix designs from Phase 3, as well as incorporating leaching test methods determined to be more representative of actual field conditions than would be represented by the TCLP that was used in Phase 3. Phase 6 of the WDL TS was designed to confirm the chosen ISS mix designed to solidify WDL sediments and immobilize inorganic and organic COIs.

The results for each phase of the TS are summarized below. Sample and core locations are presented on Figure 3. The entire Final WDL TS Report is provided as Attachment 1 to this EE/CA.

Phase 1 – Characterization Sediment Sampling

WDL sediment was characterized during Phase 1 by collecting and analyzing 23 sediment samples for eight classes of compounds (VOCs, SVOCs, chlorinated herbicides, organochlorine insecticides, dioxins/furans, total petroleum hydrocarbons [TPHs], metals, and polychlorinated biphenyls [PCBs, as Aroclors]) to determine the nature and extent of RP-related constituents in WDL. The three main findings of the first TS phase are summarized below.

1. WDL sediment lithology consists of lenses of silt, silty sand, and debris within soft, black to gray clayey silt. These observations are consistent with the lithologies

observed during prior sediment sampling activities at WDL. The bottom of the impacted sediment was visible at 11 feet bwsi, where sediment changed from black silt to tan silt. The maximum depth of exploration was 20 ft bswi. The WDL IRAM is intended to address only the remediation of lake sediments. Field observations indicate that the proposed ISS depth of 12 feet bwsi would be sufficient to treat the vertical extent of impacted WDL lake sediment.

2. Discontinuous, discrete NAPL blebs were detected between 5 and 11 feet bwsi in the core collected at W002, located at the southern end of the lake, near the Lake Area Drainage Ditch (LADD). This is consistent with observation of NAPL at a nearby location during previous sediment sampling activities at WDL (AMEC, 2004b). Total sediment constituent concentrations are also generally greatest in the southern end of WDL, particularly in W002 where NAPL was observed, except for polynuclear aromatic hydrocarbons (PAHs) and some metals.

3. The magnitude of organic COI concentrations in the TCLP leachate results are generally consistent with the total sediment results, with the greatest COI concentrations detected in the leachate from samples collected in the southern portion of WDL.

Based on these characterization results, three locations were selected for collection of representative bulk sediment samples for Phase 2 of the TS.

Phase 2 – Representative Sediment Sampling

The distribution of constituents in WDL sediment was further characterized during Phase 2 by collecting and analyzing three representative bulk sediment samples (TS-1, TS-2, and TS-3). TS-1 was collected at the south end of WDL where NAPL was observed to represent a worst-case scenario. TS-2 and TS-3 were collected near the center of WDL, to represent the average-case scenarios. The WDL sediment lithology observed during Phase 2 sampling was similar to that observed during Phase 1.

As in Phase 1, NAPL blebs were observed in the core collected from the southern end of the lake (TS-1) from 3 to 6 feet bwsi. Total sediment constituent concentrations generally are greatest in the TS-1, and less in the samples collected to the north. The TCLP leachate results again follow the total sediment results, with the greatest organic constituent concentrations detected in the leachate from TS-1.

Phase 3 – Mix Design Testing

Four mix designs were tested during Phase 3, as summarized in the table below. Physical testing was performed to evaluate the ability of each mix to maintain its structure over time. TCLP leachate from each mix design was also analyzed by a variety of methods for the seven classes of WDL COIs: VOCs, SVOCs, chlorinated herbicides, organochlorine insecticides, metals, dioxins/furans, and PCBs (Aroclor analysis).

Mix ID	Additives to Sediment by % Volume		
	Portland Cement	Fly Ash	Bentonite
A	10	0	5
B	10	10	5
C	10	0	10
D	20	10	10

As described in the TS (Attachment 1), the performance criteria for the quantitative physical tests for samples that had cured 28 days were as follows: an unconfined compressive strength (UCS) of at least 50 pounds per square inch (psi); a hydraulic conductivity of less than or equal to 1×10^{-7} centimeters per second (cm/sec); and less than 20 parts per million for VOC off-gassing. For the wet/dry durability tests, a sample was considered to have failed if the sample cylinders broke in any of the 12 wet/dry cycles.

Physical Test Results – Overall, Mix D outperformed the other mixes with respect to unconfined compressive strength (UCS), hydraulic conductivity, wet/dry durability, and moisture content. Mix D's performance is likely a function of the relatively high percentages of Portland cement and fly ash. Although Mix D performed best in physical testing, all mix designs are considered to be adequate for solidification purposes; therefore, chemical (stabilization) data drive the final mix design selection.

Chemical Test Results – TCLP results indicate that each of the four treated mixes performed similarly in stabilizing COIs. Although TCLP is an aggressive procedure that does not represent actual leaching, dioxins and PCBs were not detected in leachate from the stabilized/solidified samples, and concentrations of VOCs, SVOCs, and some metals in the TCLP extracts for the treated mixes showed improvement over untreated sediment TCLP concentrations. Phase 3 data support the conclusion that Portland cement effectively stabilizes selected organic and inorganic analytes in WDL sediment. Because Mix A generally performed better in chemical testing, with fewer screening criteria exceedances than the other mixes, it was carried forward for optimization in Phase 4.

Phase 4 – Mix Optimization and American National Standards Institute (ANSI) Leachate Testing

Phase 4 was designed to optimize the preferred mix from Phase 3, Mix A, and to evaluate the performance of the optimized mix by using a leaching method (modified ANSI 16.1-1986) that was more representative of field conditions anticipated following

ISS. Mix A was modified by adding 1% granular activated carbon (GAC) to increase its capacity to adsorb COIs; the optimized mix was designated Mix E.

Mix ID	Additives to Sediment by % Volume			
	Portland Cement	Fly Ash	Bentonite	GAC
E	10	0	5	1

Physical testing of Mix E included UCS and hydraulic conductivity. Mix E TCLP leachate was analyzed by a variety of methods for the seven classes of WDL COIs: VOCs, SVOCs, chlorinated herbicides, organochlorine insecticide, metals, dioxins/furans, and PCBs (Aroclor analysis), in order to compare its results to those mixes tested during Phase 3. Mix E leachate from a modified ANSI (16.1-1986) leaching method was also analyzed for the two compound classes of greatest concern based on the Phase 3 results: metals and chlorinated herbicides.

Mix E passed both compressive strength and hydraulic conductivity criteria. However, Mix E demonstrated less than optimal control of ionizable organics (such as herbicides), likely attributed to high pH levels resulting from use of Portland cement coupled with insufficient adsorptive (i.e., activated carbon and organophilic clay) media. To explore the pH effects of Portland cement, Phase 5 was implemented with decreased Portland cement content and the addition of pozzolanics to treated Mixes F, G, and H, along with the addition of organophilic clay (OPC) and larger proportions of activated carbon to one of the three new mixes tested in Phase 5.

Phase 5 – Further Characterization, Mix Design Optimization, and SBLT Testing

Phase 5 was designed to determine the most effective mixture of ISS additives needed to solidify WDL sediments and immobilize inorganic and organic COIs by isolating the effects of mix materials used during Phases 3 and 4, and by evaluating the addition of pozzolans to reduce pH of the cement. Additionally, the mixes were evaluated using a sequential batch leach test (SBLT) method (United States Army Corps of Engineers [USACE], 2003). The SBLT method is considered the most representative of field conditions anticipated following ISS because it uses site groundwater as the leachant and has been demonstrated to address sediment leaching at hundreds of sites under auspices of the USACE dredged materials management program (USACE-DMMP).

During the characterization portion of Phase 5, additional sediment volume was collected from the worst-case location and one average-case location sampled previously in Phase 2. Sediment samples were analyzed for eight classes of compounds: VOCs, SVOCs, chlorinated herbicides, organochlorine insecticides, dioxins/furan, TPHs, metals, and PCBs (as congeners due to volume constraints associated with leachate testing). Results from sediment characterization are consistent with those from all prior investigative sediment work at WDL, with the exception of the PCB congener results, which had not previously been tested in WDL sediment.

Also during characterization, groundwater was collected from monitoring well RP-05-47 and analyzed for eight classes of compounds, including VOCs, SVOCs, chlorinated herbicides, organochlorine insecticides, dioxins/furans, TPHs, metals, and PCBs (as Aroclors because of turnaround time requirements) to determine if it would be a suitable leachant for the SBLT testing. Organic constituent groundwater concentrations were very low to nondetected, and metal concentrations were considered representative of background conditions; therefore, approximately 225 liters of groundwater was collected for use in Phase 5 of the TS.

Half of the Portland cement volumes tested for Mixes A through E (from Phases 3 and 4) was replaced with pozzolans (specifically a high-silica zeolite) in Mixes F, G, and H. Mix E, as tested during Phase 4, was also tested during Phase 5 to provide a baseline for comparison. Composition of the tested mixes is presented below.

Mix ID	Additives to Sediment by % Volume				
	Portland Cement	Zeolite	Bentonite	OPC	GAC
E	10	0	5	0	1
F	5	5	0	5	5
G	5	5	5	0	0
H	2.5	2.5	10	0	0

The decreased Portland cement content did not result in a significant decrease in leachate pH. The decreased Portland cement content did, however, cause Mixes F, G, and H to perform poorly from a physical integrity and strength standpoint, with most mixes never meeting the UCS criterion of 50 psi even after 28 days of curing time. This poor physical strength is indicative of the presence of insufficient alkali to allow proper curing of the concrete and demonstrates that use of pozzolanic cements in place of Portland cement is not appropriate for a WDL IRAM.

The diminished strength of Mixes F, G, and H resulted in very soft material that disintegrated during the SBLT procedure, forming a slurry. As a result, concentrations of metals and non-ionizable organics (e.g., PCBs and dioxins/furans) were greater in SBLT leachate from Mixes F, G, and H than those observed in the other mixes that were prepared using higher ratios of Portland cement.

Although Phase 5 testing indicated that the use of pozzolanic cement in place of Portland cement had little effect in controlling pH and led to post-stabilization materials that did not meet required physical strength and integrity requirements, the Phase 5 results did indicate better control of the leachability of ionizable organics. Despite the high pH, the introduction of organophilic clay (5%) and higher GAC content (5%) in Mix F considerably decreased the leachate concentrations of ionizable organics, including herbicides that leached in previous TS mixes. The diminished physical strength and integrity of the lower Portland cement content of Mixes F, G, and H did, however, prevent metals, specifically arsenic, and certain nonionizable organics from being physically stabilized to the extent that was observed in Phase 4.

Based on the Phase 5 results, it is clear that Portland cement at no less than 10% by volume, and likely at 20%, is a key component for a suitable ISS mix design. Furthermore, adding adsorptive capacity by including OPC and increasing the GAC content also significantly improved the ability of Mix F to retain ionizable organics. Given the results from Phase 5, DEQ requested a final optimization test to verify that the proposed mix (Mix I), including increased Portland cement along with OPC and carbon, would best minimize leaching potential from WDL following implementation of ISS.

TS Phase 6 – Final Optimization and SBLT Testing

As described above, Mix design I was developed based on the results of Phases 3, 4, and 5 of the TS to combine the positive effects the admixture components tested into a single mix design. Phase 6 of the WDL TS was designed to confirm the chosen ISS mix designed to solidify WDL sediments and immobilize inorganic and organic COIs. The addition of 5% each of OPC and GAC to Mix I were intended to stabilize organic constituents, the increased Portland cement content of 20% was intended to provide strength and to stabilize inorganics and nonionizable organics, and the addition of 5% bentonite was intended to decrease the hydraulic conductivity of the solidified monolith.

Mix ID	Additives to Sediment by % Volume			
	Portland Cement	OPC	Bentonite	GAC
I	20	5	5	5

Mix I meets all physical testing performance criteria, resulting in a strong, low-permeability monolith. No constituents detected in Mix I SBLT leachate exceed excavation worker RBCs, and fewer organic and inorganic constituents exceed SLVs in Mix I than any other TS mix (refer to Table 19 of the Final WDL TS Report provided as Attachment 1). Generally, the detected organic constituent concentrations are less than untreated sediment SBLT leachate concentrations.

All organic constituent concentrations exceeding SLVs in Mix I leachate meet their respective SLVs when input into the BIOSCREEN model under representative conditions for a biodegradation scenario. Furthermore, treatability results demonstrate that leachability is substantially reduced for all metals not commonly associated with Portland cement and that inorganic material that may leach from stabilized WDL sediment is not likely to contribute to unacceptable risk to human or ecological receptors at NDL. A comparison of Mix I leachate results to SLVs is provided in Table 19 of the Final WDL TS Report (Attachment 1). Therefore, Mix I is considered protective of NDL and should be considered an effective IRAM for stabilizing WDL sediments.

Phase 6 testing indicates that the final mix composition meets all physical performance and chemical screening criteria. ISS of WDL sediments using Mix I will improve significantly upon current in-situ conditions.

3.4.5 Geotechnical Investigation (2006-2007)

A geotechnical investigation was completed in 2006, and revised in 2007, to evaluate the effects of various WDL remedy components on the BNSF embankment stability. A summary of the geotechnical investigation is provided below. The entire Revised Geotechnical Investigation Report is included as Attachment 2 of this EE/CA. The scope of the geotechnical investigation included the following activities:

- Literature review of previous geotechnical and environmental reports, historical railroad documents, historical photographs, and historical maps of the site and adjacent properties;
- Site reconnaissance to observe the current conditions of WDL and adjacent sections of the BNSF embankment;
- A geophysical investigation to evaluate the condition of shallow soils near WDL, and to estimate the geometric configuration and structural makeup of the BNSF embankment;
- Field data collection, consisting of eight cone penetration test (CPT) soundings, two flat plate dilatometer (DMT) soundings, three mud-rotary borings, and one sonic boring;
- Laboratory testing of relatively undisturbed soils for moisture content, dry density, grain size, plasticity, consolidation-related properties, and triaxial strength;
- Settlement analysis, including traditional settlement calculations and finite element computer modeling (FEM) using the computer program PLAXIS version 7.12; and
- Identification of geotechnical concerns related to the construction of the proposed WDL IRAM, and recommendations for monitoring systems and an action plan to address potential settlement during IRAM implementation.

The conclusions reached as a result of these activities indicate that the proposed fill at WDL will cause relatively insignificant settlements beneath the crest of the BNSF embankment, with somewhat greater settlements at the toe of the BNSF embankment and the center of WDL. Settlements at the crest of the BNSF embankment are expected to range from 2.9 to 4.9 inches following the final remedy, with most of the settlement occurring over a period of 15 days to 21 months. Settlements at the toe of the BNSF embankment are expected to range from 10 to 21 inches. The potential settlement differential between the crest and the toe of the BNSF embankment may cause additional embankment cracking or may exacerbate the existing cracks in the embankment.

Additionally, FEM and slope stability analysis indicate that dewatering the embankment and/or excavating unsolidified lake sediments at the toe of the railroad embankment would create unacceptable risks to the railroad embankment. Dewatering alone, which would be necessary to affect any successful unsupported excavation and replacement operation, would result in slope stability factors of safety below 1, imposing unallowable risk to property and public safety (e.g., Amtrak trains on the embankment). Removing sediments would further increase the risk via three significant mechanisms: (1) additional slope failures; (2) differential settlements; and (3) heaving of lake sediments, most likely undermining the embankment. Additional information on this topic can be found in Section 4.1.2 and Attachment 2.

It is expected that any potential settlement of the railway at the crest of the embankment associated with an ISS remedy will be mitigated by implementing a settlement monitoring program and by routine railway maintenance prior to, during, and following construction. Overall, FEM calculations indicate that the proposed ISS remedy will help stabilize the embankment slope, although, some minor sloughing of the slope might occur following construction.

As previously stated, the entire Revised Geotechnical Report is provided as Attachment 2 to this report. Additional discussion of geotechnical constraints associated with implementation of a WDL IRAM is presented in Section 4.1.2 and Section 6.2. Section 6.2 also provides an evaluation of excavation methods that were considered for potential sediment removal activities at WDL.

4.0 WDL CONCEPTUAL SITE MODEL

The WDL CSM presented in this section is based on findings and conclusions reached during the studies summarized in Section 3.4, as well as on the available knowledge of historical facility operations and the known filling history of Doane Lake as presented in Section 3.2.

4.1 WDL Subsurface Conditions

The following sections describe the subsurface conditions at WDL and those conditions that could impact the selection of a remedial action for the WDL IRAM.

4.1.1 WDL Lithological Characteristics

WDL sediment is defined by the BNSF railroad embankment on the north and west, and the toe of the slope of WDL to the south and east where BNSF property adjoins the RP (LA) and ESCO properties.

WDL sediments primarily consist of very soft to soft, black to gray, silts and silty sands. Permeability test results indicate a range of 10^{-7} to 10^{-8} cm/sec for particle sizes ranging from clayey sands to high plasticity silts. Coarse materials, believed to have sloughed off the railroad embankment, were often encountered on the northern edge of WDL where borings were advanced very close to the BNSF embankment. Black and gray sands, believed to be foundry sands from the ESCO property, are generally only encountered in borings completed in the northern half of WDL, which is adjacent to ESCO property. The maximum depth beneath the sediment/water interface at WDL where impacted sediment was visually observed is approximately 11 feet. The total depth explored beneath WDL is 20 feet. A simplified cross section of WDL, based on all explorations completed to date, is provided as Figure 4.

Debris is observed on the eastern edge of WDL in the LA from historical filling activities conducted within the former Doane Lake. Debris types observed to date includes brick, gravel, wire, concrete, and battery casings. Similar debris might be present within WDL sediments and is believed to be the cause of some drilling refusals during WDL investigations.

The RP property and vicinity have been defined by a geologic CSM and hydrogeologic CSM as presented in the Draft SCE Report (AMEC, 2008a). The geologic and hydrogeologic zones recognized across the RP property and adjacent properties, as previously mentioned in Sections 2.2 and 2.3, also are represented beneath WDL, including the Alluvium, DAG, and Basalt Geologic Zones, and the Fill, Alluvium, Deep Gravel, and Basalt Hydrogeologic Zones.

The most relevant geologic zone to the WDL IRAM is the Alluvium, which includes unconsolidated fill materials and debris, as have been observed at WDL investigations. Beneath WDL, the Alluvium is interpreted to be approximately 60 to 90 feet thick. All explorations to date at WDL have occurred within the Alluvium, and visually impacted sediment is known to be present only in the upper 11 feet of the Alluvium beneath WDL. A lithologic cross section (G-G') illustrating the relationship of WDL and its underlying lithology to the lithologies underlying the RP and vicinity properties is provided as Figure 5.

4.1.2 WDL Geotechnical Considerations

Based on the investigation work completed at WDL, there exist two primary limiting physical conditions that are relevant to an evaluation of removal technologies. These physical conditions include the following:

- Saturated Sediments: WDL sediment is fairly uniform in density and water content. The sampling and testing conducted for both the TS and the geotechnical investigation have shown that a large portion of the sediment is in the “liquid state.” Physical test results from these studies are presented in Attachment 1 (Final WDL TS Report) and Attachment 2 (Revised WDL Geotechnical Investigation Report), respectively. This physical condition constrains which removal technologies would effectively remove sediments at WDL.
- Slope Stability: Both FEM and slope stability calculations/modeling indicate an unacceptable risk to embankment stability as a result of scenarios including dewatering and/or excavating sediment from the toe of the existing embankment without support, or over a large area (Attachment 2, Revised WDL Geotechnical Investigation Report).

These limiting physical conditions are used as the basis for evaluating removal technologies in 6.3.4.

4.1.3 WDL Chemical Impacts

The findings of all the investigations completed at WDL to date indicate that the most highly impacted sediment is located at the southern end of the lake. Discontinuous NAPL blebs were observed in multiple borings completed within the southern 75 feet of WDL. NAPL was observed between approximately 3 and 11 feet bswi in three locations associated with one boring each from the 2004 leachability analysis sampling (WDL-201-S), the 2005 sediment characterization (W002), and the 2006 and 2008 bulk sediment sampling (TS-1). Though NAPL was not directly observed at the 2002 RRI boring WDL-101-S during exploration, indirect evidence suggests NAPL is present at this location based on positive UV light tests and the presence of NAPL blebs in a nearby surface water sample collected during the same investigation. Figure 6 depicts the locations of these borings and the estimated extent of NAPL-affected sediment.

COI concentrations are generally the highest at the southern end of WDL, with the exception of PAHs and some metals. Maximum constituent concentrations are typically found in samples collected from depths of 4 to 8 feet bswi.

4.2 WDL Fate and Transport

Due to some uncertainty regarding the current hydrologic relationship between WDL and NDL, the potential for transport of COIs from WDL to NDL under post-IRAM conditions (assuming an ISS remedy) was evaluated. The following discussion first summarizes the relevant hydrogeologic zones and their relationships to each other, to WDL, and to NDL, then describes the 1-dimensional transport evaluation completed as part of the TS (as described in Section 13.3.2 of Attachment 1).

The most relevant hydrogeologic zones to the WDL IRAM are the Fill and Alluvium Zones. Water in the southern portion of WDL is the surface expression of the water table, with water levels at the monitoring wells closest to WDL (RP-04-16, RP-15-25, W-08-26, W-09-D(38), RP-18-30, RP-06-30, and MW-03-S(27)) typically at 10 to 15 feet bgs. Based on the shallow occurrence of groundwater at these monitoring wells, and their location within the former Doane Lake footprint, they are considered Fill Zone wells. Prior water balance evaluations completed for the RP Site indicate that water is lost through evaporation and discharge from the northern portion of WDL to groundwater, and that water is gained from stormwater runoff from the LADD and groundwater recharge in the southern portion of the lake (AMEC, 2005b).

A downward vertical gradient is present in the Fill Zone, indicating that it is connected to the underlying Alluvium Zone. The Fill Zone is not directly hydraulically connected to the River, based on water level measurements near the River collected by LWG and as part of an ongoing RP property transducer evaluation, but it is indirectly connected via the Alluvium Zone. The hydraulic conductivities measured in both the Fill and Alluvium zones, based on slug test results, are generally less than 1 foot per day (AMEC, 2008a).

Water levels measured in NDL are lower than those measured in WDL, suggesting these two surface water bodies are not hydraulically connected via the Fill Zone. Historically, a connection might have existed between the two water bodies when the configuration of the former Doane Lake and NDL were significantly different.

Following the completion of the WDL remedy, the closest potential exposure point for either a human receptor consuming fish or for ecological receptors will be at NDL. The EPA screening model (BIOSCREEN [Newell and McLeod, 1996] version 1.4, July 1997) was used to estimate hypothetical NDL exposure point concentrations (EPCs) via 1-dimensional transport for organic constituents exceeding bioaccumulation or ecological SLVs in Phase 6 leachate. Two scenarios were evaluated, including a representative-case and a worst-case. The BIOSCREEN-estimated concentrations for all organic constituents exceeding SLVs in Phase 6 leachate meet their respective SLVs at NDL, assuming conservative representative-case conditions and no biodegradation over the model duration of 30 years post-stabilization. These model results indicate that transport of COIs from WDL to NDL at concentrations greater than applicable screening criteria is not anticipated because the analytes effectively degrade in the groundwater system before they can reach potential receptors at NDL. A complete description of the 1-dimensional transport evaluation and the results are presented in the Final WDL TS Report (Section 13, Attachment 1).

SLLI initially attempted to use the geochemical model PHREEQC (Parkhurst, 1999) to evaluate the potential for transport of metals. PHREEQC is a United States Geological Survey (USGS) code for simulating chemical speciation, batch-reactions, one-dimensional transport, and mixing scenarios for waters of differing geochemical compositions. SLLI evaluated a mixing scenario between WDL TS leachate results and WDL area groundwater to simulate potential precipitation reactions. SLLI also simulated an advection-transport scenario representing leachate transport between the WDL monolith and NDL area groundwater. However, based on the small size of the geochemical data set for the groundwater in the WDL vicinity, and the inherent sensitivity of geochemical modeling, SLLI has elected not to use the results from the modeling exercise due to lack of information on several potentially important input variables.

Instead, SLLI conducted a semi-quantitative evaluation of hypothetical groundwater transport from WDL to NDL. This evaluation consists of a series of comparisons of the metals detected in Mix I leachate that exceed SLVs at the monolith, to the following three sets of analytical results: (1) untreated sediment leachate, (2) groundwater from the wells surrounding WDL shown on Figure 6, and (3) to current conditions at NDL. The current sediment conditions and groundwater fate and transport conditions are believed to have existed at WDL for several years. The intent of these comparisons is to demonstrate that, under current conditions and under post-stabilization conditions, inorganic materials leaching from WDL sediment do not reach the potential surface water exposure point at NDL at concentrations that result in unacceptable risk.

