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DRAFT

Focused Feasibility Study

Volume 1: TECHNICAL REPORT

Reynolds Metals Company
TROUTDALE FACILITY

CH2MHILL

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Abbreviations and Acronyms

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AC	acre(s)
AOC	area of concern
ARARs	applicable or relevant and appropriate requirements
bgs	below the ground surface
BPA	Bonneville Power Administration
CaCl	calcium chloride
CaF_2	calcium fluoride
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
cfs	cubic feet per second
cm/sec	centimeters per second
COE	U.S. Army Corps of Engineers
Co.L.	Company Lake
COPC	constituent of potential concern
cy	cubic yard(s)
CYIP	cubic yard(s) in place
1,1-DCE	1,1-dichloroethene
DEQ	Oregon Department of Environmental Quality
EA	each
EE/CA	Engineering Evaluation/Cost Analysis
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
ESP	electrostatic precipitator
FE	focused extraction
FF	Flood Fringe (zoning)
FFS	Focused Feasibility Study
FML	flexible membrane liner
GCL	geosynthetic clay liner
gpm	gallons per minute
GS&G	Gresham Sand and Gravel
GWTS	groundwater treatment system
HDPE	high-density polyethylene
HHRA	human health risk assessment

HI	hazard index
HM	Urban Heavy Manufacturing (zoning)
HQ	hazard quotient
hp	horsepower
kWh	kilowatt-hour
lb/day	pound(s) per day
LDRs	land disposal restrictions
LS	lump sum
MCC	Multnomah County Code
MCL	maximum contaminant level
MCPC	Multnomah County Planning Commission
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
µg/L	microgram(s) per liter
NA	not applicable
NCP	*National Oil and Hazardous Substances Pollution Contingency Plan*
NGVD	National Geodetic Vertical Datum
NLF	north landfill
NPDES	National Pollutant Discharge Elimination System
NPV	net present value
NRDA	Natural Resource Damage Assessment
NS	native soil
O&M	operation and maintenance
OAR	Oregon Administrative Rule
ORS	Oregon Revised Statute
OSLF	onsite landfill
OWRD	Oregon Water Resources Department
PAHs	polynuclear aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene
PPE	personal protective equipment
ppm	parts per million
PR	process residue
psi	pounds per square inch
PWO	production well optimization
RA	risk assessment
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RI/FS	remedial investigation/feasibility study

RMC	Reynolds Metals Company
RME	reasonable maximum exposure
RO	reverse osmosis
ROD	Record of Decision
RSA	removal site assessment
SEC	Significant Environmental Concern (zoning)
sf	square foot (feet)
SGA	Sand and Gravel Aquifer
SIP	Site Inspection Prioritization
SLF	south landfill
SVOCs	semivolatile organic compounds
SY	scrap yard
TPH	total petroleum hydrocarbons
TSCA	Toxic Substances Control Act
TTC	time to compliance
UF-20	Urban Future (zoning)
UGS	upper gray sand
USA	Unconsolidated Sedimentary Aquifer
V	volt(s)
VOCs	volatile organic compounds
WWTS	wastewater treatment system

Summary of Conclusions

Summary of Conclusions

A 5-year remedial investigation (RI), a focused feasibility study (FFS), and numerous early actions have been completed at the Reynolds Metals Company (RMC) aluminum reduction facility in Troutdale, Oregon. The studies have concluded that the following additional actions will fulfill the remedial action objectives (RAOs) for the site:

- Excavate the waste layer in the north portion of the scrap yard and implement institutional controls in the south area
- Cap the north landfill to reduce exposure to constituents on the surface and to protect against erosion
- Dredge Company Lake to remove process residue
- Provide an onsite landfill for disposal of excavated and dredged material
- Optimize operation of the plant production wells for hydraulic containment of groundwater that exceeds drinking water standards
- Provide focused extraction of groundwater at the scrap yard and at the east potliner area

The remedial actions described above are collectively known as Alternative B in this FFS. The estimated net present value (NPV) cost of implementing this alternative is $12.64 million (see Table S-1). These costs are in addition to approximately $7.1 million spent to date for implementation of early actions plus another $14.9 million to characterize the site and evaluate remedial options.

For this FFS, three sitewide alternatives were developed and evaluated as a response to site conditions. Table S-1 summarizes these alternatives and their associated costs.

Each of the three alternatives incorporates a distinct approach to achieve the RAOs:

- Alternative A – Cap and contain – uses permeable caps for the landfills, the scrap yard, and Company Lake, and hydraulic containment of groundwater.
- Alternative B – Protection of the intermediate and deep groundwater zones (the preferred alternative)—implements source removal at the areas that most directly affect groundwater quality in the intermediate zone: the scrap yard and Company Lake. It also includes focused extraction of groundwater at the scrap yard and the east potliner area, and hydraulic containment.
- Alternative C – Source removal – includes excavation at the scrap yard and the landfills; dredging at Company Lake; focused extraction of groundwater at the scrap yard, the east potliner area, the south landfill, and Company Lake; and hydraulic containment.

All three alternatives include deed restrictions in some areas.

Alternative A satisfies the threshold criteria, but it does not include active remediation of either the source materials or the groundwater as Alternative B does.

Alternative B is protective and cost effective, and it satisfies the RAOs for the site by:

- Removing the primary sources of fluoride migration to intermediate- and deep-zone groundwater at the scrap yard and Company Lake.
- Providing onsite containment of the existing fluoride plume in the plant area by production well optimization.
- Operating focused extraction wells at the scrap yard and east potliner to intercept the groundwater plume in the upper gray sand (UGS). This significantly reduces migration to the intermediate and deep groundwater zones.
- Protecting the north landfill against erosion.
- Providing institutional controls to prevent human exposure to chemicals of potential concern (COPCs) at the south landfill and to groundwater during implementation of the groundwater remedial actions.

Alternative C costs approximately twice as much as Alternative B but does not achieve a higher level of risk reduction over the long term.

This FFS summarizes the evaluation of possible remedial actions at the site. The sequence of the evaluation presented is as follows:

- A summary of the RI results (Section 1)
- Development of the RAOs for the site on the basis of applicable or relevant and appropriate requirements (ARARs), the baseline risk assessment, and the fate and transport evaluation for the constituents detected (Section 2)
- Identification of appropriate remedial technologies (Section 3)
- Evaluation of appropriate technologies at the various site locations, and combination of multiple technologies into area-specific remedial options (Section 4)
- Development of three sitewide alternatives by combining area-specific options (Section 5)
- Evaluation of the sitewide alternatives against EPA's seven criteria for remedial action (Section 6)
- Comparative analysis of the sitewide alternatives, and identification of the preferred alternative (Section 7)

Table S-1
Sitewide Remedial Alternatives [a]

Alternative	North Landfill	South Landfill	Scrap Yard	Company Lake	Groundwater	Onsite Landfill Disposal	Total NPV Cost	Total As-Spent Cost
No Action	No further action	No further action	No further action	No further action	Continued operation of production wells as needed to satisfy industrial process requirements only	None	$0	$0
A	Riprap cover (Option NLF-2)	Soil + vegetation cap (Option SLF-2)	Gravel cap in north area; institutional controls in south area (Option SY-2)	Permeable cap (Option CL-2)	Production well optimization (Option GW-1)	None required		
	$697,000	$1,026,000	$597,000	$4,734,000	$1,057,000		$8,111,000	$17,741,000
B	Riprap cover (Option NLF-2)	Institutional controls (Option SLF-1)	Excavate waste layer in north area; institutional controls in south area (Option SY-3)	Dredge process residue and mechanically dewater (Option CL-3)	Production well optimization + focused extraction (2 wells at east potliner and scrap yard); extracted groundwater used as makeup in wet ESP system (Option GW-2)	Onsite landfill		
	$697,000	$106,000	$584,000	$7,118,000	$1,763,000	$2,370,000	$12,637,000	$21,682,000
C	Excavate waste layer (Option NLF-4)	Excavate waste layer (Option SLF-4)	Excavate waste layer in north area; institutional controls in south area (Option SY-3)	Dredge process residue and mechanically dewater (Option CL-3)	Production well optimization + enhanced focused extraction (6 wells: 3 southwest of Company Lake, 1 at east potliner, 1 at south landfill, and 1 at scrap yard); up to 40 gpm extracted groundwater used as makeup in wet ESP system; remaining groundwater treated by reverse osmosis/ precipitation (Option GW-3)	Onsite landfill		
	$1,571,000	$2,082,000	$584,000	$7,118,000	$6,818,000	$5,826,000	$23,998,000	$43,666,000

[a] All cost estimates (except Total As-Spent Cost) are NPV.