Based on the results of this semi-quantitative evaluation, inorganic materials that may leach from the WDL monolith do not pose unacceptable risk to receptors in NDL when the Mix I leachate results are compared with pre-stabilization leachate concentrations, with current conditions at NDL, or with concentrations detected in groundwater surrounding WDL. The lines of evidence to support this conclusion for each metal detected in Mix I leachate at concentrations exceeding SLVs, are presented separately for human and ecological receptors in Section 13.3.1 of Attachment 1.

Given what is known about the hydrogeologic characteristics of the Fill and Alluvium Zones, including their low hydraulic conductivities and the results of the transport evaluation, COIs in WDL leachate are not likely to reach receptors at either NDL or the

River at concentrations that would pose an unacceptable risk. In addition, it is important to remember, as previously mentioned, that the WDL IRAM is not intended to be a single, standalone remedy, but rather one of a series of remedial actions that together comprise the site-wide remedy. Post-construction monitoring of conditions in WDL, NDL, and groundwater near these water bodies would allow any potentially unfavorable response to be identified and additional remedial components designed to address any resulting potential risk.

5.0 REMEDIAL ACTION OBJECTIVES AND CRITERIA

The purpose of this EE/CA is to evaluate applicable remedial technologies that could be used as an IRAM for WDL sediment, and to ultimately recommend a remedial alternative that will satisfy WDL RAOs. The remainder of Section 5 of this document presents a discussion of WDL RAOs and the screening/performance criteria required to evaluate whether those RAOs are likely to be satisfied by the remedial alternatives. These topics are presented here to prepare for discussion of the identification, screening, and selection of remedial technologies in Section 6 below.

5.1 Remedial Action Objectives

RAOs are site-specific goals established to protect human health and the environment. The RAOs provide a framework for developing and evaluating remedial action technologies (DEQ, 1998). Five RAOs have been identified for this WDL EE/CA:

1. Minimize or eliminate direct human exposure to WDL COIs in surface water/sediment.

2. Minimize or eliminate direct ecological receptor exposure to WDL COIs in surface water/sediment.

3. Reduce the potential for WDL COIs to migrate from sediment to groundwater at concentrations greater than screening or performance criteria (Section 5.2), where human receptors, such as a future excavation worker, may potentially be exposed.

4. Reduce the potential for WDL sediment to serve as a source of COIs that potentially could leach to groundwater above the screening or performance criteria and discharge to the River, where potential exposures to human and ecological receptors may occur.

5. Reduce the potential for WDL sediment to serve as a source of COIs that potentially could leach to groundwater above the screening or performance criteria

and discharge into NDL, where potential exposure to human and ecological receptors may occur.

To aid in evaluating the likelihood that a given remedial technology can achieve these RAOs, a set of screening and performance criteria were developed to apply to any COIs that might leach from WDL sediments to groundwater after the remedial action is completed. These screening criteria were presented to DEQ during a September 23, 2008 progress meeting, and subsequently, including summary tables and backup materials, for DEQ review on October 23, 2008 (submitted via e-mail). The screening criteria are described in Section 5.2 below.

5.2 Selection and Development of Screening and Performance Criteria

Any selected remedy would successfully eliminate potential direct contact between human or ecological receptors and surface water or sediment in WDL because all remedial options under consideration lead to filling and capping WDL. As part of the WDL TS, screening criteria were selected and performance criteria were developed to evaluate the ability of each mix design to minimize the COI concentrations that might leach from the stabilized WDL sediment to groundwater once the ISS remedy is completed. Performance criteria were developed for future human receptors potentially exposed to COIs that might be leached to groundwater from the WDL sediment monolith following stabilization. This scenario specifically considers possible exposure to a hypothetical excavation worker. There are no future ecological receptors at WDL because WDL will no longer exist after the IRAM has been implemented.

Screening criteria were selected for receptors at NDL based on the potential for WDL leachate to be transported via groundwater migration to potential future receptors at NDL, including humans that might be exposed through fish consumption, and ecological receptors that either reside in or at WDL, or frequent NDL for food.

While these screening and performance criteria were developed as part of the evaluation of ISS technology, it should be noted that they are equally applicable to all other evaluated technologies. As pointed out in recent documents by the National Academy of Sciences (NAS, 2007) and the USACE (USACE, 2008), all dredging techniques leave behind some residual materials. As mentioned previously, it is critical to evaluate the proposed WDL IRAM as a single, but necessary, *component* of a larger remedial action program for the RP Site.

Table 1 summarizes the human health and ecological screening criteria used to evaluate WDL TS results. The selection and development of these criteria are described in detail in Section 7 of the Final WDL TS Report (Attachment 1). As previously stated, following the completion of the WDL remedy, the closest potential exposure point for either a human receptor consuming fish or for ecological receptors will be at NDL. The EPA BIOSCREEN model was used to calculate potential EPCs in NDL for organic constituents that may leach from the WDL monolith. SLLI conducted a semi-quantitative transport evaluation comparing the metals detected in Mix I leachate and that exceed SLVs at the monolith, to the following three sets of analytical results: (1) untreated sediment leachate, (2) groundwater from the wells surrounding WDL shown on Figure 6, and (3) to current conditions at NDL. A complete description of the organic and inorganic constituent transport evaluations and the results can be found in Section 13 of the Final WDL TS Report (Attachment 1).

The screening and performance criteria described above have been integrated into consideration of remedial technologies presented in Section 6 below. Depending on the individual technology, the discussion and application of these criteria to the specific technology may be either quantitative or qualitative in approach.

6.0 IDENTIFICATION, SCREENING, AND SELECTION OF REMEDIAL TECHNOLOGIES

This section presents the applicable relevant and appropriate requirements (ARARs, Section 6.1), and identifies, evaluates, and screens a selection of remedial technologies for the WDL IRAM (Sections 6.2 and 6.3). The retained technologies will be used to assemble the IRAM alternatives in Section 6.4. A detailed description of the remedial alternatives is presented in Section 7 and a detailed evaluation of the remedial alternatives is presented in Section 8.

6.1 Selection of Remedial Technologies

The remedial technologies potentially applicable to WDL sediment can be divided into four categories:

A. <u>Institutional Controls:</u> No remedial measures are taken; instead, institutional controls, such as deed restriction, are implemented to minimize contact;

B. <u>Engineering Controls:</u> Physical remedial measures are implemented, such as capping, barrier wall, and other physical means of containment or control;

C. <u>Treatment:</u> Physical and/or chemical treatments are implemented so that COI quantity, toxicity, or mobility are reduced or eliminated; and

D. <u>Removal:</u> The impacted sediment is removed, in part or whole, and disposed of or treated.

The technologies are identified and briefly described in Section 6.2, and they are evaluated and screened for retention in Section 6.3. Table 2 summarizes the technologies evaluation and selection.

6.2 Identification of Remedial Technologies

The technologies identified for WDL sediment are described below for each category. The treatment technologies can be further divided into in-situ and ex-situ classes. The removal technologies can be divided into unsupported excavation, supported excavation, and disposal classes. The technologies described in this section were originally presented to DEQ at the September 23 and October 9 progress meetings.

6.2.1 Institutional Controls

Deed Restriction - A deed restriction will identify the presence and nature of the hazards at WDL on the deed. Typically, the area and the nature and concentration of COIs are permanently recorded on the deed, which is filed with the local authority and available to the public. This technology will provide a warning and restriction to certain activities (e.g., excavation) to the present and future property owner(s), as well as the public.

Signage – Posting signs at WDL will alert humans to the presence of hazards at WDL, thus warning them against coming into contact with the lake sediment. SLLI has posted signage at WDL warning potential trespassers of its hazards. The signs were posted in January 2009.

6.2.2 Engineering Controls

Fencing - Installing a perimeter fence will create a physical barrier and prevent humans and large terrestrial animals from coming into contact with the impacted sediment.

Barrier Wall – This technology creates a subsurface perimeter barrier wall to minimize conveyance of COIs to the surrounding area by the groundwater. Barrier walls can be constructed by different techniques, such as sheet piles, slurry walls, vibrating beam walls, and columns. Barrier walls rely on their low permeability to minimize the flow-through of groundwater. Barrier walls are typically one of two types: cutoff or hanging. A cutoff barrier wall is characterized by a wall that is keyed into an aquitard to minimize flow under the wall; a hanging barrier wall is terminated within a porous layer but below the depth of concern. Barrier wall technology will be evaluated as part of site-wide remedial action and, therefore, is not discussed further for the WDL IRAM.

Capping – Installing an aboveground cap over the impacted sediment would prevent direct contact by human and ecological receptors, and minimize stormwater infiltration through the impacted sediment. Caps are usually constructed with several layers of earthen and/or geosynthetic material with a crowned surface to promote stormwater runoff and, thus, minimize the potential for infiltration.

6.2.3 Treatment

In-Situ

Monitored Natural Attenuation (MNA) – This technology uses the ongoing natural processes to break down the organic COIs, thereby reducing their quantity and toxicity. The progress is measured by monitoring (i.e., sampling) the impacted media, such as groundwater, on a schedule and evaluating the changes over time.

Enhanced Aerobic Bioremediation – This technology is used to accelerate in-situ aerobic bioremediation of COIs by indigenous microorganisms in the subsurface. Enhanced aerobic bioremediation technologies provide a supplemental supply of oxygen to the subsurface, and include: biosparging; bioventing; use of oxygen releasing compounds; pure oxygen injection; hydrogen peroxide infiltration; and ozone injection. The enhancement of oxygen, coupled with the presence of trace nutrients (bio-available forms of carbon, nitrogen and phosphorus, or augmentation with microbes), stimulates the growth of hydrocarbon-degrading bacteria. This technology is typically not employed within heavily contaminated source areas.

Enhanced Anaerobic Bioremediation – This technology is also used to accelerate naturally occurring in-situ anaerobic bioremediation of COIs by indigenous microorganisms in the subsurface. Typically, this remediation technique involves the introduction of carbon sources to act as electron donors for chemical reduction reactions, and requires the presence of trace nutrients (bio-available forms of carbon, nitrogen, and phosphorus, or augmentation with microbes). Typically, the reductive dehalogenation (e.g. dechlorination) of COIs occurs, along with changes to the valence states of metals. This technology can also be implemented by the construction of permeable reactive barriers utilizing zero-valent iron or other compounds which can create anaerobic conditions in the subsurface.

Chemical Oxidation – This technology puts strong oxidants (e.g. hydrogen peroxide, persulfates) into contact with COIs. The oxidant molecules strip electrons from the COI molecules, leading to degradation or chemical alteration of the COIs and to decreases in COI mass, concentration, and toxicity. .

In-Situ Soil Heating – This technology involves the addition of heat to the subsurface environment, leading to volatilization and capture of organic COIs. Typically, the heating is generated by one of three methods - electrical resistance heating, in situ thermal resistor heating, or steam injection. The first two methods involve insertion of electrodes into the sediment at relatively small spacing and applications of electric current to increase the temperature of either the heater probe or of the sediment media itself. Steam injection involves the use of specialized injector tools. Heating methods require an effective vapor recovery component.

Air Sparging and Soil Vapor Extraction (AS/SVE) – This technology involves introducing pressurized air to saturated sediment and applying a vacuum, typically to the vadose zone, to capture the volatilized organic COIs. Collected vapors are typically burned, oxidized, or sorbed to carbon.

Stabilization – This technology involves mixing the sediment with cement and other additives that will fixate COIs and, thus, reduce their mobility. The process involves mixing a slurry at a batch plant using water and stabilization/solidification admixtures, then pumping it to a deep soil mixing rig via hoses. The mixing rig will be equipped with a hollow-stem Kelly bar, where the slurry will enter from the top. A mixing head or attachment to the Kelly bar, such as multi-pronged arms or an auger with mixing paddles, will stir the sediment by rotating and penetrating. While the sediment stirring occurs, the slurry is ejected from the tip of the mixing head, thus mixing the sediment and slurry. The assembly is raised and lowered several times while rotating, thus homogenizing the mass.

Ex-Situ

Soil Washing – This technology involves excavating the sediment, washing it with one or more appropriate chemical solutions followed by clean water under carefully controlled conditions to remove the COIs, and then treating the rinsate to remove COIs prior to water discharged. The “cleaned” sediment would then be returned to the excavation as backfill.

6.2.4 Removal

Unsupported Excavation

Trackhoe Excavation – Normally, technology uses a standard trackhoe to excavate the sediment. To excavate using a trackhoe, the sediments must be solidified sufficiently to support the weight of the machine and to facilitate sediment handling. Long reach, or long “stick”, trackhoes can be used to excavate sediments without placing the machinery on top of unstable sediment.

Clamshell Excavation – This technology uses a standard clamshell to excavate the sediment.

Vacuum Truck – This technology uses vacuum trucks to remove the sediment.

Trenching Equipment – Trenching equipment allows the sediment to be continuously excavated and backfilled in a trenching sequence. The sediment is removed by a series of small buckets attached to a large chain, rotating around an extension arm. The buckets empty the sediment on the ground surface. The machine may be equipped with a backfill hopper, where the backfill will fall into the cavity created by the excavation. To do this, the sediments must be solidified sufficiently to support the weight of the machine.

Railroad Embankment Support Systems – These technologies are not directly related to the remediation effort, but are required to provide structural support and safety for the embankment to allow unsupported excavation of the sediment to proceed. Some examples of embankment support systems are sheet pile walls, soil nailing, grout injection, and soldier piles.

Supported Excavation

Trench Box – This technology uses a standard, open-ended trench box to allow removal of the sediment.

Open Casing – This technology involves inserting or driving an open-ended casing into the sediment and then evacuating the sediment from inside the casing by a standard solid stem or bucket auger.

Portable Box – This technology uses a closed-ended trench box or a prefabricated portable cofferdam to allow removal of the sediment.

Cofferdam – This technology involves driving sheet piles in an enclosed pattern to create a box to allow removal of the sediment. Once the backfill is completed within the cofferdam, the sheet piles are removed for reuse. Cofferdams can be constructed in different shapes and sizes.

Disposal

On-Site – This disposal approach involves excavating the impacted sediment and permanently storing the sediment on-site within the contamination area and above the groundwater table.

Off-Site – This disposal approach involves transporting and disposing the excavated sediment at an off-site landfill.

Incineration – The disposal approach involves transporting the excavated sediment to an incineration facility where it is treated by high heat to incinerate the COIs. Ash, slag, and metals/minerals dusts from the incinerator are placed into a landfill.

6.3 Screening of Remedial Technologies

The remedial technologies are evaluated qualitatively in this section with respect to the RAOs and the technology feasibility as determined by the following balancing factors: (1) effectiveness, (2) long-term reliability, (3) implementability, (4) implementation risk, and (5) reasonableness of cost. The evaluation described in this section focuses on the balancing factor that limits the technology. Each category of technologies is discussed separately in the following sections, and a complete evaluation summary is presented in Table 2.

6.3.1 Institutional Controls

No institutional controls are retained for further evaluation in this EE/CA (Table 2). Deed restriction is beneficial to inform the public and the future property owners of the site conditions. While deed restriction is not retained for further discussion in this EE/CA as a primary remedy, it may be included as part of the final selected remedial package for the WDL IRAM.

Signage is a reasonably effective, reliable, implementable, and low-cost technology to inform humans about potential dangers. Signs were posted at WDL and will be maintained until the IRAM is complete; therefore, signage is not retained for further discussion as part of the WDL IRAM. The existing signage at the RP property and vicinity will be maintained as part of site-wide remedy and maintenance.

6.3.2 Engineering Controls

Only one engineering control, capping, is retained for further evaluation in this EE/CA (Table 2).

Fencing is an effective, reliable, implementable, and low-cost technology to prevent human and large terrestrial receptors from coming into contact with the impacted sediment. This technology is already in place and will be maintained as part of site-wide remedy; therefore, fencing is not retained for further discussion as part of the WDL IRAM.

Barrier wall technology is an effective, reliable, implementable, and relatively low-risk technology with moderate installation cost. This technology will be considered as part of site-wide remedy, which will include the southern portion of WDL where NAPL-affected sediment is present; therefore, barrier wall technology is not retained for further discussion as part of the WDL IRAM.

Capping effectively prevents human and ecological receptors from coming into contact with the sediment. In addition, it reduces stormwater infiltration and, thus, reduces generation of leachate from the sediment. Capping meets RAOs 1, 2, and 3, and helps to satisfy RAOs 4 and 5. This technology is proven in the field as a reliable, implementable, and low-risk technology with moderate installation cost; therefore, it is retained for the WDL IRAM.

6.3.3 Treatment

Two treatment technologies, MNA and stabilization, are retained for further evaluation in this EE/CA (Table 2).

MNA is somewhat effective, reliable, and implementable, and it has little or no risk and a low cost. While this technology does not meet the RAOs, it contributes to them, especially as a follow-on component to more active remedial technologies. Therefore, MNA is retained for further discussion as part of the WDL IRAM.

Aerobic bioremediation, anaerobic bioremediation, chemical oxidation, reduction by zero-valent iron, and AS/SVE are moderately effective for some organic compounds, but implementability is prohibitive at this location because these technologies require somewhat uniform air or substrate/additive circulation and distribution throughout the sediment. The wide range of COIs present in the sediment limit the effectiveness of any one of the technologies. The relatively low porosity/permeability of the lake sediments (Tables 2 and 15 of Attachment 1) prevents adequate circulation of treatment media through the sediment. There is no vadose zone above the lake sediment, so vapor capture by SVE would require a large cover infrastructure across the entire lake. In addition, equipment needed to implement these technologies cannot get access over the soft sediment unless it has been solidified. Furthermore, these technologies address only a limited list of organic COIs, and do not effectively address all constituent classes that drive exposure risk at WDL. Therefore, these technologies are considered to have limited effectiveness and are not implementable for the WDL IRAM. Aerobic bioremediation, anaerobic bioremediation, chemical oxidation, reduction by zero-valent iron, and AS/SVE are not retained for further discussion as part of the WDL IRAM.

In situ heating technologies are effective for a limited list of organics only. They are reliable, and have low risk for implementation. Access over the soft sediment for equipment to implement the technology is not possible unless the sediment has been solidified. These technologies are relatively expensive due to the electricity usage needed to generate high temperatures throughout the sediment, and rank low in terms of sustainability or green remediation factors. The limitation of effectiveness to organic compounds only, coupled with the very high cost, renders these technologies as not feasible for this application; therefore, they are not retained for further discussion as part of the WDL IRAM.

Stabilization is well established, very effective, reliable, and implementable, and it has low risk and moderate costs. With the right mixture of additives, this technology will homogenize the sediment, fixate a large number and quantity of the COIs within the sediment, minimize leaching, and solidify the sediment so that equipment can travel over it. This method will not remove any wet sediment; therefore, it has very low risk during implementation. Once completed, this technology will meet all the RAOs; therefore, stabilization is retained for further discussion as part of the WDL IRAM.

Soil washing is an effective and reliable technology in certain applications; however, it is not easily implementable nor is it likely to be effective in this application, creates a high risk, and is very expensive. To implement this technology, the sediment needs to be excavated in its current fluid state, which will create a safety hazard for the railroad embankment. The issues with embankment stability are discussed in more detail in Section 6.3.4. Handling the wet sediment during excavation and then during soil washing will present a very high risk to the workers due to the high potential for exposure to both liquid and vapor-phase COIs. This technology also has not been shown to reliably reduce COI concentrations present in WDL sediments below acceptable levels. Sediment washing is, therefore, considered infeasible due to limitations on implementation, very high implementation risk, the very high cost, and questions about potential effectiveness. Soil washing is not retained for further discussion as part of the WDL IRAM.

6.3.4 Removal

SLLI has evaluated multiple removal options in this EE/CA. However, the WDL IRAM will take place on BNSF property, and regardless of the implementability of a removal option, BNSF has stated in a letter dated February 6, 2009 that; "*BNSF cannot authorize any excavation below the water table adjacent to the embankment*." The evaluation of removal methods considered for this EE/CA is presented below, and summarized on Table 2.

Unsupported Excavation

As discussed in Section 3.4.5, the slope stability analyses performed on the embankment indicates that the sediment layer within WDL buttresses the embankment, and its removal without immediate backfill would likely create a stability and safety hazard. Therefore, any technology that doesn't allow for immediate backfill or include other means of supporting the embankment will not be considered for this project.

Due to the sediment's fluid nature, excavating the unsupported sediment to the depth of 12 feet would result in a sediment side slope of 10 horizontal to 1 vertical (10H:1V) that would extend a distance of 120 ft from the excavation point. Depending on the backfill material used, the side slope of the backfill could range from 1H:1V to 2H:1V. To avoid commingling the clean backfill with the impacted sediment, a minimum distance of 5 ft of separation between the toe of the sediment and the toe of the backfill would be needed (Figure 7).

This configuration of slopes would result in an exposed embankment surface area of approximately 850 square feet (sq ft) and a volume of approximately 1,800 cubic yards (CY) of excavated sediment. Excavating and backfilling this volume of sediment would require between 3 and 5 weeks to complete. The area of the exposed embankment toe and its exposure duration will create an unacceptable safety hazard.

Installing new structures such as sheet piles to support the embankment would not be possible because the equipment would not be able to travel over the liquid sediment to reach the embankment. Therefore, this technology is eliminated from further evaluation. Furthermore, the technologies that are based on excavating unsupported, wet sediment without backfilling the same day (trackhoe, clamshell, and vacuum truck) are eliminated from further discussion as part of the WDL IRAM.

Several technologies allow for daily backfill of an excavated area. However, the effectiveness of such technologies, where the temporary excavation would stay open and unsupported for a short period, is driven by the solid nature of sediment being excavated. As noted earlier, the existing sediment at WDL is fluid in nature and would fill the excavation as excavation occurs. Backfilling within an unsupported sediment excavation would result in the backfill mixing with the sediment, thus impacting the backfill and negating the removal objective.

Furthermore, excavating liquid sediment using trenching equipment was discussed with a specialty trenching contractor (Dewind One Pass Trenching) and a Ditch Witch® equipment sales representative. Both entities stated that this process would not work in liquid conditions because the excavation is immediately filled with sediment. Based on these discussions, the trenching technologies (e.g., Ditch Witch®) are eliminated from further discussion as part of the WDL IRAM.

In conclusion, the sediment must be stabilized with cement to gain sufficient strength to support the equipment load and allow its unsupported excavation (see photo below). Therefore, sediment stabilization using a soil-mixing technique and excavation via a trackhoe is retained for further discussion as part of the WDL IRAM.

Trench excavated with a track hoe following ISS.

<u>Supported Excavation</u>

Sediment can be safely excavated and backfilled within small support systems. Only two general systems may be considered for such an approach: (1) small portable containers, such as trench box and open casing used to construct deep foundations (e.g., drilled piers), or (2) temporary, small support structures, such as sheet-piling, within the sediment (e.g., cofferdam).

A portable container must be large enough to allow for an excavator or clamshell bucket to enter and remove the liquid sediment. Other removal techniques, such as solid stem or bucket augers, cannot contain the sediment during removal; therefore, a long, rectangular box would be required. Sediment removal must begin from the banks of the lake so that equipment has access toward the railroad embankment over the firm backfill. Placement of such a container to effectively seal the bottom, to prevent intrusion or leaking of the sediment into the box, will require a relatively flat surface. This physical condition does not exist along the banks of WDL, where the initial work must occur. Therefore, trench box, open casing, and other portable box technologies are eliminated from further discussion as part of the WDL IRAM.

Installing a temporary support system will only be possible where the system can be driven into the lake banks, thus creating a temporary wall to hold the sediment and allow its excavation. The only sediment support system that is considered technologically viable is a cofferdam system; therefore, the cofferdam will be retained for further discussion as part of the WDL IRAM.

Disposal

The disposal options presented below were discussed with DEQ at the November 4, 2008 progress meeting. At this meeting, DEQ and SLLI addressed the unknowns currently associated with temporary storage and on-site disposal, and how these unknowns adversely impact SLLI's ability to fairly evaluate an on-site disposal option as part of this EE/CA. As noted below, on-site disposal options are under consideration as part of the final site remedy.

Some sediments in WDL may be classified as dioxin-bearing wastes and could carry the Resource Conservation and Recovery Act (RCRA) F027 hazardous waste code. There are currently no incinerator facilities in the United States that will accept wastes bearing the F027 code. Thus, incinerating the sediments is, therefore, not permissible due to the waste code(s) associated with the sediments. Incineration will not be retained for further discussion as part of the WDL IRAM.