SECTION 1

Introduction

SECTION 1

Introduction

This Focused Feasibility Study (FFS) presents an evaluation of additional response actions that are under consideration for the Reynolds Metals Company (RMC) facility at Troutdale, Oregon. (See Figure 1-1 for a map of the vicinity.[1]) This evaluation is based on the results of a remedial investigation (RI) conducted at the site from 1994 to 1999 under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

The results of the RI and the site baseline risk assessment are critical to understanding the evaluation presented here and are provided in the following documents:

- *Draft Groundwater Remedial Investigation Report* (CH2M HILL, June 1999)
- *Draft Nongroundwater Remedial Investigation Report* (CH2M HILL, August 1999)
- *Draft Baseline Risk Assessment, Part 1—Nongroundwater Media* (CH2M HILL, May 1999)
- *Draft Baseline Risk Assessment, Part 2—Groundwater* (CH2M HILL, July 1999)

1.1 Purpose, Organization, and Scope of This Report

1.1.1 Purpose

The purpose of this FFS is to evaluate remedial actions for areas at the site that require remediation based on the results of the RI and the baseline risk assessment (baseline RA).

The goals of this report are to:

- Summarize the key findings of the RI and baseline RA as a basis for evaluation of additional actions.
- Present practicable remedial objectives for the remedial actions considered.
- Identify and evaluate robust, proven technologies that could reliably be expected to achieve the remedial objectives for each area.
- Explain how these technologies could be combined into sitewide remedial alternatives.
- Evaluate a limited number of sitewide remedial alternatives using the criteria required by the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP) [U.S. Environmental Protection Agency (EPA), March 8, 1990].

1.1.2 Report Organization

Section 1 introduces the site and project with sufficient background information to support an understanding of the sections that follow. This section presents an inventory of the site areas and media that were investigated in the RI.

[1] In this FFS, tables and figures are located at the end of each section.

Section 2 summarizes the baseline RA results and identifies the remedial action objectives for the site.

Section 3 identifies and screens technologies that are appropriate for remedial responses at this site.

Section 4 combines the technologies retained in Section 3 into "options" for each area and/or medium needing additional action and evaluates these options for effectiveness, implementability, and cost.

Section 5 combines the area/media options into a range of sitewide "alternatives."

Section 6 summarizes the evaluation of the sitewide alternatives according to the NCP criteria.

Section 7 presents a comparative analysis of the sitewide alternatives and identifies the preferred alternative.

Section 8 lists the references used in this report.

The following information is provided in appendixes:

Appendix A	Groundwater Modeling Evaluations
Appendix B	ARARs Evaluation
Appendix C	Cost Estimates for Remedial Options
Appendix D	Cost Estimates for Remedial Alternatives
Appendix E	Fluoride Mass Calculations
Appendix F	*Technical Memorandum No. GW-19: Evaluation of the Minimum Effective Influent Concentration (MEIC) for Fluoride Treatment*
Appendix G	Performance Monitoring Plan and Conceptual Contingency Plan
Appendix H	*Memorandum: South Landfill and East Potliner Silt Unit Groundwater Drainage Trench Evaluation*

1.1.3 Scope of the FFS

During the course of the RI, early actions were taken at several areas as opportunities were identified. These actions focused on known sources of fluoride migration to groundwater and on direct-contact risk, and represented a proactive approach to site remediation. Figure 1-2 shows key site features, including areas that are evaluated in this FFS and those in which early actions have been completed.

The baseline RA, completed after the early actions and concurrently with the remedial option evaluations for this FFS, concluded that several investigated areas, including those where early actions were conducted, did not require further evaluation. This FFS, therefore, focuses on the remaining areas and on groundwater. This FFS evaluates a full range of remedial actions for (a) three soil and debris areas: the north landfill, the south landfill, and the scrap yard; (b) Company Lake, a National Pollutant Discharge Elimination System

(NPDES) treatment pond north of the plant; and (c) sitewide groundwater, which contains elevated concentrations of some plant-related constituents.

1.2 Site Physical Setting

The RMC facility is a primary aluminum reduction plant where alumina is reduced to aluminum. The plant is located approximately 20 miles east of Portland, Oregon, and 1.25 miles north of the City of Troutdale, Oregon, at the confluence of the Columbia and Sandy Rivers. RMC owns the 80.25-acre plant area and approximately 715 acres of surrounding rural land.

1.2.1 Location and Topography

The RMC property is bordered by the Columbia River to the north, the Sandy River to the east, the Troutdale Airport to the south, and Salmon Creek to the west. A U.S. Army Corps of Engineers (COE) flood control dike runs approximately west to east through the northern portion of the RMC property, then turns south at the eastern property boundary. The Troutdale substation, located within the plant boundary, is owned and operated by the Bonneville Power Administration (BPA).

The site topography is generally flat (ranging from 20 to 30 feet elevation above mean sea level), with some minor relief toward the north and northeast.

Plant process buildings are located in the central portion of the site. Site areas north and east of the dike are within the 100-year floodplain; some areas lie within the 10-year floodplain. The eastern part of the plant site inside (west and south of) the dike consists of open fields. There are some wooded areas close to the plant fence. The eastern part of the plant site outside the dike is a generally flat, sandy area with some vegetation cover.

North of the flood control dike, the topography is mostly flat, slopes gently toward the river, and is transected by numerous small east-west-trending drainages. The area is wooded, with relatively heavy vegetation in most areas.

1.2.2 Climate

The study area is characterized by a mild, temperate marine climate with moderately warm, dry summers and wet winters. The average annual precipitation in the area is approximately 37 inches per year. Forty to 50 percent of the total annual precipitation falls in January and February. The average daily maximum temperature is 62°F, and the average daily minimum temperature is 44°F (Ecology and Environment, Inc., 1991). RMC staff members have indicated that the prevailing winds near the plant site are from the south and southwest in summer and from the east in winter.

1.2.3 Land Use

The RMC property south of the flood control dike is currently zoned Urban Future (UF-20) and Urban Heavy Manufacturing (HM). Both of these zoning designations allow community service uses under the provisions of Multnomah County Code (MCC) 11.15.7005-30 as conditional use. The property north of the flood control dike is zoned UF-20, with overlays for Significant Environmental Concern (SEC) and Flood Fringe (FF).

The surrounding area to the west and south of RMC-owned land is used mainly for agricultural and commercial purposes. The Port of Portland's Troutdale Airport is located approximately 0.25 mile south of the RMC property.

Recently, zoning changes have been proposed for the area surrounding and including the RMC site. The Troutdale City Council has recommended to the Multnomah County Planning Commission (MCPC) that unincorporated land north of the City of Troutdale (including RMC) be zoned General Industrial, with the exception of RMC property north of the dike, which would be zoned Open Space. The proposed zoning map for the RMC area[2] was distributed during recent correspondence with MCPC. It is anticipated that future land use at and surrounding the RMC property will remain industrial, with the exception of the land north of the dike.

1.2.4 Water Use

Onsite deep production wells [between approximately 140 and 640 feet below the ground surface (bgs)] supply process water and drinking water for workers at the RMC facility. Of the 18 deep production wells, eight are still active. In most areas of the plant, bottled water is available for drinking. There is no current use, nor is there anticipated future use, of shallow groundwater for domestic purposes in the vicinity.

A survey of local groundwater use was conducted; the results are presented in Section 3.4 of the *Draft Groundwater Remedial Investigation Report* (CH2M HILL, June 1999).

1.2.5 Definition of Water-Bearing Zones

The unconsolidated sediments within the uppermost regional groundwater system beneath the RMC facility have been subdivided into four water-bearing zones. The four zones are defined by the site stratigraphy and the depths at which monitoring wells have been constructed. These four zones and their terminology are:

- **Silt Unit.** Where present, the silt unit extends from ground surface to approximately 30 feet bgs. The silt unit is also referred to as "the silt" in this report.
- **Upper Gray Sand (UGS).** The UGS extends to a depth of approximately 50 feet bgs. It is present at ground surface north of the flood control dike and lies beneath the silt unit south of the dike.
- **Intermediate Sand.** The intermediate sand extends from the base of the UGS to a depth of 100 feet bgs. It is also referred to as "the intermediate-depth zone" in this report.
- **Deep Sand/Gravel.** The deep sand/gravel extends from the base of the intermediate sand to a depth of 200 feet bgs. It is also referred to as "the deep zone" in this report.

1.3 Project History and Early Actions

The plant was constructed for the U.S. Government in 1941 for wartime operations. RMC first leased the plant from the government in 1946 and purchased it in 1949. For a descrip-

[2] See Figure 2-2 of the *Draft Baseline Risk Assessment, Part 1—Nongroundwater Media* (CH2M HILL, May 1999).

tion of plant operations, see the *Draft Current Situation Summary* (CH2M HILL, April 5, 1996).

In 1992 and 1993, EPA conducted a Site Inspection Prioritization (SIP) project at the RMC facility, including a review of background information and a site visit to conduct limited sampling. The results of this work are summarized in the *Final Site Inspection Prioritization Report* (PRC, October 19, 1993).