On-site disposal of the impacted sediment requires designing and constructing a permanent on-site containment facility (OCF), or temporary storage within the area of concern (AOC) with final off-site disposal. At this point, because the requirements for on-site disposal are unknown, on-site storage will not be carried forward for further evaluation in this EE/CA. Constructing an OCF and/or temporary on-site storage is under consideration as part of the final site remedy, and also may be considered for other IRAMs that are anticipated to be complete before the ROD is issued for the RP Site.

Off-site disposal of the impacted sediment, assuming Corrective Action Management Unit (CAMU) eligibility, meets the RAOs, and is effective, reliable, and implementable once the sediment is stabilized. This method does have a moderate risk of implementability due to handling and transporting the impacted sediment off site, because of the potential risk for spills or accidents on the road. In addition, there are high greenhouse gas emissions associated with waste transport to distant treatment, storage, and disposal (TSD) facilities. This disposal method is retained for further discussion in this EE/CA.

6.4 Development of Remedial Alternatives

The remedial technologies that have been retained through the screening process for further development as viable alternatives are described in the following sections.

6.4.1 Alternative 1 – No Action

This alternative assumes that no action is taken and the existing site conditions remain. While this alternative obviously does not meet the RAOs, it is used as the baseline for evaluating the relative improvement afforded by other alternatives.

6.4.2 Alternative 2 – In-Situ Stabilization

This alternative treats the impacted sediment in place to meet the RAOs. The required components of this alternative include the following:

1. ISS of the sediment to immobilize the COIs;
2. Installation of an impermeable cap over the stabilized mass to prevent direct contact with the stabilized monolith, to prevent infiltration of stormwater;
3. Monitored natural attenuation as part of a long-term monitoring program; and
4. Stormwater controls to prevent off-site runoff and treatment of any accumulated stormwater that is not used on site in the ISS process. Additionally, stormwater that lands on the clean cap would be collected and either discharged to the City of Portland storm sewer system, or treated post-implementation for a demonstration period, until the City of Portland provides approval for direct discharge.

6.4.3 Alternative 3 – In-Situ Stabilization with NAPL-Affected Sediment Removal and Off-Site Disposal

This alternative involves removing NAPL-affected sediment to mitigate potential contribution of leachate to the groundwater from the most impacted sediment and the NAPL, and replacing it with imported backfill.

Approval for disposing the sediments off site would require a determination of eligibility of the sediment for off-site disposal as a CAMU-eligible waste under 40 Code of

Federal Regulations (CFR) 264.555. Reducing the leachability of COIs from the sediment through stabilization is expected to meet the treatment requirements of the CAMU-eligibility determination process. Additionally, Alterative 3 assumes that the non-NAPL-affected sediments would be treated using ISS. Therefore, stabilization of the entire WDL sediment body (both NAPL-affected and non-NAPL-affected sediments) with the same additive mixtures as that selected for Alternative 2 is assumed.

Two sediment removal technologies were retained in Section 6.3.4: ISS followed by trackhoe removal for dry excavation and cofferdam for wet excavation. ISS and removal would require two steps: stabilization and excavation. Cofferdam technology would require three steps: cofferdam installation, excavation, and ex-situ stabilization. The cofferdam approach would require that cofferdams be temporarily installed and removed in small areas (e.g., 1,000 sq ft) so that the area of excavation and backfill would be within acceptably safe limits to prevent bottom heave.

The extra step of cofferdam installation would have a much higher implementation risk associated with it because the wet sediment must be handled ex-situ, thus increasing the risk of worker exposure to COIs. Furthermore, this extra step would add to the project schedule and cost. Since the cofferdam technology and wet excavation would have higher risk, longer duration, and added cost without offering any additional benefit to the project or the environment, only ISS and trackhoe excavation will be considered as a NAPL-affected sediment removal option.

This alternative has the same components as Alternative 2 plus the removal and off-site disposal of the stabilized NAPL-affected sediment. The NAPL-affected sediment will be stabilized along with the rest of the WDL sediment so that it can be safely removed and meet the requirements of the CAMU process for off-site disposal. The excavated volume of the NAPL-affected sediment would be backfilled with clean, imported fill material.

6.4.4 Alternative 4 – In-Situ Stabilization, Sediment Removal, and Off-Site Disposal

This alternative involves removing all of the stabilized sediment and backfilling with imported material. The components of this alternative are the same as Alternative 3, except that all of the stabilized WDL sediment would be removed and disposed of off site. The excavated WDL would be backfilled with clean, imported material and then covered with an engineered cap.

7.0 DESCRIPTION OF REMEDIAL ALTERNATIVES

This section presents a detailed description of each remedial alternative that was retained above, as well as the construction approach and estimated cost. Table 3a summarizes the costs in 2008 dollars for each alternative, and Table 3b presents supporting information. These costs are accurate to within +50%/-30%. In addition, estimated greenhouse gas emissions for Alternatives 3 and 4 were calculated based on guidelines presented in the EPA *Inventory of Greenhouse Gas Emissions and Sinks*: *1990-2005* (EPA, 2007). These estimates are provided on Table 4a, with supporting documentation on Table 4b.

7.1 Alternative 1 - No Action

This alternative is the existing condition, where no remedial action is taken or remedial measures implemented. No action is used as the baseline for evaluating the relative improvement offered by each other alternative. The existing conditions were described in Section 4, and Sections 6.3.1 and 6.3.2 (signage and fencing, respectively).

7.2 Alternative 2 - In-Situ Stabilization

Components of this alternative are ISS, an impermeable cap, and MNA, a key component of long-term monitoring. ISS would solidify the sediment, reduce its hydraulic conductivity, and immobilize the COIs within the sediment. Following sediment ISS, an impermeable cap would be constructed over the stabilized monolith, which would prevent potential human and ecological receptor contact with the monolith and prevent stormwater infiltration, further reducing leachate generation from the already nearly impermeable stabilized sediment. The cap discussed in this EE/CA is limited to WDL; at a later date, the entire RP property would be permanently capped as part of the final site-wide remedy. The final site-wide remedy cap would tie in to the WDL IRAM cap. Following are the elements of Alternative 2:

- Site Preparation
- Stormwater Management
- Debris Removal
- ISS
- Cap Construction
- Construction Oversight
- Long-Term Monitoring

These elements are discussed in more detail below, and the primary elements of Alternative 2 are shown on Figure 8.

7.2.1 Site Preparation

Site preparation includes installing temporary fencing around the work areas, preparing staging areas including the decontamination area, clearing the work area, installing erosion and sedimentation control measures, and installing temporary and permanent improvements to facilitate the work.

Most of the RP property and vicinity is fenced to prevent unchecked access by human and large terrestrial ecological receptors. Temporary fencing would be installed around the work areas that are not currently fenced. Additionally, temporary fencing may serve as delineation of exclusion zones in certain areas. An estimated 2,000 linear feet (lf) of temporary fencing has been included for cost estimating purposes.

Some of the rainwater that falls on the LA naturally drains toward WDL. At all other areas within the work footprint, surface grades would be modified, constructed, or maintained to eliminate surface flow out of the work area, and to minimize stormwater run-on from outside of the work area. In addition, erosion and sediment control best management practices (BMPs) would be followed, and required engineering controls would be installed to reduce sediment transfer by stormwater, even within the work area.

Subsequently, temporary roads and pads would be installed and existing roads would be improved with imported crushed rock to allow equipment to move around the work area without disturbing the existing grades and generating sediment runoff during storm events. A layer of sacrificial geotextile would be placed first to separate and delineate the crushed rock from the existing site soil. Once the project is completed, the roads would be removed from all non-RP property, unless otherwise directed by the property owner. For cost estimating, a road bed approximately 1 foot deep, 12 feet wide, and 1,500 feet long is assumed.

Two staging areas are envisioned for this project. One staging area would be used to store and place equipment, material, and other supplies for the duration of the project (Figure 8). The batch plant would be positioned within this staging area, where all material delivery and ISS slurry preparation would be conducted. It is anticipated that the staging area would be located on the southwestern portion of the LA, near the RP water treatment plant (WTP), where power and water supplies are available for use. The contractor might elect to place additional crushed rock in this area to serve as a working pad.

The other staging area would serve to handle impacted material and debris removed from WDL, as well as other miscellaneous waste that would be transferred off site for disposal. This waste staging area would likely be migrated along WDL as the work progress.

Water and power would be needed for the batch plant. The batch plant would likely have a 20,000-gallon water storage capacity to maintain a steady supply of water. The water would be transferred from a source near the WTP by pump(s) and hoses. Additionally, the existing water in WDL at construction, and any accumulated stormwater within the work area, would be transferred into this tank so it could be used to prepare the ISS slurry. Overhead power is available near the south end of WDL; additional poles and appropriate transformers would be installed to supply the ISS staging area and extended further to WDL as needed, to feed the stormwater pumps described below.

7.2.2 Stormwater Management

The stormwater generated within the work area for the project duration would be collected and either used in the ISS slurry batches or transferred to the existing WTP and treated and discharged under the existing industrial National Pollutant Discharge Elimination System (NPDES) permit. Two lift stations would be installed, one each at the south and north ends of WDL. Each lift station would be a precast concrete manhole equipped with a pump and level controls. Power to the lift stations would be supplied by extending the available overhead power near the LA Pilot Study compound to the lift stations. The controls for each lift station would be installed locally, next to each lift station.

The north lift station would pump the accumulated stormwater to the south lift station. From there, the water would be lifted to either the batch plant storage tank(s) or to the WTP. All stormwater conveyance piping would be installed aboveground to eliminate the need for excavation and associated waste management. During IRAM implementation, the piping would be temporary 4-inch flexible hoses to allow unobstructed traffic movement.

Following remedy implementation, fixed, aboveground piping would be installed to transfer stormwater across the ESCO property over its closed landfill, as well as from the south lift station across the Lake Area to the WTP. This method of stormwater management would be used until approval is received from DEQ and the City of Portland to discharge stormwater from the WDL cap directly to the municipal storm sewer. One line would be installed from the north lift station along WDL to the midsection of the lake, where it would discharge on the cap surface and flow in a surface ditch to the south lift station. Another line would be installed from the south lift station to the WTP. Stormwater lines would be 6-inch diameter, high-density polyethylene (HDPE) pipes installed on aboveground concrete pedestals, positioned approximately every 15 feet. Each concrete pedestal would be anchored into the ground by a steel helix anchor (auger type). The pipes would be fastened onto saddles on each pedestal. This approach would prevent excavation within the upland area, resulting in less waste requiring management and disposal and greater flexibility for implementing future remedy components that would be part of the final site-wide remedy. The pipes will be equipped with valves and cleanouts for long-term maintenance. An estimated 1,000 linear feet of piping and 70 pedestals would be needed.

7.2.3 Debris Removal

As a result of the historical activities and fill placement, miscellaneous debris is present on the banks of WDL and in WDL sediment. The known debris primarily consists of brick, cobbles, steel rebar, wire, and boulder-sized pieces of concrete. The debris would be removed, rinsed, and disposed of off site as hazardous waste.

The surface debris along the east bank of WDL would be removed by an excavator, rinsed off by a fire hose over the lake, and placed directly into trucks or roll-off bins for off-site shipment and disposal. The debris within the sediment would be removed daily as the ISS progresses. Debris would be removed ahead of ISS by an excavator with a three-prong hydraulic arm grapple attachment, or similar equipment, for grabbing large items. The attachment will be placed in the sediment and dragged from one side to the next, to find and remove large pieces of debris that will interfere with ISS. Upon removal, the debris would be washed over the lake using fire hoses and placed within the aforementioned staging area that would be migrated along the length of WDL as ISS progresses. An excavator would then transfer the debris into roll-off bins for off-site shipment and disposal.

For cost estimating, the debris layer is assumed to be equal to a 3-inch thick layer of concrete along the length and width of the banks of WDL on the ESCO and RP properties, which is approximately 18,000 square feet (shown in yellow on Figure 8) and a 2-inch thick layer of concrete over the WDL surface area of approximately 48,000 square feet (shown in blue on Figure 8). These quantities are equal to a volume of approximately 450 CY and a weight of 900 tons.

7.2.4 ISS

The stabilization rig would be a tracked machine comparable to a 150-ton crane. It would likely approach WDL from the north, and stabilize the sediment daily in segments progressing south. The north berm of the lake, currently separating the lake from the nearby street, would be removed temporarily to allow for rig access to WDL. The excavated berm material would be stockpiled until the rig is past the berm footprint, then the berm would be reconstructed.

The ISS slurry would be prepared in the batch plant, using the additives and ratios determined to be optimal during the WDL TS. The contractor would determine the best approach to adding the ingredients to the mixing tank. Cement might be delivered to the ISS staging area in bulk and stored in a portable silo, or delivered in super sacks. Bulk cement may be transferred directly into the mixing tank by electronic controls, but super sacks would be handled manually. Super sacks hold between 1 and 2 tons of material (e.g., cement, clay, etc.). They will be moved by a forklift, using the straps on top of the sack. Most sacks also have a bottom “throat” that is tied shut. A forklift would position the sack over a hopper, and then the bottom tie is opened to release the cement into the hopper. The batch plant operator would control how much cement is transferred from the hopper into the mixing tank electronically. Similarly, other admixtures would be added from super sacks or smaller bags.

The rig (see photograph) can travel only over the sediment that has been stabilized and has gained sufficient strength to support the weight of the rig. The project objective is to achieve an ultimate strength of 50 psi. However, a lower strength of approximately 20 psi would be sufficient to allow rig access. The contact pressure of the rig can be reduced by placing crane mats to spread the weight of the rig over a larger area. ISS would reach sufficient strength to support the weight of the rig in 1 to 3 days. The rig would be large enough to reach forward for up to 3 days of stabilization from the same position. After 3 days, the sediment would reach sufficient strength to support the weight of the rig, allowing the rig to move forward over the stabilized sediment.

Soil would be mixed using a circular cutting head with cutting teeth or mixing blades (see photo below). ISS slurry would be pumped to the hollow stem Kelly bar of the rig and then be continuously ejected from the tip of the cutting head. The soil would be mixed by auger action as the ISS slurry is introduced into the soil. The mixing would continue until the entire column of soil is homogenized with the ISS slurry and a uniform “grout” is formed. Mixing would continue in this fashion, with overlapping columns, to achieve 100% mixing of the sediment. The column rows and spacing would be established daily by premeasured tapes prior to the start of work.

Subsequent rows would be offset to a predetermined distance based on the cutting head diameter to assure overlapping columns.

Deep soil mixing rig showing auger head with grout spraying from cutter head.

The total volume of sediment to be stabilized is 48,000 square feet to the depth of 12 feet, or 21,300 CY. Based on an average production rate of about 200 cy per day, stabilization would require about 106 working days or 18 calendar weeks (6-day work weeks) to complete. ISS is expected to increase the sediment volume by approximately 30%, resulting in approximately 4 feet of vertical rise. Final sediment surface grades, on average, are expected to be approximately 10 feet below the upland grades. Stabilized sediment would be graded to create a smooth surface for cap installation.

7.2.5 Cap Construction

The cap would consist of a multi-layered system of imported earthen and geosynthetic material with appropriate stormwater collection features and slopes, designed to prevent surface water infiltration from reaching the stabilized sediment. The approximate surface area of the cap in plan view would be 90,000 square feet. Figure 9 shows the conceptual cross section of the cap; the layers are described below.

A 1-foot thick clay layer would be placed over the stabilized sediment and WDL banks to seal the surface. The clay layer would be graded to slope away from the railroad embankment toward the east WDL bank at a slope of approximately 1%. The clay layer would be overlain by geosynthetic clay liner (GCL) to provide a seal and working surface for installation of a geomembrane. A 40-mil thick, HDPE geomembrane would be installed over the GCL, and separate geomembrane segments would overlap a minimum length of 1 foot and be welded. The geomembrane would extend up the banks of WDL and be anchored in shallow trenches.

A geotextile-wrapped, 6-inch diameter, perforated HDPE pipe would be installed at a low point in the surface of the GCL, near the east bank of WDL, to collect infiltrated stormwater. The pipe would be sloped to the north and south to drain into the stormwater lift stations at a slope of approximately 0.5 to 0.6%.

The geomembrane and the pipe would be covered with a 1-foot thick layer of free draining sand, which would be covered with a layer of filter geotextile to minimize siltation and subsequent clogging of the drainage sand. Structural fill would be placed over the geotextile in compacted layers to the desired grades and would have a crest in the middle of WDL, at the toe of the railroad embankment, and slope down to the north and south and toward the east bank, at about 0.5%. This grading would direct the stormwater runoff toward the north and south stormwater lift stations.

The structural fill would be covered with a layer of 6-mil plastic sheeting to demarcate the fill and then covered with a 1-foot thick layer of topsoil. A surface swale would be constructed to collect the stormwater runoff from the cap and direct it to the north and south stormwater lift stations. The topsoil and the swale would be hydroseeded to maintain a vegetative cover.

7.2.6 Construction Monitoring

During construction, all work aspects would be monitored for Quality Control/Quality Assurance (QC/QA), worker safety, environmental conditions (i.e., ambient air quality, noise levels, and dust control), and adherence to the construction plans and specifications.

Ambient air within the workers breathing zone and the work areas would be monitored for dust and vapor generation using real-time monitoring equipment and sampling and analysis. Engineering controls and appropriate personal protection equipment (PPE) would be used to keep worker exposure below Occupational Safety and Health Administration's (OSHA's) permissible exposure limits (PELs).

The existing railroad embankment would experience settlement along its toe and crest due to increase of the mass within WDL. Settlement monitoring points would be established on the embankment to electronically monitor three-dimensional movement of the embankment by dedicated instrumentation. Subgrade settlement and, in turn, embankment settlement, would be slow enough to be detected and, if necessary, mitigated. The geotechnical evaluation, summarized in Section 3.4.5, indicates the embankment settlements would be within its tolerance and should not create a safety hazard that would require mitigation. Any railroad track adjustment due to settlement is expected to be within the tolerances managed by BNSF as part of their routine track maintenance.

ISS quality and effectiveness would be monitored continuously, both visually and by collection of QA/QC samples. The stabilized sediment would be a homogeneous grout in the liquid form for several hours, and the viscosity of the mix would be monitored routinely by slump testing. The slurry water content would be adjusted regularly, based on the slump test, to adjust the mix viscosity for variations in sediment gradation. Areas with higher sand content would require less water to achieve the desired mix. Cylinder samples of the mix would be collected daily and tested as needed for strength and permeability to confirm the anticipated performance. During the mixing process, the quantity of all mix components added would be recorded to ensure the proper design ratios are maintained.

All cap geomembrane welds would be seal-tested as the work progresses, and any segment that fails would be corrected by welding a patch to cover the segment. The patch welds would be seal-tested to verify effectiveness.

7.2.7 Long-Term Monitoring

The long-term monitoring (LTM) of the remedial measure would include monitoring the railroad embankment using the monitoring network installed during construction, for a period of two years once construction is completed, or until any movements have stabilized after several successive readings. Groundwater quality would be monitored annually by analyzing groundwater samples from downgradient wells. A complete groundwater and cap monitoring program would be presented in the WP for the selected remedial alternative.

7.2.8 Cost and Schedule

The estimated capital and LTM costs for this alternative are $8.4 and $4.7 million, respectively, for a total cost of $13.1 million (Table 3a). These costs include contingency factors of 25% for contractor costs, 20% for consultant costs, and 30% for LTM costs. Alternative 2 is estimated to require approximately 6 months to construct, following 2 months of site preparation. This schedule assumes that several tasks would be conducted simultaneously, including ISS and cap construction. The ISS will start at the north end of WDL, which is a fairly linear feature. Once the stabilized sediment has reached sufficient strength, cap construction will commence and will follow ISS progression from north to south.

7.3 Alternative 3 - In-Situ Stabilization with NAPL-Affected Sediment Removal and Off-Site Disposal

This alternative would have the same components and elements as Alternative 2. In addition, the area of NAPL-affected sediment identified in Section 4.1.3, which is considered a hot spot for the purpose of this EE/CA, would be excavated and disposed of off site as hazardous waste following the CAMU process. The excavation would be conducted after sediment has been stabilized and in sections sufficiently small to be completed and backfilled on a daily basis. This is necessary to minimize the potential for bottom heave within WDL during excavation. Assuming CAMU eligibility, the excavated material would be loaded directly onto trucks and transported to a Subtitle C landfill.

The excavated section would be backfilled with controlled density fill (CDF) with the addition of approximately 5 to 10% bentonite clay. Standard CDF is a mixture of sand, water, and cement that is self-leveling, does not require compaction, and gains strength as the cement cures. Adding bentonite would reduce the CDF's permeability and minimize shrinkage cracking. This mixture is similar to that used as backfill and seal around monitoring well risers, per the Oregon Water Resource Department's (OWRD's) well construction standards. The CDF would yield a relatively impermeable backfill to prevent free flow of upgradient and impacted groundwater, and would gain enough strength to allow unsupported excavation of stabilized sediments within 1 to 2 days. The NAPL-affected sediment excavation and backfill sequence may follow a checkerboard pattern to allow the CDF to sufficiently cure. All other components and elements of Alternative 3 are the same as Alternative 2, including long-term monitoring.

The estimated volume and weight of the stabilized NAPL-affected sediment to be disposed of off site would be 1,800 CY and 2,500 tons, respectively. This quantity of waste would require that approximately 100 truck loads be transported to a Subtitle C landfill in eastern Oregon (CWM Arlington). The excavation, loading, off-site transportation (roundtrip), and import of backfill to replace it would consume an estimated 72 gallons of fuel per truck load. Therefore, an additional 7,200 gallons of fuel would be consumed to implement this alternative compared with Alternative 2. Each gallon of fuel is estimated to generate approximately 0.01 tons of greenhouse gases. Therefore, this alternative would generate approximately 80 tons of additional greenhouse gases as compared to Alternative 2. The calculations supporting this analysis of greenhouse gas emissions are presented on Tables 4a and 4b, and are based on guidelines presented in the EPA *Inventory of Greenhouse Gas Emissions and Sinks*: *1990-2005* (EPA, 2007).

Cost and Schedule

The estimated capital and LTM costs for this alternative are $10.3 and $4.7 million, respectively, for a total cost of $15.0 million for this alternative. These costs include contingency factors of 25% for contractor costs, 20% for consultant costs, and 30% for LTM costs. Alternative 3 is estimated to require approximately 7 months to construct. The added duration of 1 month is due to the additional step of excavating NAPL-affected sediment and backfilling, as compared with Alternative 2.

7.4 Alternative 4 - In-Situ Stabilization, Sediment Removal, and Off-Site Disposal

This alternative is essentially the same as Alternative 2 through ISS completion. Following ISS, the entire mass of stabilized sediment would be excavated in sections small enough to be excavated and backfilled in a single day. By limiting excavations to a daily basis, potential heave of the excavation bottom can be monitored and controlled. The excavated sediment would be loaded directly into trucks for off-site disposal following certification of the stabilized waste as CAMU-eligible. The excavated sections would be backfilled with CDF and bentonite as described in Alternative 3, and the CDF would be capped similarly to Alternatives 2 and 3 to eventually be incorporated into the final site-wide cap.

Once the backfill is completed, the surface area would be graded similar to the cap described for Alternative 2, but the accumulated stormwater would be discharged directly to a city storm sewer. The LTM for this alternative would be the same as Alternative 2, except it would be limited to 2 years.

The estimated volume and weight of the stabilized sediment that would be disposed of off site are 28,000 CY and 39,200 tons, respectively. This quantity of waste would require that approximately 1,300 truck loads be transported to the Subtitle C landfill. The additional effort for excavation, loading, off-site transportation (roundtrip), and importing backfill is estimated to consume approximately 72 gallons of fuel per truck load, or about 93,600 gallons of fuel. The additional greenhouse gases emissions for this alternative would be approximately 1,030 tons as compared with Alternative 2 (Tables 4a and 4b).

Cost and Schedule

The estimated capital and LTM costs for this alternative are $32.9 and $0.4 million, respectively, for a total cost of $33.3 million for this alternative. These costs include contingency factors of 25% for contractor costs, 20% for consultant costs, and 30% for LTM costs. Alternative 4 is estimated to require approximately 9 months to construct. The complete excavation, and subsequent backfill and grading, of the stabilized sediment is estimated to add 3 months to the total project duration as compared with Alternative 2.

8.0 EVALUATION OF REMEDIAL ALTERNATIVES

This section presents the evaluation of the four remedial alternatives described above in Section 7.0 in terms of protectiveness and the five balancing factors described in the DEQ FS guidance (DEQ, 1998). Table 5 summarizes the balancing factors for each alternative. Each alternative also is evaluated with respect to its greenhouse gas emission as described in Section 7.0 (EPA, 2007).