EPA placed the site on the National Priorities List in December 1994, making it a "Superfund" site. In June 1994, RMC began investigation and sampling at the site. A Consent Order defining agency requirements for the remedial investigation and feasibility study (RI/FS) was signed by EPA and RMC in September 1995.

Site RI activities were conducted between summer 1994 and fall 1998. The RI was conducted in phases so that data gathering could be tailored to project needs. A removal site assessment (RSA) was conducted beginning in June 1994. This work, which is summarized in the *Removal Site Assessment Report* (CH2M HILL, January 1995), included sitewide soil and groundwater sampling. The RSA was followed by supplemental data gathering that focused on supporting early actions and improving the overall understanding of constituent presence at each area identified in the RSA. Formal RI activities began in May 1996 and continued through fall 1998. All investigations completed at the site to date are summarized in the *Draft Groundwater Remedial Investigation Report* (CH2M HILL, June 1999) and the *Draft Nongroundwater Remedial Investigation Report* (CH2M HILL, August 1999).

Samples were collected from surface and subsurface soils, surface water, and sediment. An extensive monitoring well system was installed and quarterly monitoring performed. Approximately 70 Geoprobes were installed to sample soil and groundwater. Figure 1-3 shows the location of monitoring wells and existing plant production wells, and Figure 1-4 shows the location of Geoprobes. Samples were analyzed for fluoride, cyanide, polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), and EPA priority pollutant metals (antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc). Some samples were analyzed for solvents, pesticides, other metals, and petroleum hydrocarbons. From this general list of constituents, a shorter list was developed during preliminary risk assessments at each area in collaboration with EPA and the Oregon Department of Environmental Quality (DEQ) on the basis of actual detections and reasonably expected exposures.

During the course of the RI, RMC completed a number of early actions and maintenance activities that resulted in cleanup at the site. Early actions were conducted to reduce migration of fluoride to the groundwater, and to reduce surface exposure risk. Maintenance activities were conducted to support day-to-day plant operations. These activities are discussed in further detail in Section 1.4.

The baseline RA for groundwater and nongroundwater media at the site was completed in August 1999, after the early actions and concurrently with the remedial option evaluations for this FFS. The RA was prepared to estimate the realistic potential for risk to human health and ecological receptors posed by the threatened or actual release of constituents of potential concern (COPCs) that are present at the site in the absence of remedial action. With the exception of south wetlands, early actions completed at the site were addressed in the

baseline RA in their current (that is, post-early-action) state. South wetlands was not addressed in this manner because the early action was completed after the draft baseline RA was submitted to EPA. The baseline RA concluded that several investigated areas (including those where early actions were conducted) did not require further evaluation. This FFS, therefore, focuses on the remaining areas and on groundwater.

1.4 Summary of Early Actions and Maintenance Activities

Early in the project, RMC and EPA agreed to perform early actions to the extent possible, and as soon as possible, to reduce migration potential and thereby reduce potential risk prior to completion of the RI/FS process and signing of the Record of Decision (ROD). In addition, RMC elected to implement a number of site maintenance activities concurrent with early actions that resulted in site cleanup. Table 1-1 provides a summary of early actions and maintenance activities completed at the site.

The cost of implementing early actions and maintenance activities at the site has been substantial. Total cost to date, including engineering, onsite storage, waste transport, and offsite disposal, is approximately $7.1 million.

1.4.1 Early Actions

Early actions are summarized below for signage and access restrictions; the east potliner, cryolite ponds, bakehouse sumps, PCB spill, and south wetlands areas; and production well decommissioning. Information provided includes a brief description of the work completed to date and, where appropriate, a summary of area risk and remedial status. See Figure 1-2.

1.4.1.1 Signage and Access Restrictions

Signage was installed north of the dike to warn occasional recreational users about the presence of industrial wastes. Signs were posted at the east end of Company Lake and at north landfill on both sides of the outfall road. Fencing to further restrict potential access to these areas was installed along both sides of the outfall road in summer 1997.

1.4.1.2 East Potliner

Description. The east potliner area is approximately 3 acres in size and is located east of the scrap yard. Aerial photographs indicate that the area was used until the early 1970s as a temporary storage area for plant solid waste. Waste thought to have been stored in this area was primarily spent potliner, but it also included rodding room waste, carbon plant waste, and used refractory brick. In 1975, approximately 6,000 tons of spent potliner was removed and transported to RMC's Longview, Washington, facility for recycling. An early action to remove residual waste materials was completed by RMC in January 1996. This action involved the excavation and offsite disposal of more than 11,148 tons of spent potliner and contaminated soil. The area was capped with a geotextile fabric and 1 to 2 feet of clean soil in October 1996. A detailed summary of this action can be found in *Final Report: East Potliner Area Removal Action* (CH2M HILL, April 3, 1997).

Summary of Risk Assessment.

- The baseline human health risk assessment concluded that none of the reasonable maximum exposure (RME) risk estimates for any exposure scenarios exceeded EPA or

DEQ target risk criteria at east potliner following the early action. This conclusion is based on confirmation samples collected after wastes were removed and before the cover was placed.

- The Tier 2 ecological risk assessment did not identify unacceptable ecological risk at the east potliner area.

Remedial Status: No Further Action. On the basis of confirmation samples collected after the removal action was completed, no further action is warranted in this area. Groundwater in the vicinity will continue to be monitored and is addressed in this FFS.

1.4.1.3 Cryolite Ponds

Description. The cryolite ponds area is located south of the plant, adjacent to South Ditch and northwest of the south landfill area. The ponds were constructed around 1965 and were used for two purposes: to dispose of carbon float from experimental carbon flotation cells used until about 1970, and to store underflow solids that occurred as a result of a process upset in 1968. An aerial photograph review, followed by site investigations, identified one main pond about 160 feet in diameter, three smaller satellite ponds, and small miscellaneous deposits in nearby locations.

This early action consisted of one main removal effort followed by several small cleanup efforts. Approximately 13,900 tons of cryolite material and contaminated soil was removed from the main and two smaller satellite ponds and disposed offsite between December 1994 and January 1995. Final cleanup of these areas was completed in August 1995, after which the area was regraded and allowed to revegetate naturally. A detailed summary of this action can be found in *Final Report: Cryolite Pond Area Removal Action* (CH2M HILL, April 11, 1996). Spot removal of small amounts of miscellaneous material from the third pond was completed in September 1999, in conjunction with the South Ditch maintenance dredging. This material was stockpiled at the south landfill for future disposal.

Summary of Risk Assessment.

- The baseline human health risk assessment concluded that none of the RME risk estimates for any exposure scenarios exceeded EPA or DEQ target risk criteria at the cryolite ponds, based on confirmation samples collected following the early action.

Remedial Status: No Further Action. On the basis of the RA conclusions, no further action is warranted in this area.

1.4.1.4 Bakehouse Sumps

Description. The bakehouse sumps serve as a dewatering system to lower groundwater levels in and around the bakehouse. Prior to the early action, 57 well points and 21 sumps were located at the bakehouse. The well points were installed in 1957 and 1958, the sumps between 1965 and 1970. Site investigation activities identified constituent presence in many of the sumps and some general physical and mechanical wear in the dewatering system.

Early actions were conducted in three phases, beginning in June 1996, and were completed in November 1997. Early actions were implemented to remove accumulated solids from each sump, to complete needed repairs, and to abandon the well points. The well points were abandoned in accordance with Oregon Water Resources Department (OWRD)

requirements between June 10 and 19, 1996. Following this action, each sump was cleaned, mechanical equipment was rehabilitated as needed, and the sumps were reconstructed to meet OWRD requirements. Surface soil in an area south of the bakehouse was removed and a new washdown water containment system was placed around the plant wet electrostatic precipitator (ESP) between June and November 1997. Bakehouse sump No. 1 was also abandoned at this time. A detailed summary of this action can be found in *Final Report: Bakehouse Sumps Area Removal Action* (CH2M HILL, April 27, 1998).

Remedial Status: No Further Action. On the basis of confirmation samples collected after the removal action was completed, no further action is warranted in this area.

1.4.1.5 PCB Spill Area

Description. The PCB spill area is located to the south of and immediately adjacent to the casthouse. Data gathering conducted in 1995 and 1996 indicated that soil in the area was contaminated with PCBs. The source of PCBs in the area is uncertain but may have been related to electrical, railroad, or hydraulic equipment, or to deterioration of building siding.

Early actions in the area were completed in about November 1996. Cleanup goals of 25 milligrams per kilogram (mg/kg) PCBs for subsurface soil and 10 mg/kg for surface soil were established for soil excavation. The initial area and depths of excavation were estimated on the basis of pre-action sampling. The depths and extent of excavations were adjusted during construction on the basis of confirmation sampling results. The excavation started adjacent to the building and extended south to the second set of railroad tracks. Approximately 515 tons of PCB-containing soil was excavated and disposed offsite. A detailed summary of this action can be found in *Final Report: Casthouse Remediation Area Removal Action* (CH2M HILL, April 9, 1998).

Summary of Risk Assessment.

- The PCB spill area was remediated to agreed-upon risk-based cleanup levels, and a risk assessment was not required.

Remedial Status: No Further Action. On the basis of confirmation samples collected after the removal action was completed, no further action is warranted in this area.

1.4.1.6 Fairview Farms Debris Piles

Site investigations conducted in Fairview Farms in 1995 and 1996 identified between 50 and 100 cubic yards of miscellaneous debris. Although this material was deemed to be non-hazardous, RMC elected to move it to a stockpile area constructed at the south landfill. This early action was completed in fall 1996.

Summary of Risk Assessment.

- The baseline human health risk assessment concluded that none of the RME risk estimates for any exposure scenario exceed EPA or DEQ target risk criteria.

Remedial Status: No Further Action.

- On the basis of confirmation samples collected after the removal action was completed, no further action is warranted for the debris piles.

1.4.1.7 Production Well Decommissioning

Nine production wells (PW04, 06, 09, 11, 12, 14, 15, 16, and 17) at the Troutdale facility were decommissioned as an early action. The decision to decommission these wells was made in 1995 after site investigations revealed that the wells had not been closed in accordance with OWRD requirements. The wells were decommissioned over a period that began in early 1995 and ended in January 1999. A detailed summary of the methods used to close each well will be provided in the Final Report: Production Well Decommissioning scheduled to be released by RMC and CH2M HILL in fall 1999. All remaining production wells are expected to remain in use to support plant operations. The decommissioned production wells listed in Table 1-1 are shown on Figure 1-5.

1.4.1.8 South Wetlands

South wetlands is a 23-acre area located south of the plant and west of the south landfill. The area has been affected by historical discharge of process wastewater from various operations at the plant. RI activities conducted in this area identified a small (20- by 20-foot) area with PCB concentrations in shallow soils greater than 10 but less than 50 mg/kg. In accordance with previous work completed in the PCB spill area, it was decided to remove these materials and stockpile them onsite in a secure containment area pending a decision to construct an onsite landfill or dispose of materials offsite. In September 1999, a total of approximately 60 cubic yards of material was excavated and hauled to a containment cell constructed over the south landfill. Confirmation samples were collected after the removal action was completed. These data indicate that PCB concentrations are at or below detection limits in the soil beneath the excavation.

Groundwater fluoride concentrations measured in the silt zone beneath south wetlands exceeded 100 mg/L in some samples. However, this occurred in a limited area, and there is no evidence of fluoride migration out of the silt zone.

Summary of Risk Assessment.

- The RME risk estimates for soil do not exceed EPA or DEQ target risk levels for cumulative constituent exposure. DEQ's target risk level for individual chemicals is exceeded by PCBs for the Building 97 area only, under an occupational exposure scenario. The highest concentration detected, however, is below the EPA recommended cleanup level of 10 to 25 mg/kg for industrial settings. The ecological hazard quotient for PCBs (for mink) slightly exceeds target risk levels, when only onsite habitat is considered. The presence of abundant suitable habitat in the vicinity of south wetlands reduces the significance of this finding.

Remedial Status: No Further Action.

- On the basis of confirmation sample results, no further action in this area is anticipated at this time.

1.4.2 Maintenance Activities

Maintenance activities completed at the site are summarized in Table 1-1. Although these areas are not included in the RI/FS, the maintenance work completed supports long-term site remediation.

Two maintenance activities, for the ESP containment system and South Ditch, are noteworthy in terms of supporting sitewide remediation. Construction of the ESP containment system (and, in particular, process modification piping) prevents further discharge of PAH-containing solids from this unit process to the bakehouse sumps. This in turn minimizes solids that may be discharged to South Ditch and protects a future remedy to be constructed in Company Lake. Maintenance dredging in South Ditch provides similar benefits to Company Lake through removal of PAH-containing solids.

1.5 Remedial Investigation Summary

This section provides an overview of data-gathering activities conducted at RMC-Troutdale. Detailed results of site investigation activities are summarized in the *Draft Groundwater Remedial Investigation Report* and *Draft Nongroundwater Remedial Investigation Report* (CH2M HILL, June and August 1999, respectively). The site RI was conducted in four related programs:

- Soil and debris areas
- Surface water and sediment areas
- Wastewater discharge areas
- Sitewide groundwater

This section briefly describes each area or environmental medium investigated, summarizes the key findings of the investigation, and explains whether remedial action is being considered.

Soil and debris, surface water, sediment, and wastewater discharge areas are shown in Figure 1-2. The nature and extent of groundwater fluoride contamination at the site is shown in Figures 1-6 through 1-18.

1.5.1 Soil and Debris Areas

Ten soil and debris areas were originally identified for investigation at the site:

- East potliner
- Cryolite ponds
- Bakehouse sumps
- PCB spill area
- North landfill
- South landfill
- Scrap yard
- Fairview Farms
- Mineral oil spill area
- South wetlands

As discussed previously, early actions were conducted in the first four areas; these are not discussed further in this FFS.

1.5.1.1 North Landfill

Description. The north landfill is located north of the COE dike. The area is approximately 2.4 acres in size and is bisected by a north-south gravel access road leading from the RMC parking lot to the Company Lake outfall. Approximately 20 percent of the north landfill lies east of the access road and 80 percent lies west of it.

Key Findings from RI.

- The north landfill contains mostly carbon waste, refractory brick, demolition waste, solid waste, and miscellaneous debris.
- Waste depths vary from 5 to greater than 14 feet bgs, with an estimated average waste thickness of 9 feet bgs. The volume of landfilled material is estimated at 33,000 cubic yards.
- Constituents identified in soil include fluoride, cyanide, metals, PAHs, total petroleum hydrocarbons (TPH), volatile organic compounds (VOCs), and PCBs.
- A localized perched groundwater zone has also been identified at the northeastern end of the landfill.
- Shallow groundwater flow beneath the north landfill area is generally from south-southwest to north-northeast toward the Columbia River.
- Groundwater elevation measurements indicate that the groundwater table rises to within a few feet of the ground surface during the wet winter months.
- Constituents (primarily fluoride) appear to have migrated from the north landfill to shallow groundwater, as a result of rainfall infiltration or as a result of contact with shallow groundwater. PAHs and PCBs, which have low solubilities and do not readily migrate, appear to be confined to soil and the waste layer.
- Elevated fluoride concentrations exist in groundwater in a limited area immediately north of the north landfill. However, within a short distance downgradient, fluoride concentrations in the UGS drop below the maximum contaminant level (MCL). Geoprobe data collected downgradient of the north landfill along the Columbia and Sandy Rivers show fluoride concentrations of less than 1 milligram per liter (mg/L). Evaluations of groundwater discharge to the rivers, as discussed in Section 1.5.2, indicate that fluoride in shallow groundwater north of the dike is not causing a measurable effect on surface water in the Columbia or Sandy River.
- The north landfill lies in the 10-year floodplain of the Columbia River and is periodically inundated by floodwaters. U.S. Army Corps of Engineers HEC-2 water surface profile modeling indicated a low potential for scour in the vicinity of the north landfill, even during a 500-year flood event.

Summary of Risk Assessment.

- The baseline human health risk assessment for nongroundwater media concluded that none of the risk estimates exceed EPA target risk criteria at north landfill; DEQ target risk criteria are slightly exceeded for the intermittent maintenance worker, trench worker, and trespasser scenarios.

- The baseline ecological risk assessment concluded that none of the Tier 2 ecological target risk criteria are exceeded at north landfill.

Status of North Landfill: Action to Be Considered in This FFS. On the basis of the RI and RA findings, the north landfill is evaluated for potential remedial action in this FFS.

1.5.1.2 South Landfill

Description. The south landfill is approximately 5.8 acres in size and is located on the south side of the plant, immediately adjacent to South Ditch. This area was used for general plant waste disposal from the early days of operation until about the late 1960s. The area continued to be used for temporary storage of materials into the 1970s. A number of materials generated during early actions and remedial investigations are currently stockpiled at the south landfill. The stockpiles are segregated and placed on plastic liner material. These materials include dredge spoils from South Ditch, PCB-containing soil from south wetlands, clean drill cuttings generated during monitoring well installation, drilling mud from production well decommissioning, brick and debris from Fairview Farms, and crushed steel slag material for use in future onsite construction projects.

Key Findings from RI.