As described in Section 7, SLLI has included remedial alternatives that include partial or complete excavation of WDL sediment. However, the WDL IRAM will take place on BNSF property, and BNSF has stated in a letter dated February 6, 2009 that; "*BNSF cannot authorize any excavation below the water table adjacent to the embankment*."

8.1 Protectiveness

According to Oregon's environmental cleanup law, remedial technologies must be protective of human health and the environment as demonstrated through completion of a residual risk assessment (DEQ, 1998). Protectiveness considers the present and future public health, safety, and welfare, and the environment. RAOs must achieve the standards of protectiveness stipulated in OAR 340-122-0040.

The evaluation of protectiveness presented here will be partly based on the screening and performance criteria presented in Section 5, and will represent the quantitative portion of the residual risk assessment.

8.1.1 Alternative 1 – No Action

The "No Action" Alternative is not considered protective because it does not mitigate any of the exposure risks posed to both human and ecological receptors by the existing impacted sediments in WDL.

8.1.2 Alternative 2 - In -Situ Stabilization

The ISS alternative is considered to be protective of both human and ecological receptors under post-ISS conditions based on the results of the WDL TS. As described earlier in this document under Remedial Action Objectives (Section 5.1), the potential future human and ecological receptors include the following:

- An excavation worker contacting groundwater adjacent to or downgradient of the WDL monolith;
- Trespassers at NDL exposed, via consumption of fish in NDL or the River, to WDL COIs hypothetically migrating from WDL in groundwater; and
- Ecological receptors that reside in or use NDL or the River for food.

In all cases, including those TS samples containing NAPL-affected sediment from the southern end of the lake, COI concentrations in groundwater at the applicable exposure points are less than the applicable screening or performance criteria, following stabilization. This is demonstrated by a direct comparison of leachate results to excavation worker RBCs, by comparison of NDL EPCs for organic COIs as determined by the 1-dimensional transport evaluation for NDL trespassers and ecological receptors to applicable SLVs, and by semi-quantitative evaluation of hypothetical groundwater transport, for inorganic constituents exceeding ecological and bioaccumulation SLVs, from WDL to NDL. Further discussion of the approaches used in the 1-dimensional organic constituent transport evaluation and the semi-quantitative inorganic constituent evaluation can be found in the Final WDL TS Report (Section 13 of Attachment 1).

Based on the TS results, ISS treats NAPL by physically binding it as part of the mixing and curing process, and minimizes leaching of COIs to groundwater such that potential groundwater transport does not result in unacceptable exposure to potential receptors at the exposure point. Thus, ISS is considered protective.

8.1.3 Alternative 3 – In Situ Stabilization with NAPL-Affected Sediment Removal and Off-Site Disposal

Alternative 3 is also considered protective, but protectiveness for the remedy components is relative to the receptor in question. At WDL, Alternative 3 would result in the stabilized NAPL-affected sediment being physically removed from WDL, thereby eliminating any potential for future release or exposure to receptors at this location. However, by excavating and transporting the material off site, human and ecological receptors would be exposed to increased risk via truck traffic, dust, noise, potential traffic accidents in transit, and potential spills or releases in transit. Alternative 3 would also create increased greenhouse gas emissions relative to Alternative 2.

In addition, the WDL TS (Attachment 1) demonstrates that ISS effectively binds NAPL, both chemically and physically. Therefore, by considering and comparing the extenuating and mitigating factors of the remedy as a whole, Alternative 3 is less protective than Alternative 2.

8.1.4 Alternative 4 – In-Situ Stabilization, Sediment Removal, and Off-Site Disposal

Alternative 4 is also considered less protective than Alternatives 2 and 3. For the same reasons as discussed in Alternative 3, the mitigating and extenuating aspects of the remedy as a whole should be evaluated. At WDL, Alternative 4 would result in all of the stabilized sediment being physically removed from WDL, thereby eliminating any potential for future release or exposure to receptors at this location. However, by excavating and transporting the material off site, human and ecological receptors would be exposed to elevated risk via truck traffic, dust, noise, potential traffic accidents in transit, and potential spills or releases in transit. Alternative 4 would also create increased greenhouse gas emissions relative to the other alternatives. Therefore, Alternative 4 is less protective than Alternatives 2 or 3, due to the increased risks and increased greenhouse gas emissions.

8.2 Feasibility of Alternatives

Balancing factors are used to qualitatively evaluate remedial technologies, as described in OAR 340-122-0085 and the Final Guidance for Conducting Feasibility Studies (DEQ, 1998). The feasibility of a remedial technology is assessed based on the balancing of five remedy selection factors: effectiveness, long-term reliability, implementability, implementation risk, and reasonableness of cost. Each balancing factor is briefly defined below:

- **Effectiveness.** Effectiveness measures the performance of the technology in achieving protectiveness up to the time when RAOs are achieved and remedy implementation is complete.
- **Long-Term Reliability.** A remedy's long-term reliability is based on the reliability of treatment technology to remain protective and, if using engineering or institutional controls, on its reliability in managing residual risks. Long-term reliability also is influenced by uncertainties associated with potential long-term risk management.

- **Implementability.** Implementability is a measure of whether it is easy or difficult to implement a remedy considering practical, technical, or legal difficulties that may be associated with construction and implementation, including scheduling delays. Implementability also depends on the ability to measure the effectiveness of the remedy and its consistency with regulatory requirements.
- **Implementation Risk.** Implementation risk evaluates the risk posed by the remedy during implementation (including construction and operation), based on potential impacts to the community, workers, and the environment, and the effectiveness and reliability of protective or mitigative measures. Implementation risk also considers the time needed to implement the remedy.
- **Reasonableness of Cost.** A remedy's reasonableness of cost is based on the following, as appropriate:
  - Cost of remedial action, including capital cost, and annual operation and maintenance (O&M) cost, in terms of net present value;
  - The degree to which the costs are proportionate to the benefits to human health and the environment created by risk reduction;
  - The degree to which the costs are proportionate to the benefits created through restoration or protection of groundwater for beneficial use;
  - The degree of sensitivity and uncertainty of the costs; and
  - Any other information relevant to cost-reasonableness.

In addition to these five balancing factors, SLLI also evaluated the greenhouse gas emissions for Alternatives 3 and 4 over those emitted during ISS alone. The volume of greenhouse gases emitted is discussed for Alternatives 3 and 4 in Section 7.0. The evaluation of greenhouse gases is discussed in Section 8.2.4.

8.2.1 Effectiveness

For the same reasons described in Section 8.1, Alternatives 2, 3, and 4 are each considered to effectively achieve protection because the residual risk to potential future receptors is acceptable and all RAOs are immediately achieved following implementation. Alternative 2 is effective, as demonstrated by the TS results, in binding the COIs, both chemically and physically, which reduces future risk to human and ecological receptors to acceptable levels. Although Alternatives 3 and 4 remove the risk from WDL, they transfer it to another (albeit controlled) location.

8.2.2 Long-Term Reliability

Alternative 2 is considered to have good long-term reliability based on the leachate test method used during the WDL TS. The SBLT leachate method provides the most representative laboratory test of how stabilized sediment would perform over the long term. Site groundwater was used as the leachant, as recommended by USACE guidance, for each of the four required cycles of leachate testing, with each cycle demonstrating approximately 10 years of time. As stated previously, the analytical results of the leachate samples indicate that screening and performance criteria are not exceeded at the applicable exposure points. Additionally, the physical test results from the WDL TS indicate that a stabilized monolith will have the physical characteristics necessary to maintain its integrity over the long term, as follows:

- The final mix consisting of 20% Portland cement demonstrates strength as indicated by a UCS of greater than 50 psi after one day of curing and demonstrates the ability to withstand changes in moisture content over time, as would be experienced by the WDL monolith during Oregon's wet winters and dry summers, as indicated by successful wet/dry durability testing; and
- The 5% bentonite clay content of the final mix results in low permeability.

The Phase 6 TS incorporates the preferred attributes exhibited by mixes tested during Phases 3, 4, and 5, and has the maximum ability to both physically and chemically bind WDL COIs, minimizing their concentrations in leachate from the stabilized monolith over the long term.

Alternative 3 is considered slightly more reliable over the long term than Alternative 2 because the most impacted sediments containing NAPL are permanently removed from WDL and, therefore, are not able to contribute to potential future leaching. The results of the WDL TS have demonstrated the ability of ISS to contain NAPL; therefore, removing NAPL-affected sediment provides only a slight improvement in long-term reliability.

Alternative 4 is considered the most reliable over the long-term because the impacted sediments are permanently removed from WDL and, therefore, cannot leach to site groundwater.

8.2.3 Implementability

Alternative 2 is the most readily implementable of the alternatives. This alternative uses conventional methods and readily available equipment and material. Implementation of ISS and geosynthetic materials requires some specialty contractors;

however, the techniques and procedures are well established and proven in the field. There are no known permitting limitations for this alternative.

Alternatives 3 and 4 incorporate additional components, including excavation, transportation, and disposal, as well as backfill of excavated portions of stabilized WDL sediment. Implementing the additional components uses readily available equipment and standard techniques. Both alternatives would require approval to dispose of the excavated sediment as CAMU-eligible waste. Stabilizing the sediment first to reduce leachability substantially increases the likelihood of approval. SLLI anticipates that excavated sediment would receive approval for disposal as a CAMU-eligible waste, if the sediment is stabilized before excavation.

8.2.4 Implementation Risk

Alternative 2 has the lowest implementation risk as compared to Alternatives 3 and 4, which require excavating, handling, and transporting stabilized sediment off site. Additionally, excavating the stabilized sediment will increase the risk of slope failure and/or bottom heave, directly affecting embankment stability, which is not a factor in Alternative 2.

Excavating the sediments increases the risk of worker exposure to COIs and the risk of spreading or spilling impacted sediment on site, and increases the quantity of waste generated as part of a cleanup.

Off-site transportation, as proposed within Alternatives 3 and 4, poses heightened risk. A release from an overturned truck would spread sediment on the roadway and nearby areas, and increase risk to the public from injuries potentially resulting from truck accidents. Additionally, accidents substantially increase the risk of spreading impacted sediment by stormwater runoff from the accident site. Furthermore, accidents expose emergency responders and the public to hazards of the sediment, and increase the volume of the waste generated as the result of cleanup.

Alternatives 3 and 4 will also have higher emissions of greenhouse gases than Alternative 2. The higher emissions will negatively impact the air quality in the region, including along the route through the Columbia River Gorge National Scenic Area and The Dalles to the disposal facility where air quality can already be very poor (NEDC, 2008). Generating additional greenhouse gases compared to the added protection afforded by the removal action under Alternatives 3 and 4 creates a higher implementation risk. Alternative 4 has the highest implementation risk due to the higher quantities of waste handling and greenhouse gas generation.

8.2.5 Reasonableness of Cost

Alternative 2 has the lowest overall cost to implement. Alternative 3 costs are approximately $2 million more, a greater than 10% premium over Alternative 2, with little or no increase in actual protectiveness to human health and the environment. Additionally, the area of stabilized NAPL-affected sediment is planned to be enclosed within a barrier wall, along with other COI source areas on the RP property, as part of the site-wide remedies. Therefore, the added cost to remove the stabilized NAPL-affected sediment, as compared to the relative reduction of releases of COIs to the environment, is not deemed a reasonable cost. Alternative 4 is the most expensive alternative, at over 2.5 times the overall cost when compared to Alternative 2 (or more than $20 million more). The added cost to remove the sediment is extremely unreasonable considering that Alternative 2 meets the RAOs.

9.0 RECOMMENDED REMEDIAL ALTERNATIVE

Based on the evaluation contained in this EE/CA, including the results presented in the WDL TS (Attachment 1) and the Revised Geotechnical Investigation Report (Attachment 2), the recommended remedial alternative for the WDL IRAM is Alternative 2, ISS.

Alternative 2, ISS, is selected based on its protectiveness, including its ability to immediately achieve all RAOs once implementation is completed. ISS is considered effective based on the TS results because NAPL is both physically and chemically bound during stabilization, and because leaching to groundwater is minimized to levels that do not provide unacceptable risk to pertinent receptors at their respective exposure points. The TS results also demonstrate that ISS will be reliable over the long term. ISS is the most readily implementable alternative having the lowest implementation risk. Finally, the ISS implementation cost is considered to be the most reasonable given its protectiveness, effectiveness, good long-term reliability, implementability, and low implementation risk.

Alternative 3, In-Situ Stabilization with NAPL-Affected Sediment Removal and Off-Site Disposal, is not selected because the slight increases in protectiveness, effectiveness, and long-term reliability are not commensurate with the greater than 10% premium in cost over Alternative 2 due to its increased complexity of implementation. In addition, it also is not selected due to the increased implementation risks, including substantial emissions of greenhouse gases during implementation and the resulting reduction in air quality along the transportation route, which traverses the Columbia River Gorge National Scenic Area.

Alternative 4, In-Situ Stabilization, Sediment Removal, and Off-Site Disposal, is not selected for the same reasons as Alternative 3. The relative increases in protectiveness, effectiveness, and long-term reliability are not commensurate with a cost increase of nearly 2.5 times that compared to Alternative 2, especially given the increased complexity of implementation and a significantly greater implementation risk.

Finally, this EE/CA has evaluated remedial alternatives that include partial or complete excavation of WDL sediment. However, the WDL IRAM will take place on BNSF property, and regardless of the implementability of the remedial alternatives that contain a removal option, BNSF has stated in a letter dated February 6, 2009 that; "*BNSF cannot authorize any excavation below the water table adjacent to the embankment*."

10.0 SCHEDULE

This section summarizes the implementation schedule, as well as the permitting activities completed to date.

10.1 Implementation Schedule and DEQ Approval

The implementation of the WDL IRAM is currently planned in 2009, based on the assumption that the remedial alternative recommended in this EE/CA (Alternative 2) is approved by DEQ by spring 2009. Construction of the remedy, including stabilization and capping, would take approximately 6 months following 2 months of site preparation, for an estimated completion in winter 2010.

10.2 Permitting Requirements for Implementation of a WDL IRAM

The WDL IRAM would permanently remove WDL and is, therefore, subject to the permitting requirements of the Oregon Department of State Lands (DSL) and the U.S. Army Corps of Engineers (USACE). Additionally, because WDL is located within an "environmental conservation" overlay zone as designated by the COP Bureau of Environmental Services (BES), the WDL IRAM requires a Type II Environmental Review. The final stages of WDL IRAM implementation would involve clearing and grading activities that require a Site Development Permit from the COP and a general construction NPDES permit (1200-C) from the DEQ.

DEQ has issued the WDL IRAM an exemption from state and local permitting requirements per ORS 465.315(3). Although state and local permits are not required, the WDL IRAM must still meet the substantive requirements of each permit. A discussion of each permitting agency's process and requirements is presented below.

10.2.1 Local Requirements - COP Zoning, (City Charter, Chapters 10, 24, 33)

The WDL parcel (Multnomah County Tax Parcel 1400) is zoned IHc (Heavy Industrial with Environmental Conservation Overlay). The "c" or environmental conservation overlay requires a Type II Environmental Review, which includes an impact analysis, alternatives analysis, project description, construction plans, mitigation plan, and responses to approval criteria.

In addition to the Type II Environmental Review, a Site Development Permit is required for grading, clearing, and/or filling activities within the COP. This permit requires that a grading, clearing, and erosion control plan be submitted with the permit application package.

Because the proposed IRAM is exempt from the COP's procedural requirements, but not exempt from the substantive requirements, the COP's review process did not include public notification, public review, or the issuance of a public decision.

The Type II Environmental Review and Site Development Permit application packages were submitted to the COP on March 28, 2006. Supplemental information to complete the package, including information on roads, stormwater management, and a mitigation plan, was submitted on July 28, 2006. COP issued their decision that substantive requirements have been met for the Type II Environmental Review on July 18, 2007 and that substantive requirements have been met for the Site Development Permit on July 25, 2007.

10.2.2 State Requirements - DEQ - NPDES Program

The EPA regulates stormwater discharge into surface water bodies (40 CFR 122). The regulations require that NPDES permits be obtained for construction activities, including clearing, grading, and excavation, that disturb one or more acres of land. DEQ administers the NPDES program for the EPA within the State of Oregon, and issues the NPDES Stormwater Discharge Permit 1200-C to cover these activities. The NPDES Permit 1200-C issued on August 25, 2007, lists requirements for implementing sediment and erosion controls at the project site.

10.2.3 State Requirements - Oregon DSL Removal/Fill Permit

Oregon's Removal-Fill Law (ORS 196.795-990) requires that entities planning to remove or place 50 CY yards or more of fill material in state waters obtain a permit from the DSL. Although the WDL IRAM is exempt from DSL's procedural requirements, a Joint DSL/USACE Permit Application Package, including a Wetland Delineation Report, was submitted to DSL on July 24, 2006, to meet substantive requirements. The DSL issued its concurrence with the Wetland Delineation Report on October 6, 2006, found that the project meets DSL's substantive requirements, and issued their decision on June 7, 2007.

10.2.4 Federal Requirements - USACE

The USACE evaluates permit applications for proposed activities in "Waters of the United States" (including wetlands) under the authorities of Section 404 of the Clean Water Act (CWA), Section 10 of the Rivers and Harbors Act, and the Marine Protection, Research, and Sanctuaries Act.

The Joint Permit Application Package was submitted on July 24, 2006 (AMEC, 2006b). The USACE determined WDL to be an isolated water body and not under jurisdiction of the USACE on October 11, 2006. No additional Federal permits or reviews are required at this time.

10.2.5 Current Permit Status

The Site Development Permit, the NPDES 1200-C Permit, and the Joint Permit are complete and current. The fees corresponding to these permits have been paid.

REFERENCES

AMEC, 2003a. Remaining Remedial Investigation Technical Memorandum, RPAC - Portland Site, prepared for SLLI. Submitted to DEQ, February 4, 2003.

AMEC, 2003b. *Final Groundwater Characterization Report, RPAC - Portland Site,* prepared by AMEC Earth & Environmental, Inc., submitted to Oregon Department of Environmental Quality, March 28, 2003.

AMEC, 2004a. *Facility Structures IRAM Technical Memorandum,* prepared by AMEC Earth & Environmental, Inc. submitted to Oregon Department of Environmental Quality, June 18, 2004

AMEC, 2004b. *West Doane Lake Sediment Leachability Analysis Technical Memorandum*, RP - Portland Site prepared for SLLI, submitted to Oregon Department of Environmental Quality August 6, 2004.

AMEC, 2005a. *Installation of Additional Extraction Wells EW-1, EW-2, EW-3 (GETS IRAM)*, RP – Portland Site, prepared for SLLI, submitted to Oregon Department of Environmental Quality January 19, 2005.

AMEC, 2005b. *Groundwater Transport Evaluation Report*, RP - Portland Site, prepared for SLLI, submitted to Oregon Department of Environmental Quality March 28, 2005.

AMEC, 2005c. *West Doane Lake Treatability Study Work Plan*, RP - Portland Site, prepared for SLLI, submitted to Oregon Department of Environmental Quality June 27, 2005.

AMEC, 2006a. *Final Deterministic Baseline Human Health Risk Assessment*. prepared for SLLI, submitted to Oregon Department of Environmental Quality, March 16, 2006.

AMEC, 2006b. *Joint Permit Application Package, West Doane Lake IRAM*, RP-Portland Site, prepared for SLLI c/co sanofi-aventis US, Inc., submitted to Oregon Department of State Lands, 775 Summer Street NE, Salem, Oregon, July 24, 2006.

AMEC, 2007a. Site-Wide Conceptual Remedy Plan, RP - Portland Site, prepared for SLLI, submitted to Oregon Department of Environmental Quality, August 21, 2007.

AMEC, 2007b. Response to DEQ November 28, 2007 Comment Letter, West Doane Lake – Draft Engineering Evaluation/Cost Analysis. December 21, 2007.

AMEC, 2008a. Draft Source Control Evaluation Report, RP – Portland Site, prepared for SLLI. Submitted to DEQ, February 13, 2008.

AMEC, 2008b. Response to DEQ March 19, 2008 Comment Letter, West Doane Lake Draft Engineering Evaluation/Cost Analysis. April 18, 2008.

AMEC, 2008c. Draft North Doane Lake Baseline Human Health Risk Assessment, RP – Portland Site, prepared for SLLI. Submitted to DEQ, June 4, 2008.

AMEC, 2008d. West Doane Lake Phase 5 Treatability Study Work Plan, RP – Portland Site, prepared for SLLI. Submitted to DEQ, June 19, 2008.

AMEC, 2008e. West Doane Lake Phase 5 Treatability Study Work Plan Addendum, RP – Portland Site, prepared for SLLI. Submitted to DEQ, July 31, 2008.

AMEC, 2008f. Proposed Sign and Sign Locations at the RP Property, West Doane Lake, and North Doane Lake, RP – Portland Site. Submitted to DEQ October 9, 2008.

AMEC, 2008g. Email to Dave Lacey and Matt McClincy at DEQ from Michelle Peterson at AMEC, WDL screening criteria – updated information, October 23, 2008.

AMEC, 2008h. Interim Measures for Wildlife Deterrence at West Doane Lake. Proposal. October, 27, 2008.

ANSI, 1986. American National Standard Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure Method ANSI/ANS 16.1-1986, 1986.

City of Portland, 2001. Guild's Lake Industrial Area Plan, Bureau of Planning, June 2001.

DEQ, 1996. Comments on Proposal for Abandonment of West Doane Lake, Rhone-Poulenc Doane Lake Facility. DEQ File #155. May 21, 1996.

DEQ, 1998. Guidance for Conducting Feasibility Studies, Oregon Department of Environmental Quality, Waste Management and Cleanup Division, July 1, 1998.

DEQ, 1999. Remedial Investigation Work Plan. Rhone-Poulenc AG Company, Portland, OR. Prepared for the DEQ by Ecology and Environment, Inc., April, 1999.

DEQ, 2001. Guidance for Ecological Risk Assessment: Levels I, II, III, and IV.

DEQ, 2004. Ambient Water Quality Criteria, Ecological Chronic Values.

DEQ, 2005. Approval letter for Final West Doane Lake Treatability Study Work Plan Rhone Poulenc, Portland Site, July 18, 2005.

DEQ, 2007. Draft West Doane Lake Engineering Evaluation/Cost Analysis Comment Letter. November 28, 2007.

DEQ, 2008a. Draft West Doane Lake Engineering Evaluation/Cost Analysis Comment Letter. March 19, 2008.

DEQ, 2008b. Approval letter for West Doane Lake Phase 5 Treatability Study Work Plan Addendum, RP – Portland. August 8, 2008.

DEQ, 2008c. DEQ Review: "Proposed Signs and Sign Locations at the RP Property, West Doane Lake, and North Doane Lake". October 29, 2008.

DEQ/EPA, 2005. Portland Harbor Joint Source Control Strategy. Updated July 16, 2007.

DSL, 2006. Approval Letter for Wetlands Delineation Report for West Doane Lake IRAM. Oregon Department of State Lands. October 6, 2006.

Newell, C.J., McLeod, K.R. 1996. BIOSCREEN Natural Attenuation Decision Support System, Version 1.3, United States Environmental Protection Agency, 64p.

EPA, 2006. National Recommended Water Quality Criteria, Ecological Chronic Values.

EPA, 2007. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005, USEPA Office of Atmospheric Programs. #430-R-07-002, http://www.epa.gov/climatechange/emissions/usgginv_archive.html, April 2007. .

Freeze, R. A. and J. A. Cherry, 1979. Groundwater. Prentice-Hall, Inc., Englewood Cliffs, NJ.

Geraghty and Miller, 1991. Hydrogeological Investigation of the Doane Lake Area, Portland, Oregon, Volume I, February 22, 1991.

NAS, 2007. Sediment Dredging at Superfund Megasites, Assessing the Effectiveness, National Academies Press, 2007.

NEDC, 2008. Local Economic Impacts of Air Pollution in the Columbia River Gorge, Northwest Environmental Defense Center http://www.lclark.edu/org/nedc/objects/GorgeFactSheet.pdf, accessed December, 2008.

Parkhurst, D. L., Appelo, C. A. J., 1999. User's guide to PHREEQC (version 2.0). A Computer Program for Speciation, Batch-Reaction, One-Dimensional Transport, and Inverse Geochemical Calculations. Water-Resources Investigations Report 99-4259. 312p. U.S. Geological Survey, Denver, Colorado, USA.

USACE, 2003. Evaluation of Dredged Material Proposed for Disposal at Island, Nearshore, or Upland Confined Disposal Facilities-Testing Manual.

USACE, 2008. The Four Rs of Environmental Dredging: Resuspension, Release, Residual, and Risk, ERDC/EL TR-08-4, USACE, Dredging Operations and Environmental Research Program, February 2008.

LIMITATIONS

This report was prepared exclusively for SLLI by AMEC Earth & Environmental, Inc. The quality of information, conclusions, and estimates contained herein is consistent with the level of effort involved in AMEC services and based on: i) information available at the time of preparation, ii) data supplied by outside sources, and iii) the assumptions, conditions, and qualifications set forth in this report. This Final West Doane Lake Engineering Evaluation/Cost Analysis is intended to be used by SLLI for the RP - Portland Site, 6200 N.W. St. Helens Road, Portland, Oregon only, subject to the terms and conditions of its contract with AMEC. Any other use of, or reliance on, this report by any third party is at that party's sole risk.

AMEC services have been performed in accordance with the normal and reasonable standard of care exercised by similar professionals performing services under similar conditions and geographic locations. Except for our stated standard of care, no other warranties or guarantees are offered as part of AMEC's contracted services.

Finally, it should be noted that no subsurface exploration can be thorough enough to exclude the possible presence of hazardous materials or wastes at a given site. In cases where contaminants have not been discovered through exploration, this should not be construed as a guarantee that contaminants do not exist. Where sample collection and testing have been performed, AMEC's professional opinions are based in part on the interpretation of data from discrete sampling locations that may not represent conditions at unsampled locations.

TABLES

TABLE 1
Human Health and Ecological Screening Level Values for WDL Treatability Study RP - Portland Site

Timeframe	POST-STABILIZATION					
	Human Health				Ecological	
Endpoint	NDL Fish Consumption		Shallow GW		NDL/Willamette River	
Receptor	Trespasser		Excavation Worker		Ecological Receptors	
Screening Criteria	DEQ Organism Only AWQC (µg/L)[1]		Site-Specific RBCs (µg/L)[2]		Federal and State SLVs (µg/L)[3]	
Metals (EPA Method 6000/7000 Series)						
Aluminum	NA		1.25E+08		8.70E+01	a
Antimony	6.40E+01		4.98E+04		3.00E+01	b
Arsenic	1.40E-02		5.81E+03		3.10E+00	b
Barium	NA		2.49E+07		4.00E+00	c
Beryllium	NA		2.49E+05		5.30E+00	c
Boron	NA		2.49E+07		1.60E+00	c
Cadmium	NA		6.23E+04		9.00E-02	d
Calcium	NA		NA		1.16E+05	c
Chromium	NA		1.87E+08		2.38E+01	d
Cobalt	NA		9.34E+04		2.30E+01	c
Copper	NA		4.98E+06		2.74E+00	d
Iron	NA		8.72E+07		1.00E+03	c
Lead	NA		NA		5.40E-01	d
Magnesium	NA		NA		8.20E+04	c
Manganese	1.00E+01		2.99E+06		1.20E+02	b
Mercury	1.46E-02		3.74E+04		7.70E-01	a
Molybdenum	NA		6.23E+05		3.70E+02	c
Nickel	4.60E+02		1.25E+07		1.60E+01	a
Potassium	NA		NA		5.30E+04	c
Selenium	4.20E+02		6.23E+05		5.00E+00	a
Silicon	NA		NA		NA	
Silver	NA		1.04E+06		1.20E-01	e
Sodium	NA		NA		6.80E+05	c
Thallium	NA		8.09E+03		4.00E+01	c
Vanadium	NA		6.23E+05		2.00E+01	c
Zinc	2.60E+03		6.23E+07		3.60E+01	e
Organochlorine Insecticides (EPA Method 8081)						
2,4'-DDD	3.10E-05		4.00E+01		1.00E-03	f
2,4'-DDE	2.20E-05		3.22E+01		1.00E-03	f
2,4'-DDT	2.20E-05		1.50E+01		1.00E-03	f
4,4'-DDD	3.10E-05		4.00E+01		1.00E-03	f
4,4'-DDE	2.20E-05		3.22E+01		1.00E-03	f
4,4'-DDT	2.20E-05		1.50E+01		1.00E-03	a
Total DDT	2.20E-05		1.50E+01	f	1.00E-03	f
Aldrin	5.00E-06		5.43E+01		6.00E-02	c
alpha-BHC	4.90E-04		2.79E+01		2.20E+00	b
alpha-Chlordane	8.10E-05		8.13E+01		4.30E-03	a,g
beta-BHC	1.70E-03		8.39E+01		2.20E+00	c
cis-Nonachlor	NA		8.13E+01		4.46E-01	h
delta-BHC	NA		1.72E+02		2.20E+00	i
Dieldrin	5.40E-06		6.70E+00		5.60E-02	a
Endosulfan I	8.90E+00		3.04E+04		5.60E-02	a
Endosulfan II	8.90E+00		3.04E+04	j	5.60E-02	j
Endosulfan sulfate	*8.90E+00*		*3.04E+04*	*j*	*5.60E-02*	*j*
Endrin	6.00E-03		4.17E+02		3.60E-02	a
Endrin aldehyde	*NA*		*4.17E+02*	*k*	*3.60E-02*	*k*
Endrin Ketone	*NA*		*4.17E+02*	*k*	*3.60E-02*	*k*
gamma-BHC (Lindane)	1.80E-01		1.72E+02		8.00E-02	e
gamma-Chlordane	8.10E-05		8.13E+01		4.30E-03	a,g
Heptachlor	7.90E-06		3.16E+01		3.80E-03	a
Heptachlor epoxide	*3.90E-06*		*6.07E+00*		*3.80E-03*	*a*
Hexachlorobenzene	2.90E-05		1.05E+01		3.00E-04	l
Methoxychlor	*NA*		*NA*		*3.00E-02*	*a*
Mirex	*NA*		*NA*		*1.00E-03*	*a*
Oxychlordane	*NA*		*NA*		*4.30E-03*	*g*
Total Chlordane	0.000081		8.13E+01	g	4.30E-03	a
trans-Nonachlor	NA		8.13E+01		4.46E-01	m
PCBs (EPA Methods 8082/1668A)						
Aroclor 1242	*NA*		*NA*		*1.40E-02*	*a*
Aroclor 1248	*NA*		*NA*		*1.40E-02*	*a*
Aroclor 1254	*NA*		*NA*		*1.40E-02*	*a*
Aroclor 1260	*NA*		*NA*		*1.40E-02*	*a*
PCB 77	5.10E-06	n	1.62E-01	n	3.80E+00	o
PCB 81	*1.70E-06*	*n*	*5.40E-02*	*n*	*7.60E-01*	*o*
PCB 105	1.70E-05	n	5.40E-01	n	7.60E+01	o
PCB 114	1.70E-05	n	5.40E-01	n	7.60E+01	o
PCB 118	1.70E-05	n	5.40E-01	n	7.60E+01	o
PCB 123	*1.70E-05*	*n*	*5.40E-01*	*n*	*7.60E+01*	*o*
PCB 126	*5.10E-09*	*n*	*1.62E-04*	*n*	*7.60E-02*	*o*
PCB 156 & 157	1.70E-05	n	5.40E-01	n	7.60E+01	o
PCB 167	1.70E-05	n	5.40E-01	n	7.60E+01	o
PCB 169	*1.70E-08*	*n*	*5.40E-04*	*n*	*7.60E+00*	*o*
PCB 189	*1.70E-05*	*n*	*5.40E-01*	*n*	*7.60E+01*	*o*
Total PCBs (non-carcinogenic)	6.40E-06		1.90E+00	p	1.40E-02	a

TABLE 1
Human Health and Ecological Screening Level Values for
WDL Treatability Study
RP - Portland Site

Timeframe	POST-STABILIZATION			
Endpoint	Human Health		Ecological	
	NDL Fish Consumption	Shallow GW	NDL/Willamette River	
Receptor	Trespasser	Excavation Worker	Ecological Receptors	
Screening Criteria	DEQ Organism Only AWQC (µg/L)[1]	Site-Specific RBCs (µg/L)[2]	Federal and State SLVs (µg/L)[3]	
Chlorinated Herbicides (EPA Method 8151A)				
2,4,5-T	NA	4.21E+04	5.00E+04	q
2,4,5-TP (Silvex)	NA	1.75E+04	5.00E+00	r
2,4-D	NA	7.21E+04	5.81E+01	s
2,4-DB	NA	4.41E+04	9.32E+02	t
Bromoxynil	NA	2.20E+05	NA	
Dalapon	NA	2.75E+06	2.22E+02	r
Dicamba	NA	5.45E+05	NA	
Dichlorprop	NA	NA	NA	
Dinoseb	NA	2.24E+03	NA	
MCPA	NA	1.62E+03	2.60E+00	u
MCPP	NA	4.25E+03	2.60E+00	v
Pentachlorophenol	3.00E-01	5.22E+01	1.30E+01	e
Volatile Organic Compounds (EPA Method 8260B)				
1,1-Dichloroethane	NA	9.55E+03	2.50E+01	r
1,2,3-Trichlorobenzene	*NA*	*8.39E+02*	*NA*	
1,2,3-Trichloropropane	*NA*	*NA*	*NA*	
1,2,4-Trichlorobenzene	NA	8.42E+02	1.10E+02	b
1,2,4-Trimethylbenzene	NA	1.62E+03	7.30E+00	r
1,2-Dibromo-3-chloropropane	NA	2.69E+00	NA	
1,2-Dibromoethane	*NA*	*NA*	*NA*	
1,2-Dichlorobenzene	1.30E+02	3.61E+04	3.30E+02	w
1,2-Dichloroethane	NA	6.01E+02	9.10E+02	b
1,3,5-Trimethylbenzene	NA	1.35E+03	7.30E+00	r
1,3-Dichlorobenzene	NA	3.30E+04	3.30E+02	w
1,4-Dichlorobenzene	1.90E+01	1.39E+03	3.40E+02	w
2-Butanone (MEK)	NA	1.14E+06	1.40E+04	b
2-Chlorotoluene	*NA*	*NA*	*NA*	
2-Ethyl-1-hexanol	NA	NA	NA	
4-Isopropyltoluene	*NA*	*NA*	*NA*	
Acetone	NA	6.90E+06	1.50E+03	b
Benzene	NA	1.67E+03	1.30E+02	b
Bromochloromethane	NA	NA	4.32E+03	x
Bromodichloromethane	*NA*	*NA*	*NA*	*x*
Bromomethane	NA	1.13E+03	1.10E+02	x
Carbon disulfide	NA	1.27E+05	9.20E-01	b
Chlorobenzene	NA	9.78E+03	5.00E+01	e
Chloroethane	*NA*	*1.87E+04*	*4.70E+01*	*r*
Chloroform	*NA*	*6.88E+02*	*2.80E+01*	*r*
Chloromethane	*NA*	*8.56E+03*	*5.50E+03*	*y*
cis-1,2-Dichloroethene	*NA*	*NA*	*5.90E+02*	*b*
Ethylbenzene	NA	1.21E+04	7.30E+00	b
Hexachlorobutadiene	NA	2.60E+02	9.30E+00	e
Iodomethane	*NA*	*NA*	*NA*	
Isobutyl alcohol	NA	1.52E+07	NA	
Isopropylbenzene	NA	4.85E+04	7.30E+00	r
m,p-Xylene	NA	1.56E+05	1.80E+00	b
Methyl tert-butyl Ether (MTBE)	NA	6.02E+04	NA	
Methylene chloride	NA	3.03E+04	2.20E+03	b
Naphthalene	NA	4.77E+02	1.20E+01	b
n-Butylbenzene	*NA*	*2.58E+03*	*7.10E+01*	*x*
n-Propylbenzene	NA	4.43E+03	1.28E+02	x
o-Xylene	NA	1.56E+02	1.30E+01	b
sec-Butylbenzene	*NA*	*NA*	*8.20E+01*	*x*
tert-Butylbenzene	*NA*	*NA*	*4.20E+01*	
Tetrachloroethene	*NA*	*NA*	*9.80E+01*	*b*
Toluene	NA	2.05E+05	9.80E+00	b
Trichloroethene	*NA*	*NA*	*4.70E+01*	*b*
Vinyl chloride	*NA*	*NA*	*3.88E+03*	*r*
Total Xylenes	NA	1.56E+05	1.30E+01	r

TABLE 1
Human Health and Ecological Screening Level Values for
WDL Treatability Study
RP - Portland Site

Timeframe	POST-STABILIZATION			
Endpoint	Human Health		Ecological	
	NDL Fish Consumption	Shallow GW	NDL/Willamette River	
Receptor	Trespasser	Excavation Worker	Ecological Receptors	
Screening Criteria	DEQ Organism Only AWQC (µg/L)[1]	Site-Specific RBCs (µg/L)[2]	Federal and State SLVs (µg/L)[3]	
Semi Volatile Organic Compounds (EPA Method 8270C)				
1,2,4-Trichlorobenzene	NA	8.42E+02	1.10E+02	b
1,2-Dichlorobenzene	1.30E+02	3.61E+04	3.30E+02	w
1,3-Dichlorobenzene	NA	3.30E+04	3.30E+02	w
1,4-Dichlorobenzene	1.90E+01	1.39E+03	3.40E+02	w
1-Methylnaphthalene	NA	2.05E+03	2.10E+00	z
2,3,4,6-Tetrachlorophenol	NA	1.92E+04	NA	
2,3,5,6-Tetrachlorophenol	NA	4.56E+04	1.20E+00	l
2,4,5-Trichlorophenol	NA	1.55E+05	6.30E+01	x
2,4,6-Trichlorophenol	NA	9.86E+03	3.20E+00	y
2,4-Dichlorophenol	NA	9.76E+03	3.65E+02	e
2,4-Dimethylphenol	NA	1.49E+05	4.20E+01	c
2-Chlorophenol	NA	4.99E+04	2.00E+03	e
2-Methylnaphthalene	NA	3.45E+03	2.10E+00	b
2-Methylphenol	NA	5.65E+05	1.30E+01	b
2-Nitrophenol	NA	9.49E+03	1.50E+02	e
3,3'-Dichlorobenzidine	*NA*	*NA*	*7.63E+02*	*e*
3/4-Cresol	NA	1.27E+05	3.00E-01	y
4-Bromophenylphenyl ether	*NA*	*NA*	*1.50E+00*	*c*
4-Chloro-3-methylphenol	NA	NA	3.20E-01	r
4-Chloroaniline	*NA*	*NA*	*NA*	
4-Nitrophenol	NA	1.27E+05	1.50E+02	e
Acenaphthene	9.90E+01	5.05E+04	2.30E+01	r
Acenaphthylene	*NA*	*NA*	*3.07E+02*	*r*
Anthracene	*NA*	*NA*	*7.30E-01*	*b*
Benzo(a)anthracene	*NA*	*NA*	*2.70E-02*	*b*
Benzo(a)pyrene	*1.80E-03*	*NA*	*1.40E-02*	*b*
Benzo(b)fluoranthene	*1.80E-03*	*NA*	*6.77E-01*	*r*
Benzo(ghi)perylene	*NA*	*NA*	*4.39E-01*	*r*
Benzo(k)fluoranthene	*1.80E-03*	*NA*	*6.42E-01*	*r*
Benzofluoranthenes	*NA*	*NA*	*NA*	
Benzoic acid	NA	5.79E+07	4.20E+01	b
Benzyl alcohol	NA	1.26E+07	8.60E+00	b
Bis(2-chloroisopropyl) Ether	*NA*	*2.10E+07*	*NA*	
bis(2-Ethylhexyl) phthalate	NA	7.42E+01	3.00E+00	e
Butylbenzylphthalate	NA	2.59E+04	3.00E+00	e
Chrysene	*1.80E-03*	*NA*	*2.04E+00*	*r*
Dibenzo(a,h)anthracene	*NA*	*NA*	*2.83E-01*	*r*
Dibenzofuran	*NA*	*NA*	*3.70E+00*	*b*
Diethylphthalate	NA	9.56E+06	3.00E+00	e
Dimethylphthalate	*NA*	*NA*	*3.00E+00*	*e*
Di-n-butyl phthalate	NA	1.35E+05	3.00E+00	e
Di-n-octyl phthalate	*NA*	*NA*	*3.00E+00*	*e*
Fluoranthene	*1.40E+01*	*NA*	*6.60E+00*	*r*
Fluorene	5.30E+02	2.53E+04	3.90E+00	b
Hexachlorobenzene	*2.90E-05*	*1.05E+01*	*3.00E-04*	*l*
Hexachlorobutadiene	NA	2.60E+02	9.30E+00	e
Indeno(1,2,3-cd)pyrene	*NA*	*NA*	*2.75E-01*	*r*
Isophorone	*NA*	*NA*	*2.34E+03*	*c*
Naphthalene	NA	4.77E+02	1.20E+01	b
Nitrobenzene	*NA*	*4.03E+02*	*5.40E+02*	*c*
N-nitrosodimethylamine	*NA*	*NA*	*1.17E+02*	*c*
N-Nitrosodi-n-propyl amine	NA	3.42E+02	1.17E+02	c
N-Nitrosodiphenylamine	*NA*	*NA*	*2.10E+02*	*b*
Pentachlorophenol	3.00E-01	5.22E+01	1.30E+01	e
Phenanthrene	NA	NA	6.30E+00	c
Phenol	NA	6.39E+06	1.10E+02	z
Pyrene	*4.00E+02*	*NA*	*1.01E+01*	*r*

TABLE 1
Human Health and Ecological Screening Level Values for
WDL Treatability Study
RP - Portland Site

Timeframe	POST-STABILIZATION					
Endpoint	Human Health				Ecological	
	NDL Fish Consumption		Shallow GW		NDL/Willamette River	
Receptor	Trespasser		Excavation Worker		Ecological Receptors	
Screening Criteria	DEQ Organism Only AWQC (µg/L)[1]		Site-Specific RBCs (µg/L)[2]		Federal and State SLVs (µg/L)[3]	
Dioxins/Furans (EPA Method 1613B/8280/8290)						
1,2,3,4,6,7,8,9-OCDD	1.70E-06	n	5.40E-02	n	3.80E+00	o
1,2,3,4,6,7,8,9-OCDF	1.70E-06	n	5.40E-02	n	3.80E+00	o
1,2,3,4,6,7,8-HpCDD	5.10E-08	n	1.62E-03	n	3.80E-01	o
1,2,3,4,6,7,8-HpCDF	5.10E-08	n	1.62E-03	n	3.80E-02	o
1,2,3,4,7,8,9-HpCDF	5.10E-08	n	1.62E-03	n	3.80E-02	o
1,2,3,4,7,8-HxCDD	5.10E-09	n	1.62E-04	n	7.60E-04	o
1,2,3,4,7,8-HxCDF	5.10E-09	n	1.62E-04	n	3.80E-03	o
1,2,3,6,7,8-HxCDD	5.10E-09	n	1.62E-04	n	3.80E-02	o
1,2,3,6,7,8-HxCDF	5.10E-09	n	1.62E-04	n	3.80E-03	o
1,2,3,7,8,9-HxCDD	5.10E-09	n	1.62E-04	n	3.80E-02	o
1,2,3,7,8,9-HxCDF	*5.10E-09*	*n*	*1.62E-04*	*n*	*3.80E-03*	*o*
1,2,3,7,8-PeCDD	5.10E-10	n	1.62E-05	n	3.80E-04	o
1,2,3,7,8-PeCDF	1.70E-09	n	5.40E-04	n	7.60E-03	o
2,3,4,6,7,8-HxCDF	5.10E-09	n	1.62E-04	n	3.80E-03	o
2,3,4,7,8-PeCDF	1.70E-09	n	5.40E-05	n	7.60E-04	o
2,3,7,8-TCDD	5.10E-10		1.62E-05		3.80E-04	d
2,3,7,8-TCDF	5.10E-09	n	1.62E-04	n	7.60E-03	o

TABLE 1
Human Health and Ecological Screening Level Values for
WDL Treatability Study
RP - Portland Site

Notes:

[1]DEQ 2004 AWQC (organism only) values from DEQ/EPA Joint Source Control Strategy Table 3.1, 7/16/07 revision. Screening levels listed for compounds detected in fish tissue evaluated for the NDL Human Health Risk Assessment (AMEC, 2004).
[2]Site-specific RBCs calculated using the Oregon DEQ Risk-Based Decision Making (RBDM) for the Remediation of Petroleum Contaminated Sites (2003).
[3]Ecological screening level values. See notes below for individual references.

a Chronic NRWQC value (EPA 2006).
b Oak Ridge National Laboratory Tier II SCV value taken from Portland Harbor Joint Source Control Strategy Table 3-1, 7/16/07
c Level II screening value from the DEQ Guidance for Ecological Risk Assessment, December 2001 update.
d EPA Ambient Water Quality Criteria adjusted to a hardness of 25 mg/L
e DEQ chronic AWQC value taken from Portland Harbor Joint Source Control Strategy Table 3-1, July 16, 2007 revision.
f 4,4'-DDT value used as surrogate
g Value for total chlordane.
h Trans-nonachlor used as surrogate
i alpha & beta-BHC values used as surrogate
j Endosulfan I used as surrogate
k Endrin used as surrogate
l EPA Region 5 Surface Water Ecological Screening Level Value
m Ecotox / 50 (as referenced in the December 10, 2008 letter from DEQ)
n Value calculated by dividing 2,3,7,8-TCDD screening value by 2005 WHO TEF for humans and mammals.
o Value calculated by dividing 2,3,7,8-TCDD PRG by 1998 WHO TEF for fish.
p Lookup value from DEQ-RBDM for total PCBs (non-carcinogenic)
q 48-h NOAEL for 2,4,5-T acid on juvenile white mullet, as reported in The Science of 2,4,5-T and the Phenoxy Herbicides (Bovey and Young, 1980).
r Toxicity Reference Values for Portland Harbor Baseline Ecological Risk Assessment. EPA, April 2008.
s NOEC for 2,4-D acid on duckweed (*Lemna gibba*) from the Environmental Fate and Effects Division's Risk Assessment for the Reregistration Eligibility Document for 2,4-D (EPA 2004).
t LOAEL for green algae (*Selenastrum capricornutum*) from the Environmental Fate and Effects Division's Risk Assessment for the Reregistration Eligibility Document for 2,4-DB (EPA 2005).
u Canadian Water Quality Guidance Surface Water Quality Screening Level Benchmark
v MCPA value used as surrogate
w Narcosis SCV from EPA Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks for the Protection of Benthic Organisms: Compendium of Tier 2 Values for Nonionic Organics. (EPA, 2008)

x TCEQ, 2006. Update to Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas RG-263 (Revised). Texas Commission on Environmental Quality Guidance. Remediation Division. January, 2006.
y EPA Region 4 Water Screening Level Value
z DEQ Ecological Risk Screening Level Value

Acronyms and Abbreviations:
µg/L = micrograms per liter
AWQC = ambient water quality criteria
BHC = hexachlorocyclohexane
DDD = dichlorodiphenyldichloroethane
DDE = dichlorodiphenyldichloroethylene
DDT = dichlorodiphenyltrichloroethane
DEQ = Oregon Department of Environmental Quality
EPA = United States Environmental Protection Agency
GW = groundwater
LOAEL = lowest observed adverse effect level
NA = Not available; For site-specific RBCs, either no toxicity data are available or analyte was not detected in leachate.
NDL = North Doane Lake
NOAEC =no observed adverse effect concentration
NOAEL = no observed adverse effect level
NOEC = no observed effect concentration
NRWQC = National Recommended Water Quality Criteria
PCB = polychlorinated biphenyl
RBC = risk based concentration
SCV = Secondary Chronic Value
SLV = screening level value
TCDD = tetrachlorodibenzo-p-dioxin
TEF = Toxicity Equivalency Factor
WDL = West Doane Lake
WHO = World Health Organization
italics = not detected in Phase 2 though 6 leachate