- The volume of waste is estimated to be approximately 44,000 cubic yards, with a maximum thickness of 6 to 7 feet.
- The south landfill contains a mixture of plant wastes, including carbon, brick, metal, and other miscellaneous debris.
- Waste material is thickest in the northern and central portions of the area.
- Constituents identified in soil at the south landfill include fluoride, cyanide, metals, PAHs, PCBs, and TPH.
- Groundwater elevation measurements indicate that, seasonally, the groundwater table rises to within a few feet of the ground surface.
- Constituents (primarily fluoride) have migrated from the south landfill to shallow groundwater as a result of rainfall infiltration or as a result of contact with shallow groundwater. Silt unit and UGS groundwater contains elevated concentrations for fluoride. PAHs and PCBs, which have low solubilities and do not readily migrate, appear to be confined to soil and waste materials.
- Low soil permeability in the silt unit limits the ability of constituents to migrate from the silt to the underlying UGS, intermediate, and deep groundwater zones. Fluoride migration from the silt was measured in only one small area of the UGS, near Geoprobe® GP59. The absence of fluoride in the intermediate-depth sands at and downgradient of the south landfill is consistent with this observation. Available data indicate that the south landfill is not a significant source of constituent migration to the UGS, intermediate, or deep groundwater zone.

Summary of Risk Assessment.

- The baseline human health risk assessment for nongroundwater media concluded that none of the risk estimates exceed EPA target risk criteria at the south landfill; DEQ target

risk criteria are slightly exceeded for the intermittent maintenance worker, trench worker, and trespasser scenarios.

- The baseline ecological risk assessment concluded that none of the Tier 2 ecological target risk criteria are exceeded at the south landfill.

Status of South Landfill: Action to Be Considered in This FFS. On the basis of the RI and RA findings, the south landfill is evaluated for remedial action in this FFS.

1.5.1.3 Scrap Yard

Description. The scrap yard is located east of the bakehouse and north of South Ditch. The area is about 5.7 acres in size, flat, sparsely vegetated, and crossed by a gravel road. Aerial photographs indicate that process waste materials may have been stored temporarily in the north-central portion of the scrap yard. Typically, the north portion was used to store scrap steel and waste materials. The south portion was used to store obsolete equipment and nonferrous metals.

Key Findings from RI.

- Waste materials include brick fill and other manufacturing by-products. The depth of fill varies but is typically less than 2 feet.
- Constituents identified in soil samples collected from the scrap yard include PCBs, PAHs, metals, cyanide, and fluoride.
- Elevated constituent concentrations in soil are limited mainly to the area north of the central road. Of the fluoride contained in the waste layer and surficial sands at the scrap yard, approximately 95 percent is in the north portion.
- PCBs and PAHs, which do not readily migrate, appear to be confined to the surface soil.
- Shallow groundwater flow beneath most of the scrap yard area is generally from southeast to northwest.
- Seasonally, groundwater levels rise to nearly the ground surface, particularly in the eastern portions of the scrap yard.
- Constituents (primarily fluoride) have migrated from waste materials in the scrap yard to shallow groundwater as a result of rainfall infiltration and contact with seasonally high groundwater. Fluoride concentration data at Geoprobe GP47 indicate a hydraulic connection between the silt and underlying sand. Plume mapping completed as part of the groundwater RI depicts downward constituent migration from the scrap yard to the intermediate and deep zones.
- Groundwater flow modeling results indicate that production well pumping has caused fluoride-containing groundwater to migrate north from the UGS in the scrap yard, through the intermediate and deep zones, toward production wells PW07 and PW08. This pumping influence is the primary cause of fluoride migration from the scrap yard to the intermediate and deep groundwater zones.
- Elevated groundwater fluoride concentrations appear to be limited to the northern portion of the scrap yard.

- Soil sample data support the interpretation of constituent migration from the scrap yard to the UGS, intermediate, and deep groundwater zones. Similar to the groundwater findings, elevated fluoride concentrations in soil are primarily limited to the northern portion of the scrap yard. Constituent concentrations in soil decrease rapidly with depth.
- Subsurface soil lithology data also support the interpretation of constituent migration from the scrap yard to groundwater. Low-permeability silts underlie much of the south plant area at thicknesses up to about 20 feet, except in the scrap yard where the silt unit is as little as 8 feet thick. The thin silt unit coincides with locations where elevated fluoride concentrations are detected in the UGS groundwater zone.

Summary of Risk Assessment.

- The baseline human health risk assessment for nongroundwater media concluded that none of the risk estimates exceed EPA target risk criteria at the scrap yard; DEQ target risk criteria are slightly exceeded for the intermittent maintenance worker and trench worker scenarios.

Status of Scrap Yard: Action to Be Considered in This FFS. On the basis of the RI and RA results, potential remedial action is considered for the scrap yard in this FFS.

1.5.1.4 Fairview Farms

Description. Fairview Farms is a 220-acre fenced area located west of the RMC plant. RMC purchased the property in 1962 and has used it since then for agricultural purposes, including grazing and berry farming. The area is generally flat, crossed by high-voltage power lines, and contains two seasonal drainage channels. Dredge spoils are present along the banks of adjacent Salmon Creek and the central drainage ditch. Four brick and debris piles were removed in 1996; no other waste materials were identified.

Key Findings from RI.

- Soil constituents identified include fluoride, metals, and PAHs.
- Low concentrations of COPCs were detected in sediment samples from drainage ditches, but flat surface grades and vegetative cover decrease the significance of these surface migration pathways.
- Fluoride concentrations of up to 21 mg/L have been detected in intermediate-zone groundwater at the northeast corner of the area. These detections appear to be the result of constituent migration from Company Lake rather than from a source at Fairview Farms.

Summary of Risk Assessment.

- The baseline human health risk assessment for nongroundwater media concluded that none of the risk estimates at Fairview Farms exceed EPA target risk criteria.
- Two individual PAHs detected in soil, and fluoride in groundwater, exceed DEQ threshold criteria for the hypothetical future residential scenario. Future residential use of Fairview Farms is unlikely, however, because of current and anticipated future zoning, the presence of high-voltage power lines, and the proximity to heavy industrial operations.

- The baseline ecological risk assessment for nongroundwater media concluded that none of the risk estimates exceed Tier 2 ecological target risk criteria at Fairview Farms when background concentrations of aluminum are considered.
- Deed restrictions prohibiting groundwater use and residential use of the property may be required.

Status of Fairview Farms: Action Not Warranted. On the basis of the RI and RA findings, remedial action (other than deed restrictions) is not warranted for this area.

1.5.1.5 Mineral Oil Spill Area

Description. The mineral oil spill area is a flat, sparsely vegetated area approximately ¼ acre in size located at the northeast end of the main plant, west of the main gate. The area contains three horizontal aboveground storage tanks surrounded by a low earthen berm. Since the beginning of plant operations, oil used to service electrical equipment has been stored in tanks within this area. In the past, mineral oil was pumped from the storage tanks to the rectifier yard. This system is no longer in use. The three tanks located within the berm have never been used to store "PCB oil," which contains PCBs at concentrations greater than 50 mg/L. The tanks have stored oil containing PCBs at concentrations less than 50 mg/L.

Key Findings from RI.

- Soil samples collected at the mineral oil spill area contained elevated concentrations of TPH from near the surface to a depth of approximately 4 feet bgs.
- No semivolatile organic compounds (SVOCs) or VOCs were detected in the area.
- Total PCB concentrations ranged from 0.3 to 2.1 mg/kg, well below the EPA recommended cleanup levels of 10 to 25 mg/kg for industrial settings.

Summary of Risk Assessment. The baseline human health risk assessment for nongroundwater media concluded that none of the risk estimates for the mineral oil spill area exceed EPA or DEQ target risk criteria.

Status of Mineral Oil Spill Area: Action Not Warranted. On the basis of the RI and RA findings, no action is warranted for this area.

1.5.1.6 South Wetlands

Description. South wetlands is approximately 23 acres in size and is located south of the RMC reduction facility and west of the south landfill. The area is made up of the Building 97 subarea, the main wetlands, and West Drainage. RMC owns the northern two-thirds of the area and the Port of Portland owns the southern third. Surface water ponds in south wetlands seasonally when groundwater elevations are high.

The area was used as a settling pond for industrial wastewater between 1941 and 1965. Discharges to south wetlands prior to 1947 are understood to have been low and may not have produced a significant area of ponded water. Use of south wetlands as a settling pond was discontinued in 1965, when wastewater flows were routed via South Ditch to Company Lake.

Key Findings from RI.

- The primary source of constituents in south wetlands is process residue solids deposited from historical wastewater discharges.
- The process residue exists in a layer approximately 4 to 17 inches deep in near-surface soil, except in the Building 97 subarea and the southern portion (primarily Port of Portland property), where it is thinner or nonexistent. The estimated volume of process residue is 48,000 cubic yards.
- Constituents detected include fluoride, PCBs, PAHs, metals, and cyanide.
- A small area contained soil PCB concentrations greater than the EPA recommended cleanup levels of 10 to 25 mg/kg for industrial settings. These soils were removed as part of an early action; see Section 1.4.1.8 for discussion.
- Fluoride has been detected in the silt-unit groundwater at south wetlands. Fluoride presence in this unit is the result of rainfall infiltration or direct contact with groundwater.
- Groundwater constituents at south wetlands appear to be confined to the silt unit; there is no indication of constituent migration from south wetlands to the underlying UGS, intermediate, or deep groundwater zone.
- Constituents present in south wetlands would be expected to occur in West Drainage, which receives runoff from south wetlands during high groundwater periods. However, surface water monitoring in Salmon Creek above and below the confluence with West Drainage did not show consistently higher concentrations in downstream samples. Also, because south wetlands is well vegetated, sediment transport into West Drainage is not expected to be significant.

Summary of Risk Assessment. The baseline human health risk assessment for nonground-water media concluded that none of the RME-case risk estimates for south wetlands exceed EPA or DEQ target risk criteria. The Tier 2 ecological hazard quotient for south wetlands does not exceed target risk criteria.

Status of South Wetlands: No Further Action. On the basis of the RA results, and confirmation samples collected following the limited removal action conducted for this area, no further action is warranted.

1.5.2 Surface Water and Sediment Areas

Four surface water and sediment areas were identified for investigation at the site and are shown on Figure 1-5:

- Columbia River
- Sandy River
- Salmon Creek
- East Lake

1.5.2.1 Columbia River

Description of Columbia River Bordering the RMC Property. The Columbia River forms the northern boundary of the RMC property. It is a tidally influenced freshwater river; the depth varies with the tidal cycle, freshwater input, and release of impounded water from the upstream Bonneville dam. The Columbia River is a local and regional groundwater discharge area and receives both shallow and deep groundwater from the RMC site and surrounding areas. RMC has a permitted NPDES outfall from Company Lake to the river.

Key Findings from RI.

- Historically, refractory brick was placed on the riverbank located at the Company Lake outfall.
- Constituents detected in soil and sediment adjacent to the brick are similar to background levels.
- Constituent concentrations in river sediments adjacent to the plant site are similar to background levels.
- Fluoride concentrations in UGS and intermediate-depth groundwater samples collected along the shore next to the river exceed the MCL in a limited area near the Company Lake outfall.
- Mixing calculations have been compiled for the Columbia River. Under the most conservative river flow conditions (7-day sustained low flow over a 10-year period), mixing factors range from 34,000 (assuming 20 percent of the river flow is available for mixing) to 84,000 (assuming 50 percent of the river is available for mixing). The mixing factors increase for higher river flows.
- Using measured groundwater concentrations and the estimated mixing factors, the increase in the in-stream fluoride concentrations in the Columbia River resulting from groundwater discharge is predicted to be extremely low (maximum concentration of 0.00005 mg/L). These concentrations are well below standard analytical detection limits (typically 0.1 to 0.5 mg/L).

Summary of Risk Assessment.

- The baseline human health risk assessment concluded that none of the RME-case risk estimates for surface water or sediment at the Columbia River exceed EPA or DEQ target risk criteria. The Tier 2 ecological hazard quotients for the Columbia and Sandy Rivers do not exceed risk threshold criteria.

Status of Columbia River: Action Not Warranted. On the basis of the RI and RA findings, action is not warranted at the Columbia River.

1.5.2.2 Sandy River

Description of Sandy River Bordering the RMC Property. The Sandy River forms the eastern boundary of the plant site. The lower reach of the river is a shallow, sand delta. The main stem channel meanders through this delta. During drier periods (late summer and early fall), water flows in sheets across the sand flats. Depths in the lower reach vary with water level elevations in the Columbia River and freshwater input. Similar to the Columbia River,

the Sandy River is a local and regional groundwater discharge zone and receives both shallow and intermediate-depth groundwater from the site and surrounding areas.

Key Findings from RI.

- Historically, refractory brick was placed along approximately 300 feet of the western shore of the Sandy River.
- Constituent concentrations detected in sediment adjacent to the brick are similar to those detected in background samples.
- Constituent concentrations in river sediments adjacent to the plant site are similar to those detected in background samples.
- Fluoride concentrations in groundwater near the Sandy River exceed 4 mg/L in the UGS but not in the intermediate or deep zone. Fluoride is likely discharging at concentrations slightly above 4 mg/L from the UGS into the Sandy River in a localized area near East Lake.
- Mixing calculations have been compiled for the Sandy River. Under the most conservative river flow conditions (7-day sustained low flow over a 10-year period), mixing factors range from about 90 (assuming 10 percent of the river flow is available for mixing) to 450 (assuming 50 percent of the river is available for mixing). The mixing factors increase for higher river flows.
- Using measured groundwater data adjacent to the river (concentrations ranged from 0.25 to 4.4 mg/L), the increase in in-stream fluoride concentrations is expected to be low (less than 0.006 mg/L). These concentrations are below standard analytical detection limits (0.1 to 0.5 mg/L). In-stream measurements adjacent to the site confirm these calculated predictions; fluoride has not been detected in the Sandy River.

Summary of Risk Assessment.

- The baseline human health risk assessment concluded that none of the risk estimates for surface water or sediment at the Sandy River exceed EPA or DEQ target risk criteria. The Tier 2 ecological hazard quotients for the Columbia and Sandy Rivers do not exceed risk threshold criteria.

Status of Sandy River: Action Not Warranted. On the basis of the RI and RA findings, no action is warranted at the Sandy River.

1.5.2.3 Salmon Creek

Description of Salmon Creek on RMC Property. Salmon Creek flows along a section of the southwest border of the RMC property and is pumped into the Columbia River from an equalization pond west of Fairview Farms. Salmon Creek provides stormwater conveyance for parts of the City of Troutdale, the City of Wood Village, and the City of Fairview. The Blue Lake watershed also drains into Salmon Creek through a control pipe near the equalization pond. Water quality in Salmon Creek is affected by urban, industrial, and Troutdale airport stormwater and discharges; groundwater discharge; and historical and current RMC discharges.

From 1941 to 1947, wastewater from the RMC facility was treated for solids removal in south wetlands and the overflow discharged to Salmon Creek. There was no wastewater discharge from south wetlands to Salmon Creek after 1947; all south wetlands wastewater overflow was directed to Company Lake at that time. Salmon Creek was rerouted between 1966 and 1968 and stormwater runoff from south wetlands was routed into Salmon Creek via the West Drainage. West Drainage flows into Salmon Creek only during wet weather conditions.

Key Findings from RI.

- Groundwater interaction with Salmon Creek is limited to the shallow silt unit. Salmon Creek is a gaining stream (that is, groundwater flows into the creek) in the winter and a losing stream during late summer and early fall. The contribution of site groundwater to Salmon Creek is understood to be small, and the potential for constituent contribution to the creek from groundwater is low.

- Sediment samples collected upstream and downstream of the Salmon Creek-West Drainage confluence showed no definitive impact from current or historical RMC discharges.

- Constituents present in south wetlands would be expected to discharge to Salmon Creek through the West Drainage. However, surface water monitoring in Salmon Creek above and below the confluence with West Drainage did not show consistently higher concentrations in downstream samples. Also, because south wetlands is well vegetated, sediment transport into West Drainage is reduced.

Summary of Risk Assessment.

- The baseline human health risk assessment concluded that none of the risk estimates for surface water or sediment at Salmon Creek exceed EPA or DEQ target risk criteria. The Tier 2 ecological hazard quotients for Salmon Creek do not exceed risk threshold criteria.

Status of Salmon Creek: Action Not Warranted. On the basis of the RI and RA findings, action is not warranted at Salmon Creek.

1.5.2.4 East Lake

Description. East Lake is located north of the COE dike and approximately 600 feet east of Company Lake. The lake is located in the 100-year floodplain of the Columbia River. There are no inlets or outlets to the lake. Occasionally, during flood conditions, the Sandy River will back up and surface water will flow from the river into the lake. The area is unfenced, although thick blackberries surround most of the lake and make human access difficult. There is no record of RMC ever using East Lake for any purpose.

Key Findings from RI.

- Constituent concentrations detected in East Lake sediments are similar to background concentrations.

- East Lake water quality varies seasonally and during flood events. The lake provides viable habitat for migratory waterfowl and terrestrial wildlife, but it is not suitable for fish.

- Surface water in East Lake is perched above groundwater except during periods of unusually high groundwater. Low levels of fluoride (less than 10 mg/L) have been detected in nearby groundwater, but at elevations of about 20 to 70 feet below the bottom of the lake. Because of the perched nature of the lake, the resulting downward hydraulic gradient, and the low fluoride concentrations in groundwater near the lake, the potential for groundwater to affect the lake is low.

Summary of Risk Assessment.

- The baseline human health risk assessment concluded that none of the risk estimates for surface water or sediment at East Lake exceed EPA or DEQ target risk criteria. The Tier 2 ecological hazard quotients for East Lake do not exceed risk threshold criteria.

Status of East Lake: Action Not Warranted. On the basis of the RI and RA findings, action is not warranted at East Lake. The area is planned for restoration as part of the Natural Resource Damage Assessment (NRDA) settlement.

1.5.3 Wastewater Discharge Areas

Two plant areas, Company Lake and South Ditch, were investigated in the RI, although they are components of the permitted NPDES operations at the facility. Company Lake is evaluated in this FFS. The following paragraphs provide a summary for these two areas.