TABLE 2
Screening of Remedial Technologies for WDL
RP - Portland Site

Category	Class	Remedial Technology	Description	Meets RAOs (5 = Highest Compliance)	Effectiveness (5 = Highest Effectiveness)	Reliability (5 = Highest Reliability)	Implementability (5 = Highest implementability)	Implementation Risk (5 = Lowest Risk)	Cost (5 = Lowest Cost)	Score	Retained
Institutional Controls		**Deed Restriction**	Restrictions on property uses are recorded.	This technology is not being considered, since the property owner is different than the project owner.						NA	No
		Signage	Warning signs are posted.	This technology is already in place and will be maintained as part of site-wide remedy.						NA	No
Engineering Controls		**Fencing**	A perimeter fence is installed to restrict access.	This technology is already in place and will be maintained as part of site-wide remedy.						NA	No
		Barrier Wall	A perimeter, subsurface , low-permeability wall is installed to reduce groundwater flow.	This technology is not retained in this IRAM, but it is addressed as part of site-wide remedy.						NA	No
		Capping	An earthen and geosynthetic cap layer(s) is constructed over the impacted sediment.	2-Low; eliminates direct contact and reduces stormwater infiltration and subsequent leaching of COIs	3-Moderate; effective to eliminate contact and reduce leachability by stormwater infiltration	5-Very high	5-Very high	5-Low	4-Low	24	**Yes**
Treatment	**In-Situ**	**Natural Attenuation**	The COIs degrade or are bound up by natural processes and the impacted media is monitored by sampling.	1-Very low; very slow degradation rate with continued leachability	2-Low; only addresses some COIs	3-Moderate; works for certain COIs only	5-Very High	1-Very high (long time frame)	5-Very low	17	**Yes**
		Enhanced Aerobic Bioremediation	Additives are injected into sediment to increase oxygen content to promote microbial populations to degrade some organic COIs.	3-Moderate; limited to certain organic COIs	3-Moderate; limited due to poor circulation within sediment, only addresses some COIs	4-High; requires periodic repetition	2-Low; access over the sediment difficult	4-Low	3-Moderate	19	No
		Enhanced Anaerobic Bioremediation	Additives are injected into sediment to decrease oxygen content to promote microbial populations to degrade some organic COIs.	3-Moderate; limited to certain organic COIs	3-Moderate; limited due to poor circulation within sediment, only addresses some COIs	4-High; requires periodic repetition	2-Low; access over the sediment difficult	4-Low	3-Moderate	19	No
		Chemical Oxidation	Strong oxidants (e.g., sodium persulfate, hydrogen peroxide) are injected into sediment to chemically degrade some organic COIs.	3-Moderate; limited to certain organic COIs	3-Moderate; limited due to poor circulation within sediment	4-High; requires periodic repetition	2-Low; access over the sediment difficult	4-Low	2-High	18	No
		Reduction by Zero-Valent Iron	Zero-valent iron is mixed with the sediment to create a reducing environment and increase adsorption and dechlorination of certain organic COIs.	3-Moderate; limited to certain organic COIs	2-Low; limited circulation within sediment, will mobilize metals, only addresses some COIs	4-High; proven in projects	2-Low; access over the sediment difficult	4-Low	2-High	17	No
		Air Sparging/Soil Vapor Extraction	Air is injected into the sediment to promote volatilization of certain organic COIs and vapors are actively removed from the sediment.	3-Moderate; limited to certain organic COIs	2-Low due to poor gas circulation and poor gas venting within sediment	4-High; requires long duration	1-Very low; access over the sediment difficult, cannot easily capture vapors in open lake	3-Moderate; very difficult to capture/control vapors in open lake	3-Moderate	16	No
		In-Situ Soil Heating	Electrodes are inserted into the sediment and current is applied to increase the temperature, thus volatilizing organic certain COIs.	3-Moderate; limited to certain organic COIs	2-Low; limited due to poor gas venting within the sediment	4-High; may require periodic repetition	1-Very low; access over the sediment difficult; cannot easily capture vapors in open lake	1-Very high; very difficult to capture/control vapors in open lake, hot and electrified surface water also potentially present	2-High	13	No
		Stabilization	Soil is mixed with cement and other additives.	5-Very high; RAOs are met	5-Very high; most COIs are immobilized	5-Very high; proven technology	5-Very high	4-Low	3-Moderate	27	**Yes**
	Ex-Situ	**Soil Washing**	Sediment is excavated, then washed with additives to remove COIs, then the concentrated COIs are addressed.	5-Very high	3-Moderate; material will be solidified for excavation, making washing less effective for many COIs	4-High; most COIs may be addressed	2-Low; difficult excavation	1-Very high	1-Very high	16	No
Removal	**Unsupported**	**Trackhoe Only**	Sediment is excavated by trackhoe.	5-Very high	5-Very high	5-Very high	1-Very low; due to fluid sediment	1-Very high due to embankment safety and handling of fluid sediment	4-Low	21	No
		Clamshell	Sediment is excavated by clamshell.	5-Very high	5-Very high	5-Very high	1-Very low; due to fluid sediment	1-Very high due to embankment safety and handling of fluid sediment	4-Low	21	No
		Vacuum Truck	Sediment is removed by vac truck.	5-Very high	5-Very high	5-Very high	1-Very low; available systems cannot handle high volume	1-Very high due to embankment safety and handling of fluid sediment	4-Low	21	No
		Trenching Equipment	Sediment is removed by trenching machines and immediately backfilled as work progresses.	3-Moderate; some sediment will remain	3-Moderate; mixing with backfill will occur	1-Very low; cannot prevent mixing with backfill	1-Very low; cannot access due to fluid sediment	1-Very high; due to handling of fluid sediment	4-Low	13	No
		Stabilization and Trackhoe	Sediment is mixed with cement and other additives.	5-Very high	5-Very high	5-Very high	3-Moderate; excavation limitations	4-Low	2-High	24	**Yes**
		Railroad Embankment Support Systems	Embankment (but not sediment) is supported to allow safe removal of sediment.	5-Very high	5-Very high	5-Very high	1-Very low; cannot access due to fluid sediment	4-Low	3-Moderate	23	No
	Supported	**Trench Box**	Sediment is removed from inside an open-end trench box.	3-Moderate; some sediment will remain	3-Moderate; mixing with backfill will occur	1-Very low; cannot prevent mixing with backfill	4-High	1-Very high; due to handling of fluid sediment	3-Moderate	15	No
		Open Casing	Sediment is removed from inside an open-end casing.	5-Very high	5-Very high	5-Very high	1-Very low; cannot achieve a seal on the bottom; cannot remove fluid sediment	1-Very high; due to handling of fluid sediment	3-Moderate	20	No
		Portable Box	Sediment is removed from inside an enclosed trench box.	5-Very high	5-Very high	5-Very high	1-Very low; cannot achieve a seal on the bottom	1-Very high; due to handling of fluid sediment	3-Moderate	20	No
		Cofferdam	Sediment is removed from inside a temporary cofferdam.	5-Very high	5-Very high	5-Very high	4-High; some difficulty with installation	2-Low; some splashing of fluid sediment may occur during installation and wet excavation	2-High	23	**Yes**
	Disposal	**Incineration**	Removed sediment is transported offsite and incinerated.	5-Very high; destroys most of the COIs	5-Very high; metals within the ash are landfilled	5-Very high; proven technology for most COIs	1-Very low; no EPA-licensed incinerator will accept it (F027 waste code)	2-High; transporting waste will increase the risk due to accidents; transportation will substantially increase carbon footprint	1-Very high	19	No
		On-Site	Removed sediment is stored within Area of Contamination.	4-High; defects could lead to site recontamination	5-Very high	4-High; some leaching may occur by future leaks	3-Moderate; standard practice, but must implement at complex site	3-Moderate; short term and short distance for handling of sediment	2-High	21	**Yes**
		Off-Site	Removed sediment is disposed in an offsite landfill.	5-Very high	5-Very high	4-High; some leaching may occur by future leaks	5-Very high; will require CAMU approval	2-High; transporting waste will increase the risk due to accidents; transportation will substantially increase carbon footprint	1-Very high	22	**Yes**

Notes:
NA = not applicable

TABLE 3a
Remediation Cost Estimates for the WDL EE/CA
RP - Portland Site

Line ID	Description	Rate	Units	ALTERNATIVE 2 STABILIZATION		ALTERNATIVE 3 NAPL-AFFECTED SEDIMENT REMOVAL		ALTERNATIVE 4 REMOVAL	
				Quantity	Cost	Quantity	Cost	Quantity	Cost
CONTRACTOR COST									
1	Mob/Demob	$500,000	LS	1	$500,000	1.3	$650,000	2	$950,000
2	Site Setup (Lines 3-6)								
3	Perimeter Fence and Berm	$5	LF	2,000	$10,000	2,000	$10,000	2,000	$10,000
4	Access Road	$30	Ton	1,350	$40,500	1,350	$40,500	1,350	$40,500
5	Stormwater Lift Stations	$15,000	EA	2	$30,000	2	$30,000	2	$30,000
6	Electrical and Mechanical	$140,000	LS	1	$140,000	1	$140,000	1	$140,000
7	Debris Management	$5,000	Day	106	$530,000	106	$530,000	106	$530,000
8	In-Situ Stabilization	$115	CY	21,300	$2,449,500	21,300	$2,449,500	21,300	$2,449,500
9	Removal (Lines 10-11)								
10	Excavation and Loading	$15	CY		$0	1,800	$27,000	28,000	$420,000
11	Offsite Transportation and Disposal	$390	Ton	900	$351,000	3,400	$1,326,000	40,000	$15,600,000
12	Controlled Density Backfill	$115	CY		$0	1,800	$207,000	28,000	$3,220,000
13	Capping (Lines 14-16)								
14	Imported Backfill	$30	Ton	34,000	$1,020,000	34,000	$1,020,000	34,000	$1,020,000
15	Geosynthetics	$3.3	SF	110,000	$363,000	110,000	$363,000		$0
16	Stormwater Piping	$35	LF	1,000	$35,000	1,000	$35,000	1,000	$35,000
TOTAL (Lines 1-16)					**$5,469,000**		**$6,828,000**		**$24,445,000**
Contingency		25	%		$1,367,250		$1,707,000		$6,111,250
CONTRACTOR COST					**$6,836,000**		**$8,535,000**		**$30,556,000**
CONSULTANT COST									
17	Design (Lines 18-22)								
18	Project Plans	$90,000	LS	1	$90,000	1	$90,000	1	$90,000
19	Drawings and Specification	$90,000	LS	1	$90,000	1	$90,000	1	$90,000
20	Geotechnical Monitoring	$100,000	LS	1	$100,000	1	$100,000	1	$100,000
21	Permitting	$30,000	LS	1	$30,000	1	$30,000	1	$30,000
22	Waste Profiling	$30,000	LS	0.5	$15,000	1	$30,000	1	$30,000
23	Project Management	$2,000	Mo	15	$30,000	16	$32,000	19	$38,000
24	Construction Management	$23,000	WK	26	$598,000	30	$690,000	39	$897,000
25	Sampling and Analysis	$300,000	LS	1	$300,000	1.1	$330,000	2	$600,000
26	Construction Report	$75,000	LS	1	$75,000	1.5	$112,500	2	$150,000
TOTAL (Lines 17-26)					**$1,328,000**		**$1,505,000**		**$2,025,000**
Contingency		20	%		$265,600		$301,000		$405,000
CONSULTANT COST					**$1,594,000**		**$1,806,000**		**$2,430,000**
TOTAL CAPITAL COST (CONTRACTOR + CONSULTANT)					**$8,430,000**		**$10,341,000**		**$32,986,000**
OPERATION AND MAINTENANCE									
27	Groundwater Monitoring	$55,000	Event	30	$1,650,000	30	$1,650,000	2	$110,000
28	Water Treatment	$55,000	YR	30	$1,650,000	30	$1,650,000	1	$55,000
29	Geotechnical Monitoring	$50,000	YR	2	$100,000	2	$100,000	2	$100,000
30	Operations & Maintenance	$40,000	YR	5	$200,000	5	$200,000	1	$40,000
O&M Subtotal (Lines 27-30)					**$3,600,000**		**$3,600,000**		**$305,000**
Contingency		30	%		$1,080,000		$1,080,000		$91,500
TOTAL O&M (in 2008 dollars)					**$4,680,000**		**$4,680,000**		**$396,500**
TOTAL PROJECT COST (CAPITAL COST + O&M COST)					**$13,110,000**		**$15,021,000**		**$33,383,000**

Notes:
CY = cubic yard
EA = each
LF = linear feet
LS = lump sum
MO = month
SF = square feet
WK = week
YR = year

TABLE 3b
Remediation Cost Estimate Backup for the WDL EE/CA
RP - Portland Site

Line ID	Description	Explanation
		CONTRACTOR COST
1	Mob/Demob	Assume 10% of contractor cost for Alternatives 2 and 3, and 5% for Alternative 4.
2	Site Setup (Lines 3-6)	
3	Perimeter Fence and Berm	Estimated quantity of 2,000 lf. Temporary fencing for less than 1 year, use $2.5/LF. Use $2.5/lf for 6" earthen berm wrapped in plastic sheeting.
4	Access Road	Assume crushed rock for a volume equal to a road 1,500 ft long, 12 ft wide, and 1 ft thick = 670 CY, using conversion factor of 2 tons/CY = 1,350 tons. Use local pricing of $30/ton delivered and placed.
5	Stormwater Lift Stations	Two precast concrete manholes; use $8,000 for the unit delivered and $7,000 for installation.
6	Electrical and Mechanical	Assume 4 power poles and wiring @ $5,000 ea. installed, 3 transformers installed @ $2,500 ea., 2 control panels installed @ $50,000 ea., and 2 pumps installed @ $2,000 ea. Total cost of $131,500; use $140,000.
7	Debris Management	Duration of ISS = 106 working days; Assume two tracked machines, one with grapple attachment and one with bucket with thumb attachment @ $2,000/day ea, including operator. One laborer for 10 hours/day @ $60/hour. Add $400/day for hoses, pumps, etc. Total $5,000 per day.
8	In-Situ Stabilization	Quantity will be equal to 48,000 sf lake surface times 12 ft deep = 21,300 CY. For the ISS application, use $75/CY per vendor. Use following additives: 10% cement = 0.13 tons @ $100/ton = $13/CY; 5% bentonite = 0.1 tons @ $120/ton = $12/CY; allow another $15/CY for other additives. Total = $115/CY.
9	Removal (Lines 10-11)	
10	Excavation and Loading	Quantity for Alt 3 will be 4,000 sf by 15.5 ft deep (fluffed) = 2,300 CY; for Alt 4 will be 48,000 sf by 15.5 ft deep = 28,000 CY. Double handling for the machine, use 1 hour to include standby per 20 CY load. Equipment, operator, and laborer @ $300/hour = $15/CY.
11	Offsite Transportation and Disposal	Debris is assumed to be equal to a concrete layer 3 inches thick over the lake bank area of 18,000 sf and 2 inches thick over the lake area of 48,000 sf; Total = 460 CY @ 2 tons/CY = 920 tons; use 900 tons. Fluffed sediment will be ~1.4 tons/CY: Alt 3 = 3,200 tons; Alt 4 = 39,000 tons. Transportation and disposal from vendor @ $300/ton.
12	Controlled Density Backfill	Alts 3 and 4 will require replacement with the same volume removed as calculated in Excavation and Loading. Vendor pricing of $105/CY, plus $10/CY labor and material to add bentonite; use $115/CY.
13	Capping (Lines 14-16)	
14	Imported Backfill	1 ft clay over 60,000 sf (90,000 sf cap area, less 30,000 sf for slopes with no fill) = 2,200 CY; 1 ft sand over 60,000 sf = 2,200 CY; Avg of 6 ft of structural fill over 60,000 sf = 13,200 CY; 1 ft topsoil over 90,000 sf = 3,300 CY; Total = 20,900 , use 21,000 CY. Use avg density of 1.6 tons/CY = 33,600 tons; use 34,000 tons. Use avg price of imported, placed, and compacted of $30/ton.
15	Geosynthetics	Geosynthetics will cover an average of 100,000 sf; add 10% for overlap and waste, use 110,000 sf. GCL = $1/sf, geomembrane = $2/sf, Geotextile = $0.25/sf, demarcation = $0.05/sf Total = $3.30/sf.
16	Stormwater Piping	1,000 lf of piping. One pedestal every 15 ft = 67 pedestals, use $300/pedesatl installed = $20/lf; add pipe @ $10/lf ; add $5/lf for fittings etc. Total = $35/lf.
		CONSULTANT COST
17	Design (Lines 18-22)	
18	Project Plans	Assume 400 manhours for draft and another 200 manhours for final. 600 manhours. Use avg of $150/hour to include ODCs. Total = $90,000.
19	Drawings and Specification	Assume 400 manhours for draft and another 200 manhours for final. 600 manhours. Use avg of $150/hour to include ODCs. Total = $90,000.
20	Geotechnical Monitoring	Assume $100,000 for instrumentation and installation.
21	Permitting	Assume 200 manhours @ $150/hour; Total = $30,000.
22	Waste Profiling	For Alts 3 and 4; Assume 200 manhours @ $150/hour; Total = $30,000.
23	Project Management	Alternative 2 will require 15 months from start to complete construction report; Alt 3 will require an extra month, and Alt 4 an extra 3 months. Use 10 manhours/ month @ $200/ hour to include ODCs.
24	Construction Management	Alts 2, 3, and 4 will require 26, 30, and 39 weeks to complete, respectively. Use 150 manhours/week @ $150/hour to include ODCs; Total = $23,000/week.
25	Sampling and Analysis	ISS QA testing:100 strength @ $150; 25 perm @ $600; 15 leachability @ $4,500. Total = $98,000; use $100,000. Allow $150,000 for OSHA and perimeter air sampling and analysis; add $50,000 for other. For Alt 3 add 10% for confirmation sampling after excavation; for Alt 4 add 100% for confirmation sampling.
26	Construction Report	Assume Total of 500 manhours @ $150/hour; add 50% for Alt 3 and 100% for Alt 4.
		OPERATION AND MAINTENANCE
27	Groundwater Monitoring	Assume 200 manhours labor (field and office) @ $150/hour; Total = $30,000. Add $4,500 analytical cost per sample or $22,500; waste handling @ $1,000, and $1,500 misc; Total = $55,000/ round.
18	Water Treatment	Assume similar effort and cost as groundwater sampling.
29	Geotechnical Monitoring	Assume annual cost of monitoring equal to 50% of installation, or $50,000. Monitor for 2 years.
30	Operations & Maintenance	Assume avg inspections and repairs of 200 manhours per year @ $150/hours, plus $10,000 contractor cost per year. Total = $40,000.

TABLE 4a
Greenhouse Gas Emission Calculations for Alternatives 3 and 4 for the WDL EE/CA
RP - Portland Site

Alternative No.	CY of Sediment Removed	Tons of Sediment Removed [1]	Truckloads (Roundtrip)	Gallons of Fuel per Truckload	Gallons of Fuel per Alternative	CO_2 Emissions per Gallon of Fuel [2] (tons)	CO_2 Emissions per Alternative (tons)
Alternative 3 Sediment Disposal GHG Emissions	1,800	2,520	100	72	7,200	0.011	79
Alternative 4 Sediment Disposal GHG Emissions	28,000	39,200	1,300	72	93,600	0.011	1030

Calculation Assumptions:

2,300 CY of sediment removed for Alternative 3.

28,700 CY of sediment removed for Alternative 4.

[1] 1.4 tons per CY of sediment removed.

The truck will be full on the trip to the landfill and empty on the return trip. Use the average mpg for calculations.

The truck gets 5 mpg on a full load and 6 mpg on an empty load, for an average of 5.5 mpg.

The excavator is used for 1 hr per load and the average burn rate for the excavator is 10 gal/hr = 10 gal per load.

A roundtrip to the landfill is 305 miles, and 305 mi x 5.5 mpg = 55 gal per load.

A roundtrip for importing backfill is 40 miles, and 40 mi x 5.5 mpg = 7 gal per load.

72 gal fuel per truckload (10 gal for excavator + 55 gal per load + 7 gal for backfill load = 72 gal)

[2] The diesel fuel CO_2 emission factor per unit volume is 10.15 kg/gal (Page 2) = 22 lbs/gal = 0.011 tons/gal.

Notes:
CY = cubic yard
gal - gallon
GHG = greenhouse gas
hr = hour
kg - kilogram
lbs = pounds
mi = mile
MPG = miles per gallon

TABLE 4b
Fuel Consumption Rates Used for Calculated Estimates of Greenhouse Gas Emissions of Alternatives 3 and 4
RP - Portland Site

Fuel Type	Tier A2 Method			Tier B/C Method
	Carbon Content (Per Unit Energy)	Heat Content	Fraction Oxidized	CO_2 Emission Factor (Per Unit Volume)
Fuel Measured in Gallons	**kg C / MMBtu**	**MMBtu / Barrel**		**kg CO_2 / gallon**
Motor Gasoline	19.33	5.218	1.00	8.81
Diesel Fuel No. 1 and 2	19.95	5.825	1.00	10.15
Aviation Gasoline	18.87	5.048	1.00	8.32
Jet Fuel A(Jet A or A-1	19.33	5.670	1.00	9.57
Kerosene	19.72	5.670	1.00	9.76
Residual Fuel Oil (#5,6)	21.49	6.287	1.00	11.8
Crude Oil	20.33	5.80	1.00	10.29
Biodiesel (B100)*	NA	NA	1.00	9.46
Ethanol (E100)*	17.99	3.539	1.00	5.56
Methanol**	NA	NA	1.00	4.10
Liquified Natural Gas (LNG)*	NA	NA	1.00	4.46
Liquified Petroluem Gas (LPG)*	17.23	3.849	1.00	5.79
Propane	17.20	3.824	1.00	5.74
Ethane	16.25	2.916	1.00	4.14
Isobutane	17.25	4.162	1.00	6.45
n-Butane	17.72	4.328	1.00	6.70
Fuels Measured in Standard Cubic Feet	**kg C / MMBtu**	**Btu / Standard Cubic Foot**		**kg CO_2 / Standard Cubic Foot**
Compressed Natural Gas (CNG)*	14.47	1.027	1.00	0.054

- Source: United States Envrironmental Protection Agency (EPA), *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2005* (2007), Annex 2.1, Tables A-31, A-34, A-36, except those marked * (from EPA Climate Leaders, Mobile Combustion Guidance, 2007) and ** (from California Climate Action Registry *General Reporting Protocol* Version 2.2, 2007, Table C.3). A fraction oxidized value of 1.00 is from IPCC, Guidelines for National Greenhouse Gas Inbentories (2006).
- Note: Default CO_2 emisssion factors are calulated using Equation 12d: Heat Content x Carbon Content x Fraction Oxidized x 44/12 x Conversion Factor. Heat content factors are based on higher heating values (HHV).
- NA = data not available.

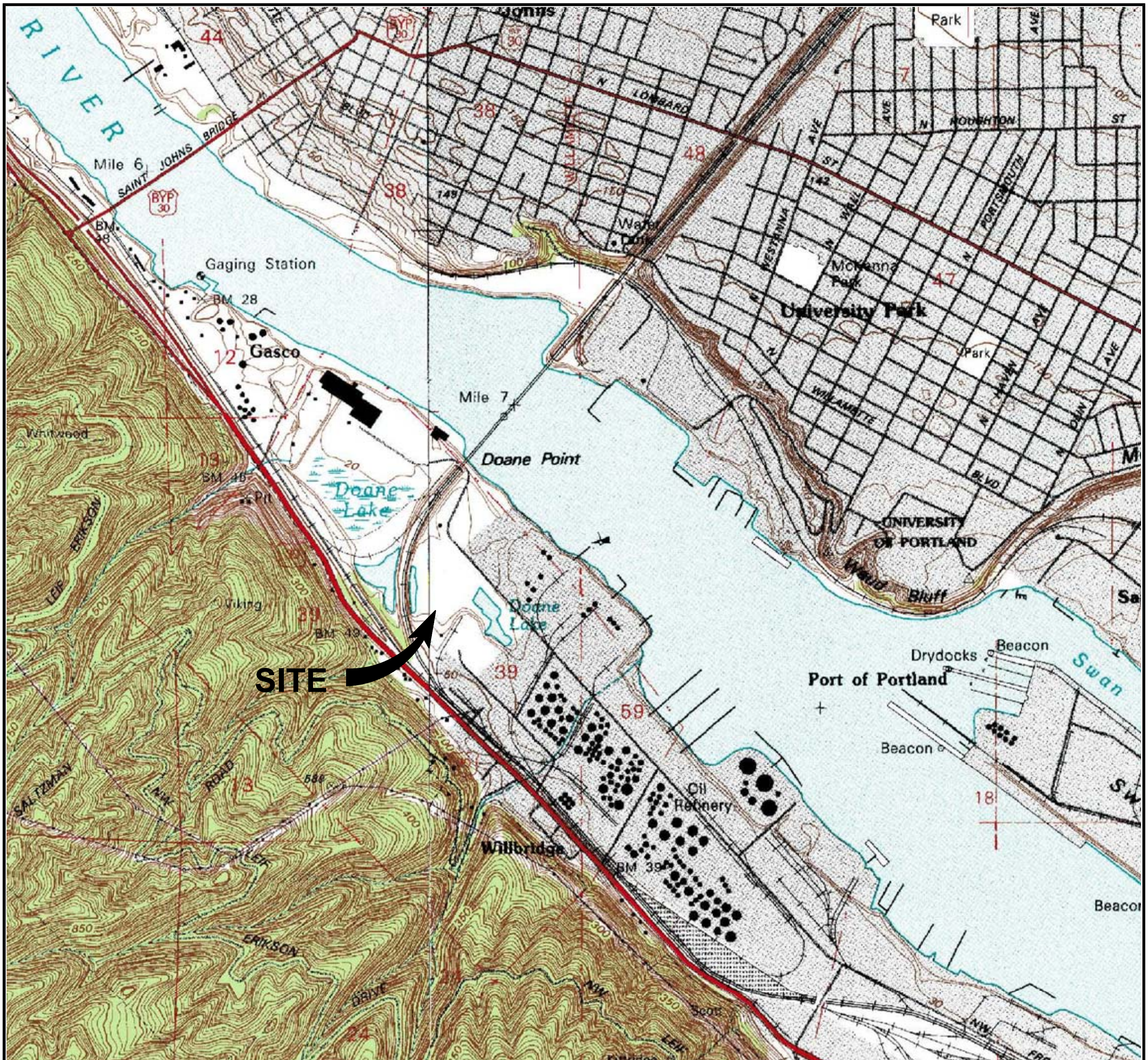
Note: Table replicated from The Climate Registry, General Reporting Protocols, Vol 1.1, Table 13.1, May 2008.