1.5.3.1 Company Lake

Description. Company Lake is located north of the COE dike and is an integral part of the plant's NPDES discharge system. It is about 14 acres in size with a normal surface water elevation of about 15.5 feet [National Geodetic Vertical Datum (NGVD)]. The COE dike forms the southern border; the northern face of the dike has been lined with refractory brick that extends into Company Lake. RMC stormwater and wastewater from South Ditch enter the lake from a discharge pipe at its southwestern end. The outfall ditch drains from the northwestern corner of Company Lake through a Parshall flume and into the Columbia River. This discharge is permitted under RMC's NPDES permit. RMC personnel routinely measure flow rate and water quality in the outfall as required by the NPDES permit.

Industrial wastewater has been routed from the plant and through Company Lake since about 1947. From 1947 until 1965, industrial wastewater and stormwater were discharged to south wetlands and then pumped to Company Lake. Use of south wetlands was discontinued in 1965 and plant wastewater was pumped directly from South Ditch to the treatment pond. Company Lake became a permitted component of the plant NPDES wastewater treatment system in 1965. Between 1975 and 1989, the bleed stream from air emission control equipment installed on the carbon bake ESP discharged to South Ditch and Company Lake. Since 1989, the bleed stream has been treated by calcium chloride precipitation in the industrial wastewater treatment system before being discharged to South Ditch and Company Lake.

West Company Lake was once a part of Company Lake but was filled in the early 1970s; it is now owned by Gresham Sand and Gravel (GS&G). Dredged materials from the Columbia River are stockpiled over West Company Lake as part of GS&G operations.

Key Findings from RI.

- Surface water samples collected in Company Lake are representative of plant industrial wastewater.
- Depending on the season and river stage fluctuations, the elevation of surface water in Company Lake can be above or below groundwater. Water balance calculations performed in fall 1997, when groundwater levels were low, estimated a surface-water-to-groundwater discharge of between 280,000 and 430,000 gallons per day.
- U.S. Army Corps of Engineers HEC-2 water surface profile modeling indicated a low potential for scour of Company Lake, even during a 500-year flood event.
- Borings drilled at West Company Lake indicate the fill is between 8 and 24 feet deep. Constituents in the soil samples collected beneath the fill contain fluoride, metals, and PAHs, but at concentrations significantly lower than those detected in Company Lake sediment. This is consistent with the belief that the primary source of process residue in Company Lake is the bleed stream from the ESP, which was discharged from 1975 to 1989.
- Refractory brick along the south side of Company Lake appears to be an insignificant source of constituents to Company Lake surface water, sediments, or nearby groundwater.
- Process residue from historical discharge of the ESP bleed stream accumulated at the bottom of Company Lake. Constituents detected in samples collected from the lake bottom include fluoride, metals, PAHs, TPH, cyanide, and low levels of PCBs.
- The process residue thickness varies from 0.1 to 2.5 feet thick; the thickest accumulations occur in the shallow western portion (near the inlet pipe from South Ditch) and in the deeper eastern portion.
- Native sediments underlying the process residue are relatively unaffected, based on fluoride concentrations.
- Groundwater both north and south of Company Lake has been affected by the leaching of constituents from the process residue. Fluoride leaching from Company Lake to groundwater is conservatively estimated at 10 pounds per day (lb/day) through vertical leakage and about 7.5 lb/day through horizontal leakage, making Company Lake the primary source of fluoride to groundwater north of the dike. These estimates are conservative because they are based on conditions when maximum hydraulic gradients occur.
- Groundwater flow modeling results, supported by field data, indicate that affected groundwater north and west of Company Lake discharges to the Columbia River (see Section 1.5.2.1), but that most affected groundwater south of the dike is captured by the plant production wells.
- Elevated fluoride concentrations exist in the UGS and intermediate-zone groundwater immediately north of Company Lake. As discussed in Section 1.5.2.1, evaluation of groundwater discharge to the Columbia River indicates that fluoride in shallow

groundwater north of the dike does not result in a measurable effect on surface water in the river.

- Groundwater flow modeling results, supported by field data, indicate that production well pumping has caused fluoride-containing groundwater to migrate south from Company Lake through the intermediate and deep zones toward production wells PW03, PW07, and PW08. This pumping influence is the primary cause of fluoride migration from Company Lake to the intermediate and deep groundwater.

Summary of Risk Assessment.

- The baseline human health risk assessment for nongroundwater media concluded that none of the risk estimates for Company Lake exceed EPA target risk criteria. However, the RME-case risk estimate for sediment does exceed DEQ target risk criteria.

- The baseline ecological risk assessment concluded that, for sitewide open water/ wetland areas, the total Tier 2 ecological hazard quotients (HQs) for fluoride (for mallard and heron) and PAHs (for mink) exceed corresponding background levels by at least 1.0. Company Lake contributes a high percentage of the estimated sitewide risk for fluoride and PAHs. Further evaluation of the home ranges indicates that, if additional offsite habitat exists that is suitable for foraging by these receptors, it can be concluded that the RMC-related exposures to fluoride and PAHs are not high enough to pose unacceptable risk. The proximity of the site to the Sandy River delta area suggests that this acreage is actually available for the mallard and mink. The smaller home range of the heron, however, makes the fluoride in Company Lake a potentially unacceptable risk.

Status of Company Lake: Action to Be Considered in This FFS. On the basis of the RI and RA findings, potential remedial action is considered for Company Lake in this FFS.

1.5.3.2 South Ditch

Description. South Ditch is a manmade ditch that serves as the primary surface water drainage feature for the RMC facility. The upstream end of South Ditch begins just inside the COE dike, northeast of the plant. The ditch runs along the south side of the plant and terminates at the pump station in the South Ditch forebay. Water in the South Ditch forebay is pumped to Company Lake.

South Ditch is part of the plant's permitted NPDES system. The eastern portion of the ditch has been used since the early days of plant operation and is primarily used for stormwater conveyance. West South Ditch receives water from the bakehouse dewatering sumps, stormwater from the plant, process cooling water, boiler blowdown, effluent from the RMC sewage treatment plant, effluent from the RMC industrial wastewater treatment plant, and groundwater during seasonally high water levels.

In 1995, sediments were removed from the eastern end of the ditch as part of a time-critical action conducted in the east potliner area. In addition, sediment and process residue were removed from portions of east South Ditch and all of west South Ditch during a maintenance action conducted in September and October 1999.

Key Findings from RI.

- Maintenance dredging and sediment removal have been completed in South Ditch. Sediments were removed to support plant operations and to minimize the discharge of potentially contaminated solids to Company Lake. No further maintenance activities are planned for South Ditch.

Summary of Risk Assessment.

- Risk was not estimated for west South Ditch because it is part of the plant's NPDES wastewater treatment system. The baseline RA for human health concluded that east South Ditch does not exceed any of the EPA target risk criteria. (Prior to removal, PAHs in sediments in east South Ditch exceeded the DEQ target risk criteria for the RME case under the trespasser scenario.) The Tier 2 ecological HQs for east South Ditch do not exceed risk threshold criteria.

Status of South Ditch. Maintenance dredging activities have been completed for west South Ditch. Limited dredging was conducted in east South Ditch, coinciding with dredging of west South Ditch. No additional remedial activities are warranted for South Ditch in this FFS.

1.5.4 Sitewide Groundwater

1.5.4.1 Description of Groundwater at Site

The RMC facility is located on the eastern part of a hydrogeologic formation known as the Portland Basin. Two regional aquifer systems exist under the site. The Unconsolidated Sedimentary Aquifer (USA) is the uppermost aquifer, and the Sand and Gravel Aquifer (SGA) is the deeper unit. As described in Section 1.2.5, four water-bearing zones occur in the USA.

Site groundwater flow is strongly controlled by hydraulic connections with the Columbia and Sandy Rivers, as well as by pumping from RMC's production wells. The rivers exert a strong control on groundwater elevations in the UGS, intermediate, and deep groundwater zones, with the Columbia River exerting a stronger influence than the Sandy River. The RMC production wells exert a strong influence in much of the deep zone and more localized influences on portions of the UGS and intermediate zones. Precipitation infiltration directly controls groundwater elevations only in the silt unit.

The Columbia River is a regional discharge location for groundwater in the UGS, intermediate, and deep zones. The Sandy River is a discharge point for groundwater in the UGS and may also capture groundwater from portions of the intermediate zone under certain conditions. Silt unit groundwater generally moves vertically into the UGS or horizontally over limited distances toward surface depressions (such as South Ditch and south wetlands).

1.5.4.2 Key Findings from RI

Silt Unit. The silt unit is the uppermost groundwater bearing zone at the Troutdale facility. This unit consists of a surficial overlying sand horizon and an underlying low-permeability silt. The overlying sand is typically less than 10 feet thick. The silt horizon varies from 8 to more than 20 feet thick. The silt unit is present in the south plant area beneath the south

landfill, scrap yard, and EPL areas. The silt unit thins north of the scrap yard and disappears altogether north of the dike.