TABLE 5
Summary of Screening Criteria and Balancing Factors for WDL IRAM Alternatives
RP - Portland Site

Alternative	Screening Criteria/Balancing Factor					
	Protectiveness	Effectiveness	Long-Term Reliability	Implementability	Implementation Risk	Reasonableness of Cost
Alternative 1 **No Action**	No Effect	No Effect	Not Applicable	Readily Implementable	Prolongs exposure risk to human health and ecological receptors.	None
Alternative 2 **ISS**	Protective - Eliminates risk to ecological and human receptors while providing an in-situ solution.	Effective - Immediately meets all RAOs. TS indicates the ISS binds COIs chemically and physically. Eliminates COI mobility/NAPL concerns.	Highly reliable - Binds constituents, preventing mobility. Creates solid, impermeable monolith.	Most Readily Implementable	Least Implementation Risk	Relatively Low Cost ~$13,000,000
Alternative 3 **ISS with NAPL-Affected Sediment Removal and Offsite Disposal**	Protective - Removes NAPL-affected lake sediment. Poses risk via excavation and transportation hazards, and increased carbon footprint.	Effective - Immediately meets all RAOs. Removes the NAPL-affected sediment from WDL. Transfers risk to controlled location.	More reliable - The NAPL-affected sediment is removed permanently from WDL.	Readily Implementable - Includes all elements of Alternative 2, with the addition of limited excavation, transportation and off-site disposal.	Moderate to High Implementation Risk - Excavation and dewatering, even in limited volumes poses a risk to railroad embankment stability. Creates unnecessary risk to workers and public via excavation, transportation, and increased greenhouse gas emissions.	Moderate Cost ~$15,000,000
Alternative 4 **ISS, Sediment Removal, and Offsite Disposal**	Protective - Removes impacted media. Poses risk via excavation and transportation hazards, and increased carbon footprint.	Effective - Immediately meets all RAOs. Removes most of the impacted media from WDL. Transfers risk to controlled location.	Most reliable - Impacted media permanently removed from WDL.	Readily Implementable - Includes all elements of Alternative 2, with the addition of complete excavation, transportation and off-site disposal.	Moderate to High Implementation Risk - Excavation and dewatering, even in limited volumes poses a risk to railroad embankment stability. Creates unnecessary risk to workers and public via excavation, transportation, and increased greenhouse gas emissions.	High Cost ~$33,000,000
Selected Alternative	**Alternative 2**	**Alternative 2**	**Alternative 4**	**Alternative 2**	**Alternative 2**	**Alternative 2**

Notes:
COI = Constituent of Interest
ISS = In-Situ Stabilization
NAPL = Non-Aqueous-Phase Liquid
NDL = North Doane Lake
RAO = Remedial Action Objective
TS = Treatability Study
WDL= West Doane Lake
~ = approximate

FIGURES



LINNTON, OR.
45122-E7-TF-024
1990
DMA 1475 III SE - SERIES V892

ROAD CLASSIFICATION

Heavy-duty		Light-duty	
Medium-duty		Unimproved dirt	======

U.S. Route State Route Interstate Route

0' 1000' 2000' 3000'

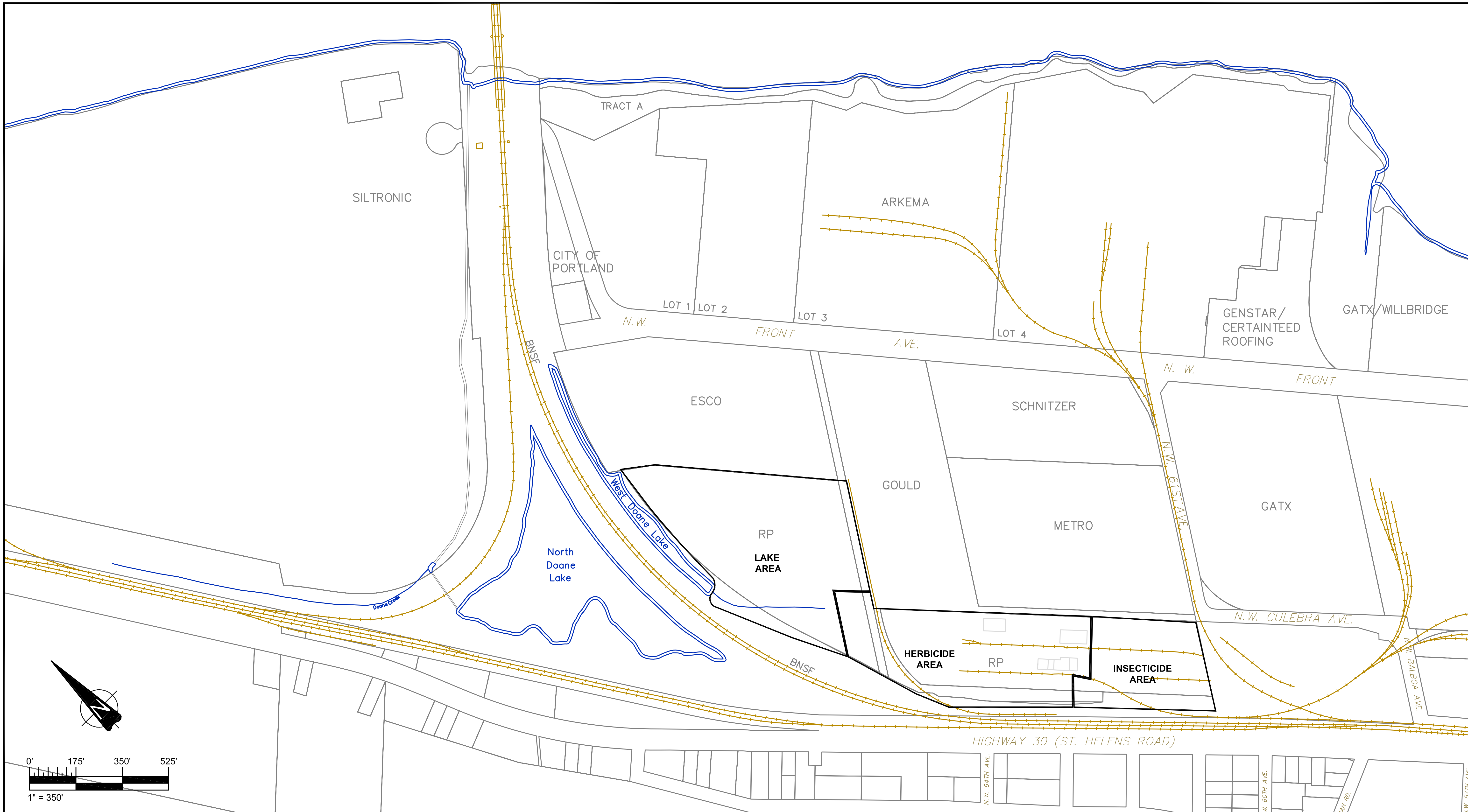
1" = 2000'

N

QUADRANGLE LOCATION

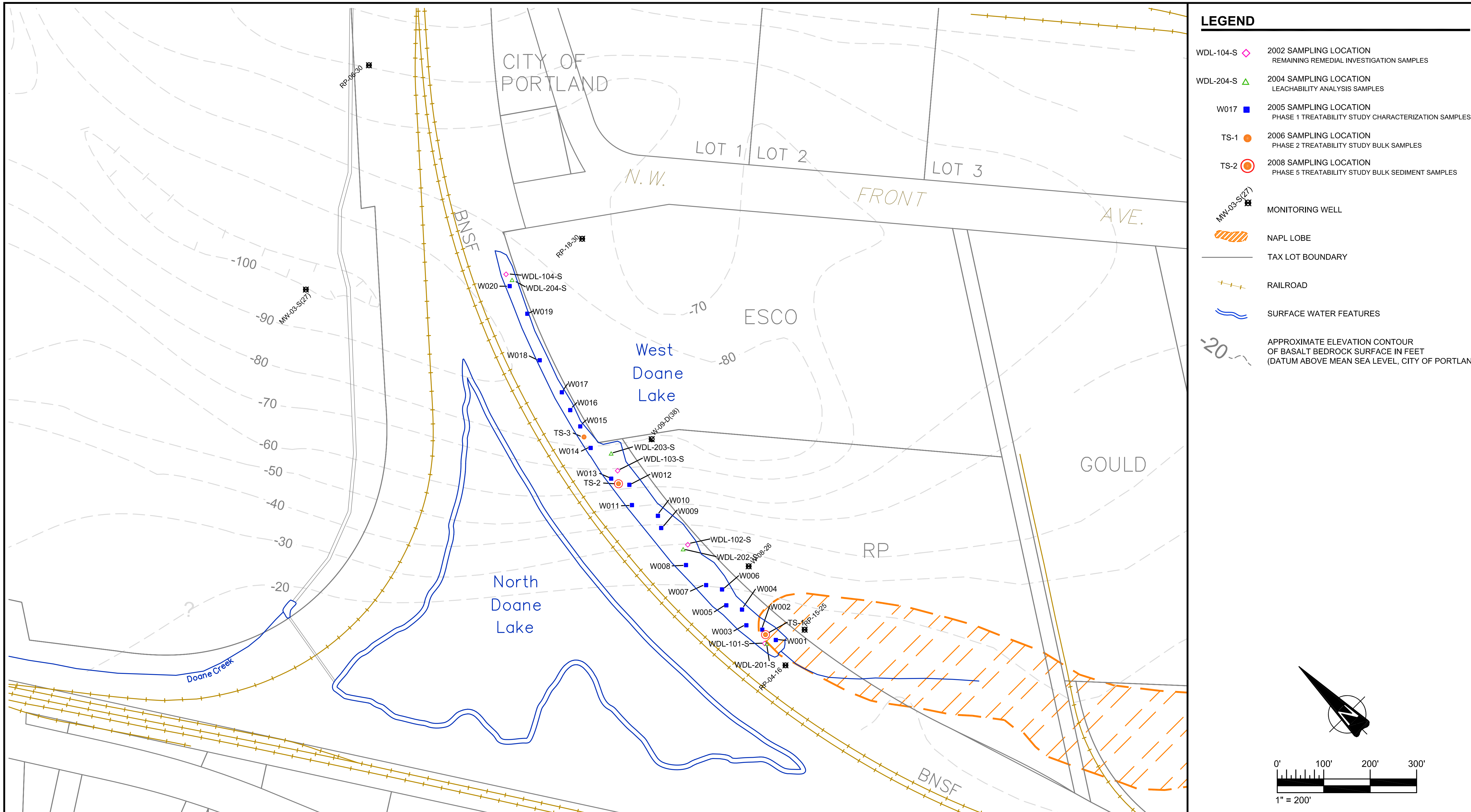
AMEC Earth & Environmental 7376 S.W. Durham Road Portland OR. U.S.A. 97224	amec		CLIENT SLLI
PROJECT RP - PORTLAND SITE	DWN BY: DD/LR	DATUM: -	DATE: FEBRUARY 2009
TITLE SITE LOCATION MAP	CHK'D BY: CH	REV. NO.: -	PROJECT NO: 0-61M-10703-0 0700 04
	PROJECTION: -	SCALE: 1" = 2000'	FIGURE No. FIGURE 1

K:\10000\10700\10703\0700 WDL\0700 Planning\04 EECA\REVISED EECA\DWG\Figure_01_Location_Map.dwg - Layout1 - Jan. 28, 2009 1:09pm - patrick.mccarthy



NOTE: THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC EARTH & ENVIRONMENTAL REPORT TITLED: FINAL WDL EE/CA	CLIENT: SLLI	DWN BY: LM/LR CHK'D BY: JE	PROJECT: RP - PORTLAND SITE	DATE: FEBRUARY 2009 PROJECT NO: 0-61M-10703-0 0700 04
	AMEC Earth & Environmental 7376 S.W. Durham Road Portland, OR. U.S.A. 97224 amec	DATUM: NAD83 PROJECTION: OR SP N. Int Ft. SCALE: 1"=350'	TITLE: WEST DOANE LAKE SITE AND VICINITY MAP	REV. NO.: 1 FIGURE No. 2

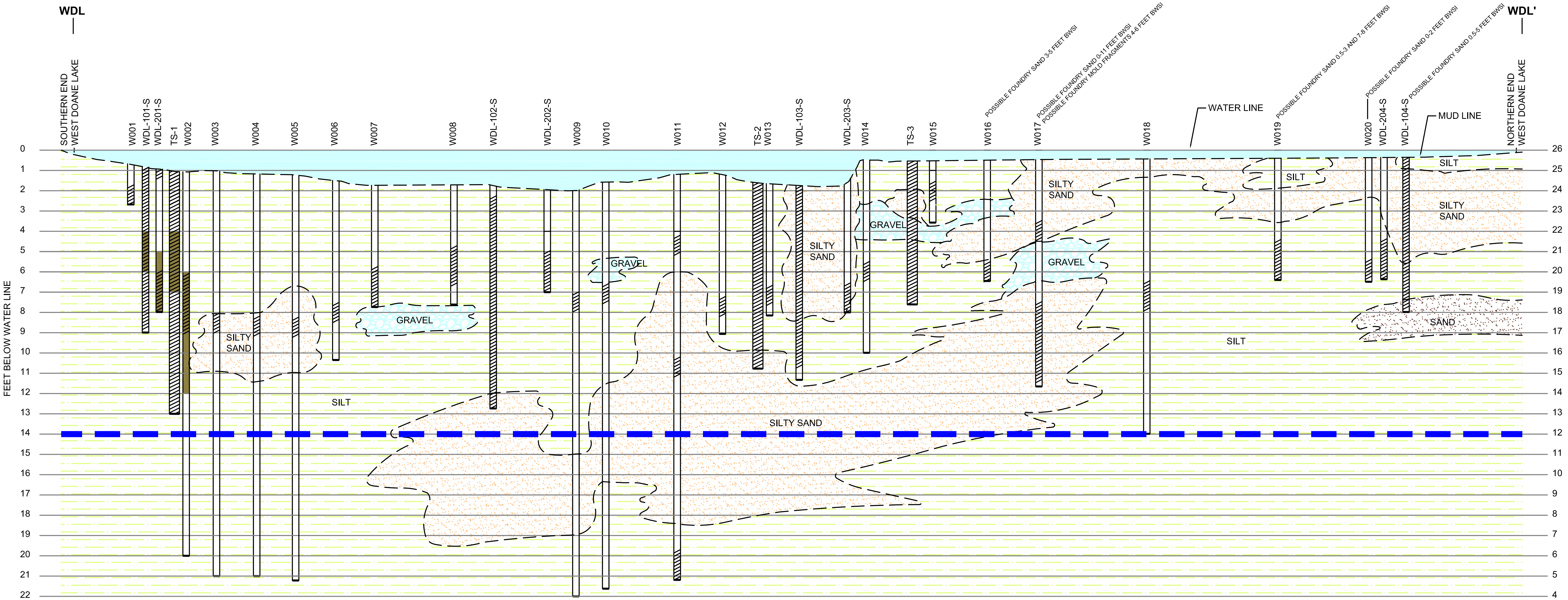
K:\10000\10700\10703\0700 WDL\0700 Planning\04 EECA\REVISED EECA\DWG\Figure_02_Site&Vicinity_Map.dwg – Layout2 – Jan. 28, 2009 1:12pm – patrick.mccarthy



NOTE: THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC EARTH & ENVIRONMENTAL REPORT TITLED: FINAL WDL EE/CA

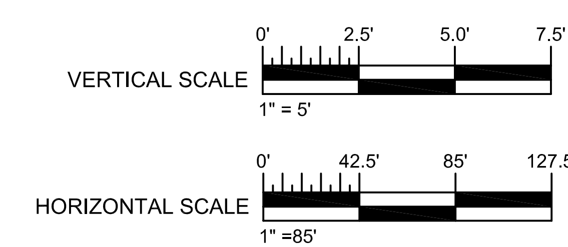
CLIENT: SLLI	DWN BY: LR/PM/BRJ	PROJECT: RP - PORTLAND SITE	DATE: FEBRUARY 2009
	CHK'D BY: RJ		PROJECT NO: 0-61M-10703-0 0700 04
AMEC Earth & Environmental 7376 S.W. Durham Road Portland, OR. U.S.A. 97224	DATUM: NAD83	TITLE: WEST DOANE LAKE SEDIMENT SAMPLING LOCATIONS	REV. NO.: 1
amec	PROJECTION: OR SP N. Int Ft.		FIGURE No. 3
	SCALE: 1" = 200'		

K:\10000\10700\10703\0700 WDL\0700 Planning\04 EECA\DWG\Figure_03_Sediment_Sampling_Locations.dwg – Layout1 – Feb. 12, 2009 2:06pm – della.fawcett



LEGEND

- NONAQUEOUS-PHASE LIQUID OBSERVED IN SEDIMENT
- SAMPLE DEPTHS ANALYZED FOR CHEMICAL CONSTITUENTS
- INFERRED LITHOLOGIC CONTACT
- APPROXIMATE DEPTH OF STABILIZATION
- BWSI BELOW WATER/SEDIMENT INTERFACE

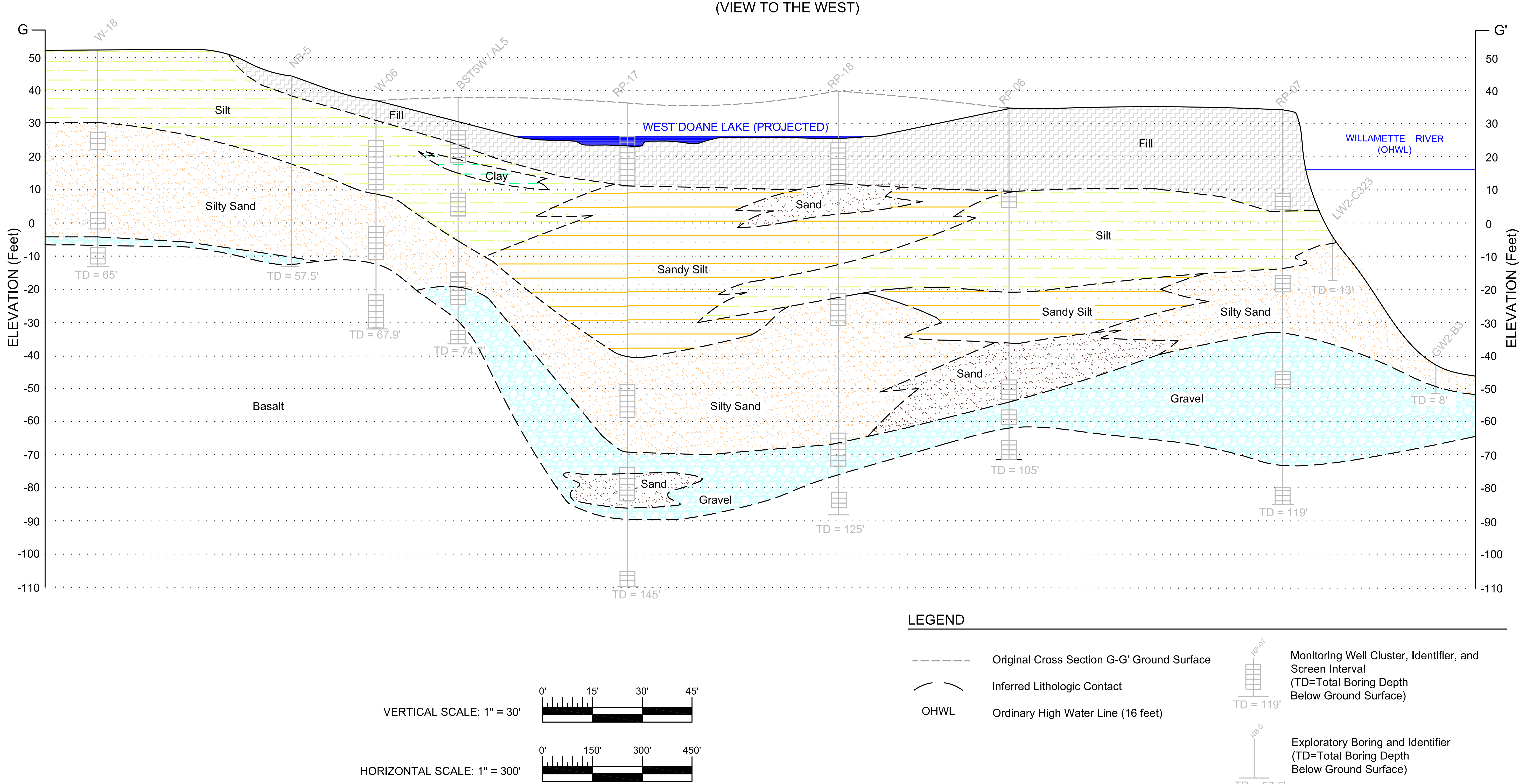


NOTE: THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC EARTH & ENVIRONMENTAL REPORT TITLED: FINAL WDL EE/CA

CLIENT: SLLI	DWN BY: LR/DD	PROJECT: RP - PORTLAND SITE	DATE: FEBRUARY 2009
	CHK'D BY: MP/JE		PROJECT NO: 0-61M-10703-0 0700 04
AMEC Earth & Environmental 7376 S.W. Durham Road Portland, OR. U.S.A. 97224	DATUM: City of Portland	TITLE: SIMPLIFIED WEST DOANE LAKE CROSS-SECTION	REV. NO.: 1
	PROJECTION: -		FIGURE No. 4
	SCALE: AS NOTED		

K:\10000\10700\10703\0700 WDL\0700 Planning\04 EECA\DWG\Figure_04_Simplified_West_Doane_Lake_Cross_Section.dwg – Layout1 – Feb. 12, 2009 2:07pm – della.fawcett

(VIEW TO THE WEST)



NOTE: STRATIGRAPHY BETWEEN DEPICTED BORINGS MAY HAVE BEEN INTERPRETED FROM ADDITIONAL BORINGS NOT SHOWN ON THIS CROSS SECTION.

NOTE: THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC EARTH & ENVIRONMENTAL REPORT TITLED: FINAL WDL EE/CA

CLIENT: SLLI

AMEC Earth & Environmental
7376 S.W. Durham Road
Portland, OR. U.S.A. 97224

DWN BY:	LR/LM
CHK'D BY:	MP/CJ
DATUM:	City of Portland
PROJECTION:	-
SCALE:	AS NOTED

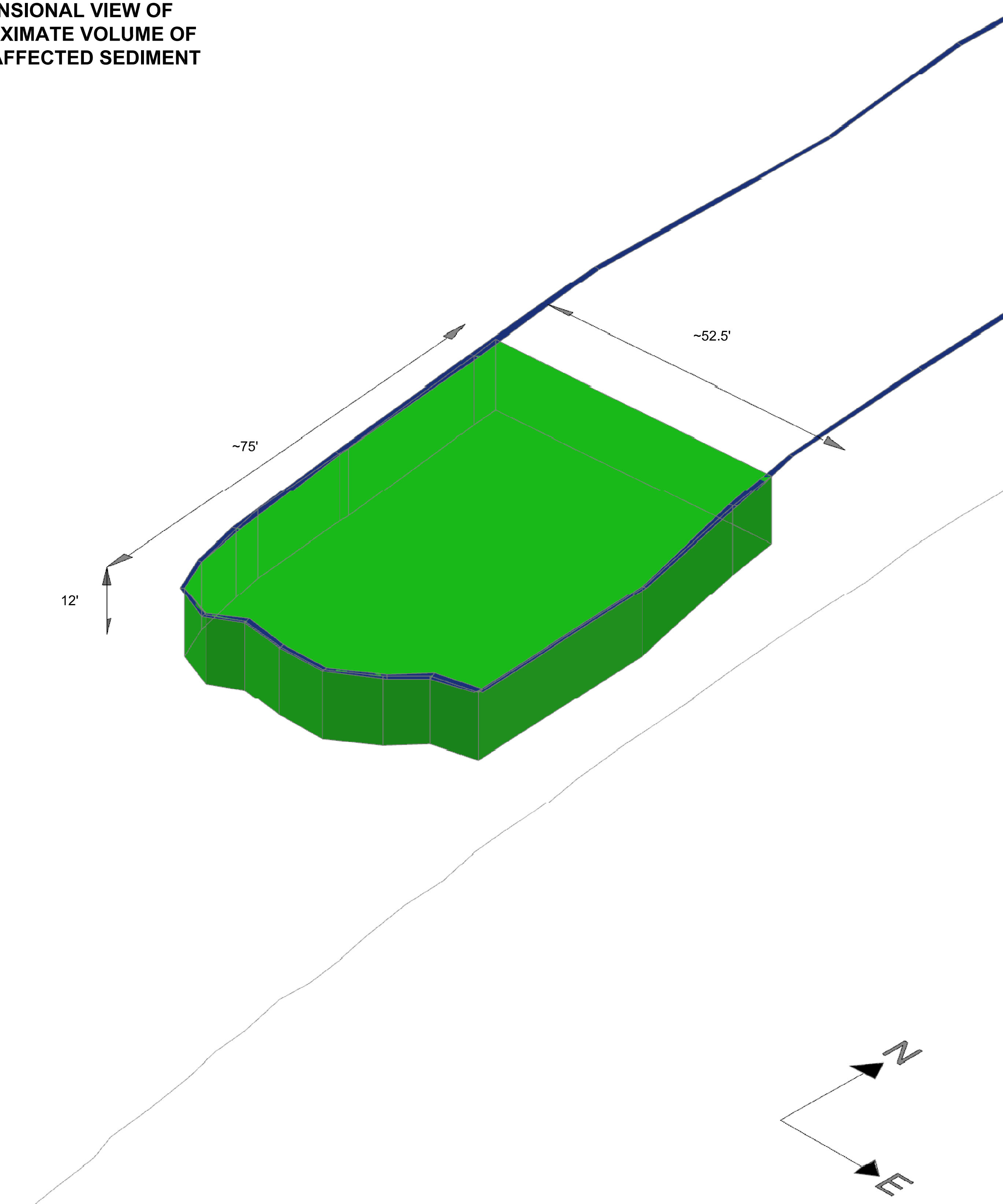
PROJECT: RP - PORTLAND SITE

TITLE: WEST DOANE LAKE PROJECTED ONTO LITHOLOGIC CROSS SECTION FROM G-G'

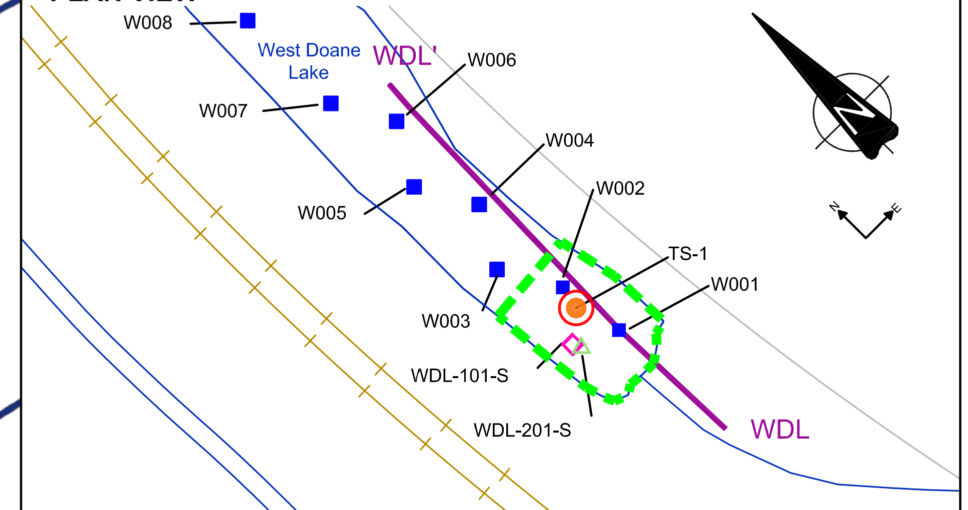
DATE:	FEBRUARY 2009
PROJECT NO:	0-61M-10703-0 0700 04
REV. NO.:	1
FIGURE No.	5

K:\10000\10700\10703\0700 WDL\0700 Planning\04 EECA\DWG\Figure_05_WDL_Projected_On_Cross_Section_G-G'.dwg – 11x17 – Feb. 12, 2009 2:08pm – della.fawcett

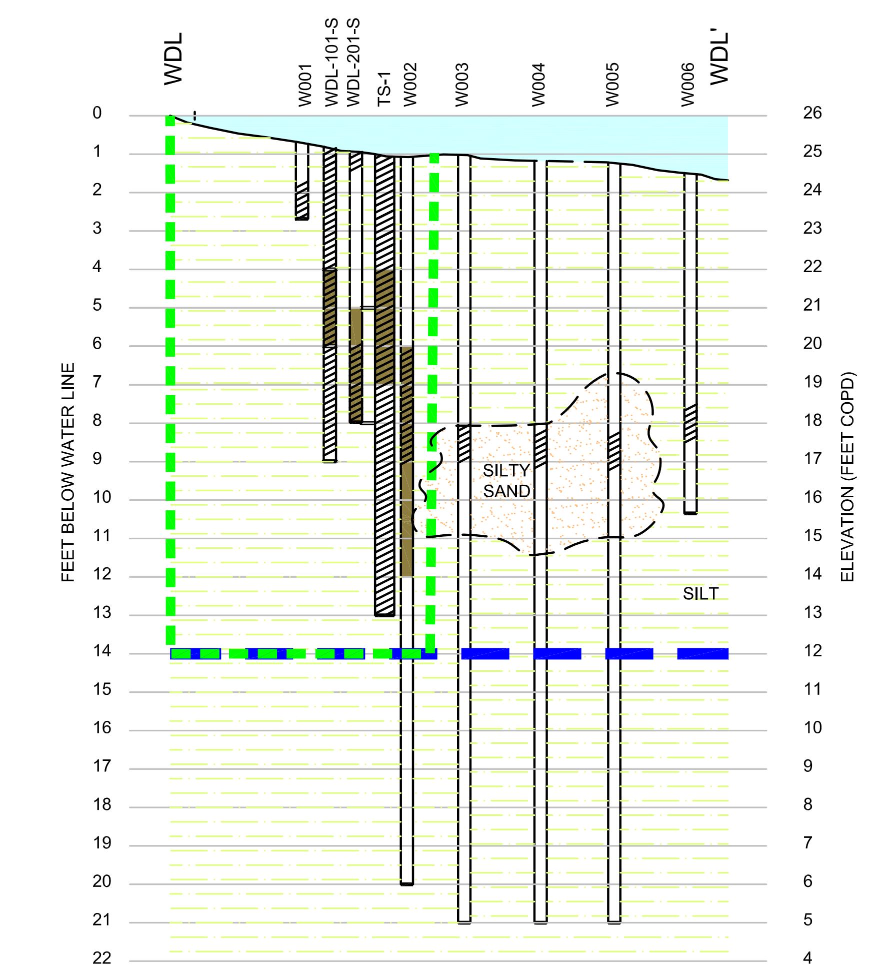
3-DIMENSIONAL VIEW OF APPROXIMATE VOLUME OF NAPL-AFFECTED SEDIMENT



PLAN VIEW



SIMPLIFIED CROSS SECTION VIEW



LEGEND

- WDL-104-S — 2002 SAMPLING LOCATION
- WDL-204-S — 2004 SAMPLING LOCATION
- W017 — 2005 SAMPLING LOCATION
- TS-1 — 2006 SAMPLING LOCATION
- TS-1 — 2008 SAMPLING LOCATION
- TAX LOT BOUNDARY
- RAILROAD
- WEST DOANE LAKE BOUNDARY FROM 95% DESIGN DRAWINGS
- APPROXIMATE EXTENT OF NAPL-AFFECTED SEDIMENT
- WDL CROSS SECTION LOCATION
- NAPL OBSERVED IN SEDIMENT
- SAMPLE DEPTHS ANALYZED FOR CHEMICAL CONSTITUENTS
- INFERRED LITHOLOGIC CONTACT
- APPROXIMATE DEPTH OF STABILIZATION
- POTENTIAL VOLUME OF NAPL-AFFECTED SEDIMENT
- BWSI — BELOW WATER/SEDIMENT INTERFACE
- NAPL — NON-AQUEOUS PHASE LIQUID
- COPD — CITY OF PORTLAND DATUM

CALCULATED VALUES FOR NAPL-AFFECTED SEDIMENT

- AREA = 3,935 SQUARE FEET (FROM 95% DESIGN CAD DRAWINGS WDL BOUNDARY)
- VOLUME (FT) = 47,220 CUBIC FEET
- VOLUME (YDS)= 1,749 CUBIC YARDS
- WEIGHT = 2,448 TONS

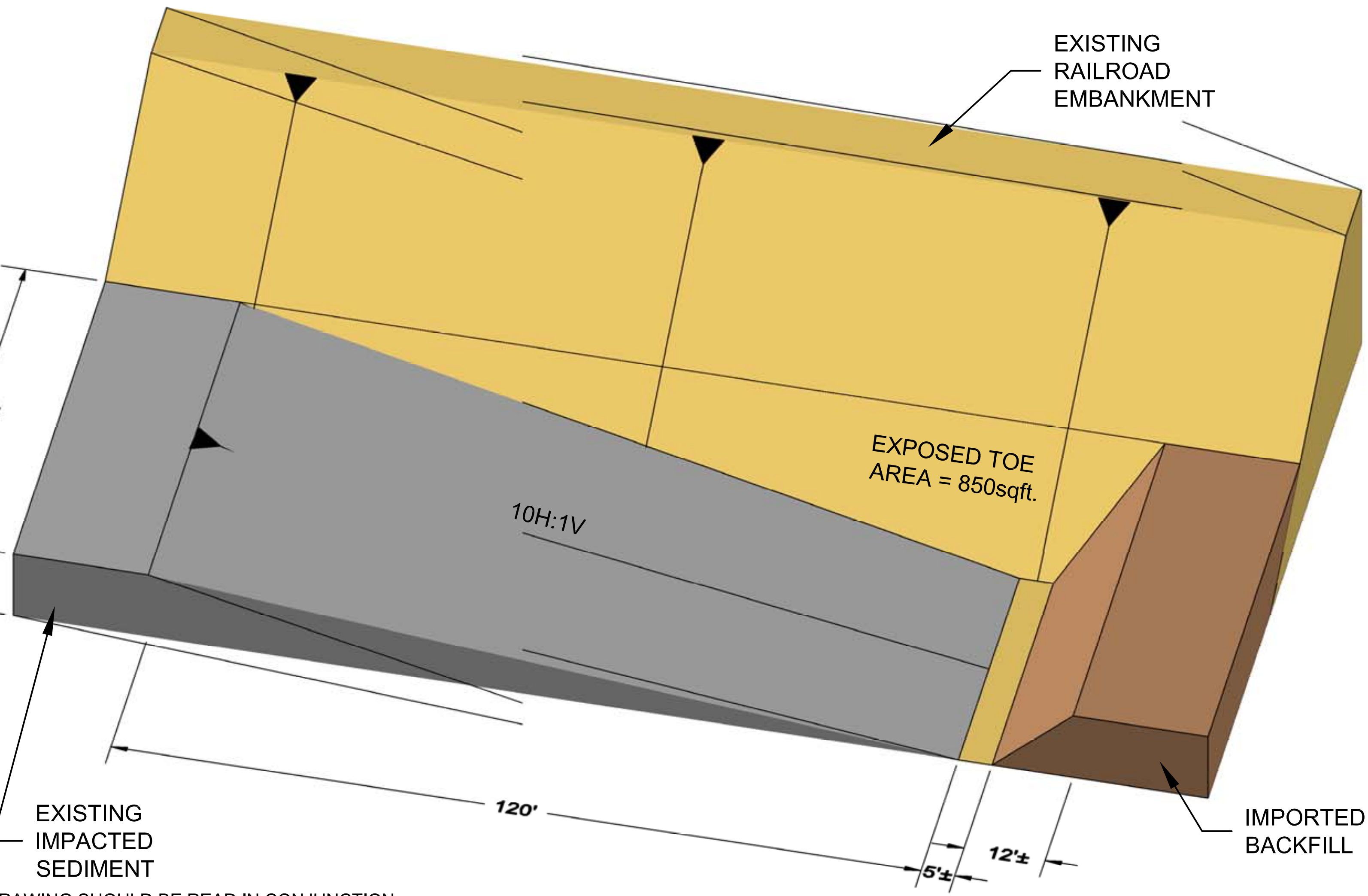
ASSUMPTIONS

- ASSUMES A LENGTH OF 75 FEET
- ASSUMES A WIDTH OF 52.5 FEET
- ASSUMES A UNIFORM DEPTH OF 12 FEET BWSI (APPROX. 13 FEET BELOW WATER LINE)
- ASSUMES NORTHERN EXTENT OF NAPL-AFFECTED SEDIMENT IS HALFWAY BETWEEN SAMPLING LOCATIONS W002 AND W003
- ASSUMES NAPL-AFFECTED SEDIMENT WEIGHS 1.4 TONS PER CUBIC YARD

NOTE: THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC EARTH & ENVIRONMENTAL REPORT TITLED: FINAL WDL EE/CA

CLIENT: SLLI	DWN BY: LR	PROJECT: RP - PORTLAND SITE	DATE: FEBRUARY 2009
	CHK'D BY: RJ/MP		PROJECT NO: 0-61M-10703-0 0700 04
AMEC Earth & Environmental, 7376 S.W. Durham Road, Portland, OR. U.S.A. 97224	DATUM: -	TITLE: APPROXIMATE VOLUME OF NAPL-AFFECTED SEDIMENT IN WDL	REV. NO.: 1
	PROJECTION: -		FIGURE No. 6
	SCALE: AS SHOWN		

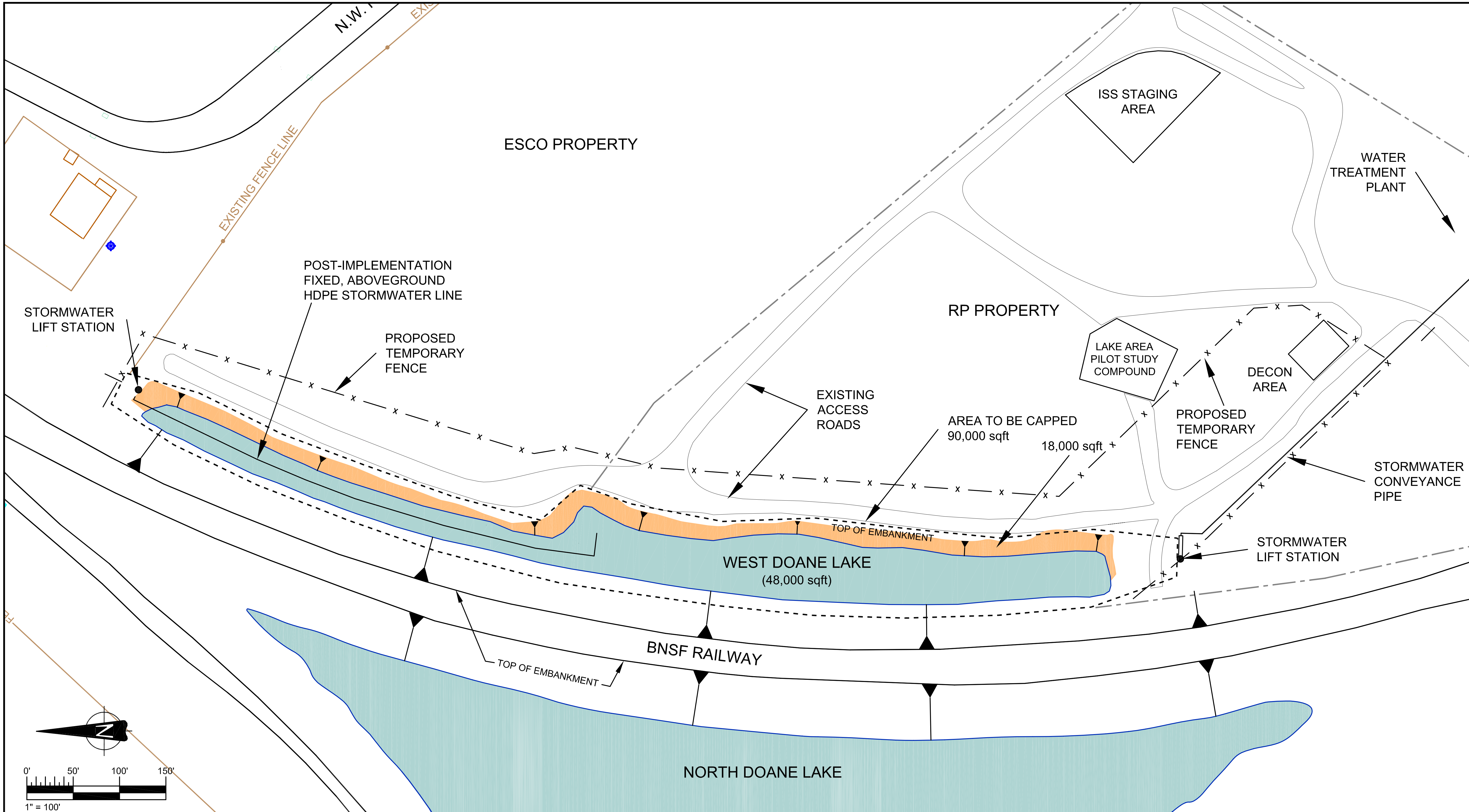
K:\10000\10700\10703\0700 WDL\0700 Planning\04 EECA\DWG\Figure_06_WDL_Excavation.dwg – Layout1 – Feb. 13, 2009 11:25am – patrick.mccarthy



NOTE: THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC EARTH & ENVIRONMENTAL REPORT TITLED: FINAL WDL EE/CA

	CLIENT: SLLI	DWN BY: -	PROJECT: RP - PORTLAND SITE	REV. NO.: -
		CHK'D BY: -		DATE: FEBRUARY 2009
AMEC Earth & Environmental 7376 SW Durham Road Portland, OR, U.S.A. 97224	amec	DATUM: -	TITLE: CONCEPTUAL 3-D MODEL OF AN OPEN EXCAVATION AT WDL	PROJECT NO: 0-61M-10703-0 0700 04
		PROJECTION: -		FIGURE No. 7
		SCALE: NOT TO SCALE		

K:\10000\10700\10703\0700 WDL\0700 Planning\04 EECA\DWG\Figure_07_Conceptual_Open_Excavation.dwg – 8.5x11 Landscape – Feb. 12, 2009 2:18pm – della.fawcett



NOTE: THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC EARTH & ENVIRONMENTAL REPORT TITLED: FINAL WDL EE/CA

CLIENT LOGO

CLIENT: SLLI

AMEC Earth & Environmental
7376 S.W. Durham Road
Portland, OR. U.S.A. 97224

amec

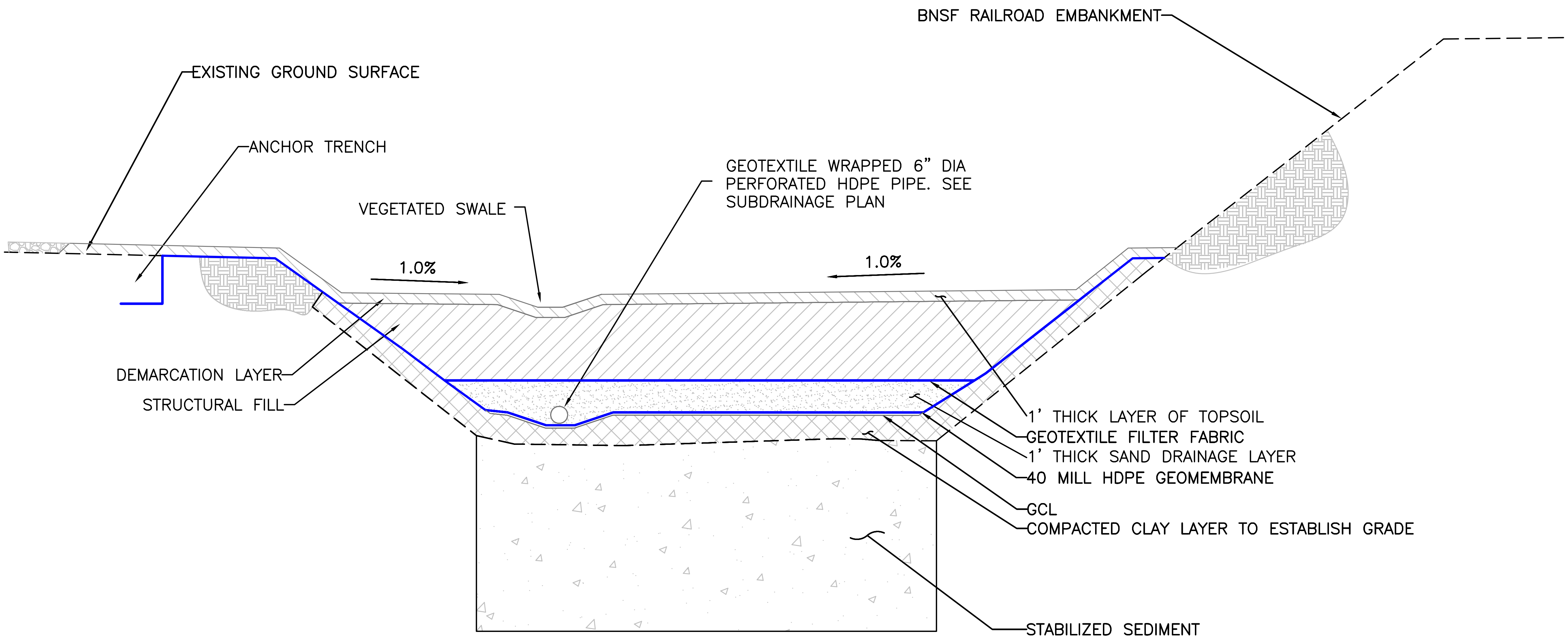
DWN BY: x
CHK'D BY: MP
DATUM: -
PROJECTION: -
SCALE: 1" = 100'

PROJECT: RP - PORTLAND SITE

TITLE: ALTERNATIVE 2 CONCEPTUAL IMPLEMENTATION LAYOUT

DATE: FEBRUARY 2009
PROJECT NO: 0-61M-10703-0 0700 04
REV. NO.: 1
FIGURE No. 8

K:\10000\10700\10703\0700 WDL\0700 Planning\04 EECA\DWG\Figure_08_Alternative_2_Implemation_Layout.dwg – Layout1 – Feb. 12, 2009 2:24pm – della.fawcett



NOTE: THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC EARTH & ENVIRONMENTAL REPORT TITLED: FINAL WDL EE/CA

CLIENT LOGO

CLIENT: SLLI

AMEC Earth & Environmental
7376 S.W. Durham Road
Portland, OR. U.S.A. 97224

amec

DWN BY: x
CHK'D BY: MP
DATUM: -
PROJECTION: -
SCALE: NTS

PROJECT: RP - PORTLAND SITE

TITLE: FINAL WDL CAP - TYPICAL SECTION

DATE: FEBRUARY 2009
PROJECT NO: 0-61M-10703-0 0700 04
REV. NO.: 1
FIGURE No. 9

K:\10000\10700\10703\0700 WDL\0700 Planning\04 EECA\REVISED EECA\DWG\Figure_09_Interim_Cap_Typical_Section.dwg — Layout1 — Jan. 28, 2009 1:47pm — patrick.mccarthy

ATTACHMENT 1

Final WDL Treatability Study Report

ATTACHMENT 2

Revised WDL Geotechnical Investigation Report