Permeability estimates, summarized in Table 3-7 of the *Draft Groundwater Remedial Investigation Report* (CH2M HILL, June 1999), indicate that the silt horizon in this unit has a vertical permeability of about 10^{-7} centimeters per second (cm/sec). This is approximately 10,000 times less than the vertical permeability of the UGS and between 10,000 and 100,000 times less than the vertical permeability of the intermediate and deep zones. The horizontal permeability in the silt is estimated to be about 10 times less than in the UGS and about 100 times less than in the deep and intermediate zones.

Site groundwater fluoride concentrations are highest in the silt unit. High groundwater concentrations are coincident with high fluoride concentrations measured in the waste layer and the underlying soil at each area. Fluoride is bound in the silt unit soil underlying the waste in the scrap yard, south landfill, and east potliner. Estimates of the fluoride mass in silts at each area of concern are provided in Appendix E of this FFS.

Fluoride migration from the silt unit to the UGS, intermediate, and deep groundwater zones is governed primarily by silt permeability. At south landfill, where the silt is estimated to be greater than 20 feet thick and the vertical permeability is low, there is little or no indication of fluoride migration to the underlying groundwater zones.

In contrast to the conditions at the south landfill, significant fluoride migration from the silt unit to the UGS and deeper groundwater is occurring at the scrap yard. Fluoride is migrating from waste and soil in this area because the silt unit is thin (less than 8 feet, compared with more than 20 feet at the south landfill) and more vertically permeable than silt elsewhere on the site. As a result, the scrap yard is the primary source of fluoride measured in intermediate- and deep-zone groundwater between the scrap yard and the production wells.

Some fluoride migration from the silt unit to the UGS has also occurred at the east potliner area. There is no evidence of migration from the UGS at the east potliner area to the intermediate or deep groundwater zone. This is discussed in more detail below.

The silt unit is not present beneath Company Lake and the north landfill; these areas are discussed in more detail below.

UGS. The UGS is a water-bearing unit consisting of moderately permeable sand. It ranges from about 25 to 35 feet thick south of the dike to about 50 feet thick north of the dike. The UGS underlies the silt in the south plant area. North of the dike, where silt is not present, the UGS is the uppermost water-bearing unit. The UGS is estimated to have a vertical permeability about 10,000 times greater than the silt but about 10 to 100 times less than the underlying intermediate and deep groundwater zones. Horizontal permeability in the UGS is about 10 times greater than in the silt but about 10 times less than in the intermediate and deep zones.

Fluoride occurs in the UGS in portions of the south plant and a small area around the north landfill, and over a broad area around Company Lake. In the south plant, the primary concern is migration of fluoride in the scrap yard area from the UGS to the intermediate and deep groundwater zones. Fluoride in the east potliner area UGS is not migrating to the

intermediate and deep groundwater zones. Groundwater flow modeling results indicate that the main reason for this is lower vertical and horizontal permeabilities in the east potliner area than in the scrap yard area, making it more difficult for constituents to migrate from the east potliner area to the deeper groundwater zones.

In the north plant, transport of fluoride has occurred from the UGS to the intermediate zone beneath and immediately adjacent to Company Lake. Transport appears to be predominantly horizontal north of Company Lake and both horizontal and vertical elsewhere around the lake.

Sands in the UGS provide little resistance to the vertical and horizontal passage of fluoride-containing groundwater to the intermediate and deep groundwater zones. This migration occurs as a result of both natural and pumping-induced vertical gradients. The horizontal and vertical distribution of fluoride in the UGS, intermediate, and deep groundwater is readily explained by groundwater flow modeling results (see Appendix A).

Intermediate and Deep Zones. The intermediate sand extends from the base of the UGS to a depth of 100 feet bgs. The deep sand/gravel extends from the base of the intermediate sand to a depth of 200 feet bgs. The intermediate and deep zones are present throughout the site. Aquifer test results indicate that horizontal and vertical permeabilities are significantly higher in both the intermediate and deep zones than elsewhere on the site.

All RMC production wells are screened in the deep zone. A total of 18 production wells have been installed at the site; nine were decommissioned as an early action (see Section 1.4.1.7). Over the last several years, RMC has operated eight of the wells in various combinations. Most production water is currently obtained through operation of wells PW03, PW07, PW08, and PW10.

RMC production well operation exerts strong influences on groundwater flow patterns across most of the site and in all groundwater zones except the silt unit. Under pumping conditions, vertical hydraulic gradients are predominantly downward throughout the pumping and overlying zones. Groundwater flow patterns in the intermediate and deep zones are strongly controlled by pumping from the production wells. Pumping of the production wells induces strong downward gradients from the UGS to the intermediate and deep zones. The horizontal extent of influence and the magnitude of the vertical gradient depend on the wells being operated and the rate of pumping.

In the south plant, an areally extensive plume is present in the intermediate zone, and to a lesser extent in the deep zone downgradient of the scrap yard. In the north plant, fluoride is more extensive in the intermediate zone because of downward vertical pressure from Company Lake and the effects of the production wells. These two effects cause fluoride to migrate southward from the lake and toward the wells.

A summary of the results of the groundwater investigations conducted from 1994 to 1999 is provided in the *Draft Groundwater Remedial Investigation Report* (CH2M HILL, June 1999). For the RI/FS, groundwater was investigated and evaluated on a sitewide basis, rather than area by area.

- Constituents of concern in groundwater at the site have been identified on the basis of 1997 and 1998 groundwater monitoring results. Nine constituents exceeded primary

MCLs: arsenic (total and dissolved), beryllium (total and dissolved), chromium (total), nickel (total), lead (total), fluoride, cyanide, 1,1-dichloroethene (1,1-DCE), and tetrachloroethene (PCE). With the exception of fluoride and cyanide, each MCL exceedance occurred in groundwater from either the silt unit or the UGS. Fluoride MCL exceedances occurred in all groundwater zones. The cyanide MCL was exceeded in one deep zone sample (MW33-165).

- The predominant COPC in groundwater at the site is fluoride because of its distribution and presence at concentrations above the MCL. With few exceptions, the other MCL exceedances are co-located with fluoride. The occurrence of the 1,1-DCE and PCE is limited to two shallow wells located near the northwest corner of the bakehouse.
- The distribution of fluoride in groundwater at the site is illustrated in Figures 1-6 through 1-11. Fluoride (as well as other constituent) concentrations are highest in the silt unit. Fluoride concentrations decrease rapidly with depth and are considerably lower in the UGS, intermediate, and deep groundwater zones.
- Primary sources of fluoride to UGS, intermediate, and deep groundwater are Company Lake and the scrap yard. Migration of fluoride from these areas is illustrated in the cross section groundwater plume maps provided in Figures 1-11 and 1-12, and 1-17 and 1-18. The north landfill and east potliner areas contribute fluoride to the UGS but not to other groundwater zones. Little or no fluoride migration to the UGS, intermediate, or deep groundwater zone has been identified to occur in the south landfill or south wetlands. Although waste materials in these areas do contribute fluoride and other constituents to groundwater in the silt unit, constituent presence is essentially confined to the silt unit and does not migrate significantly downward.
- Site data indicate that the presence of the fluoride plume in the intermediate and deep zones is attributable to the presence of natural downward gradients from the silt unit and the UGS into the intermediate zone at the scrap yard and Company Lake, plus the creation of strong downward gradients from the intermediate to the deep zone by pumping of the RMC production wells. In comparison with other areas of the site, the silt unit at the scrap yard is thin. These interpretations are supported by the site groundwater flow model, which illustrates that production well pumping is responsible for the current plume configuration.
- Fluoride in groundwater north of the COE dike is migrating toward the Columbia and Sandy Rivers. As discussed in Section 1.5.2, this discharge of groundwater has not resulted in measurable effects on the rivers.

1.5.4.3 Summary of Risk Assessment

The baseline human health risk assessment for groundwater included estimation of human health risk for four exposure settings: current onsite occupational use, current offsite occupational use, future onsite occupational use, and future offsite occupational and residential use. Of the four exposure settings evaluated, only one exceeds either EPA or DEQ risk criteria. The future offsite residential water use resulted in estimated noncancer risks exceeding EPA's risk level of a hazard quotient greater than 1.0, based on estimated fluoride concentrations at a hypothetical offsite well.

The estimated future offsite fluoride concentrations also exceed DEQ's target, the MCL (4 mg/L). However, based on current and anticipated zoning, the presence of high-voltage power lines, and the proximity of a heavy industrial complex, it is unlikely that this area will be developed for residential use. The baseline ecological risk assessment results indicated no adverse effect expected on aquatic organisms in either the Sandy or the Columbia River.

1.5.4.4 Status of Sitewide Groundwater: Action to Be Considered in the FFS

On the basis of the RI and RA findings, remedial action is evaluated for sitewide groundwater in this FFS.

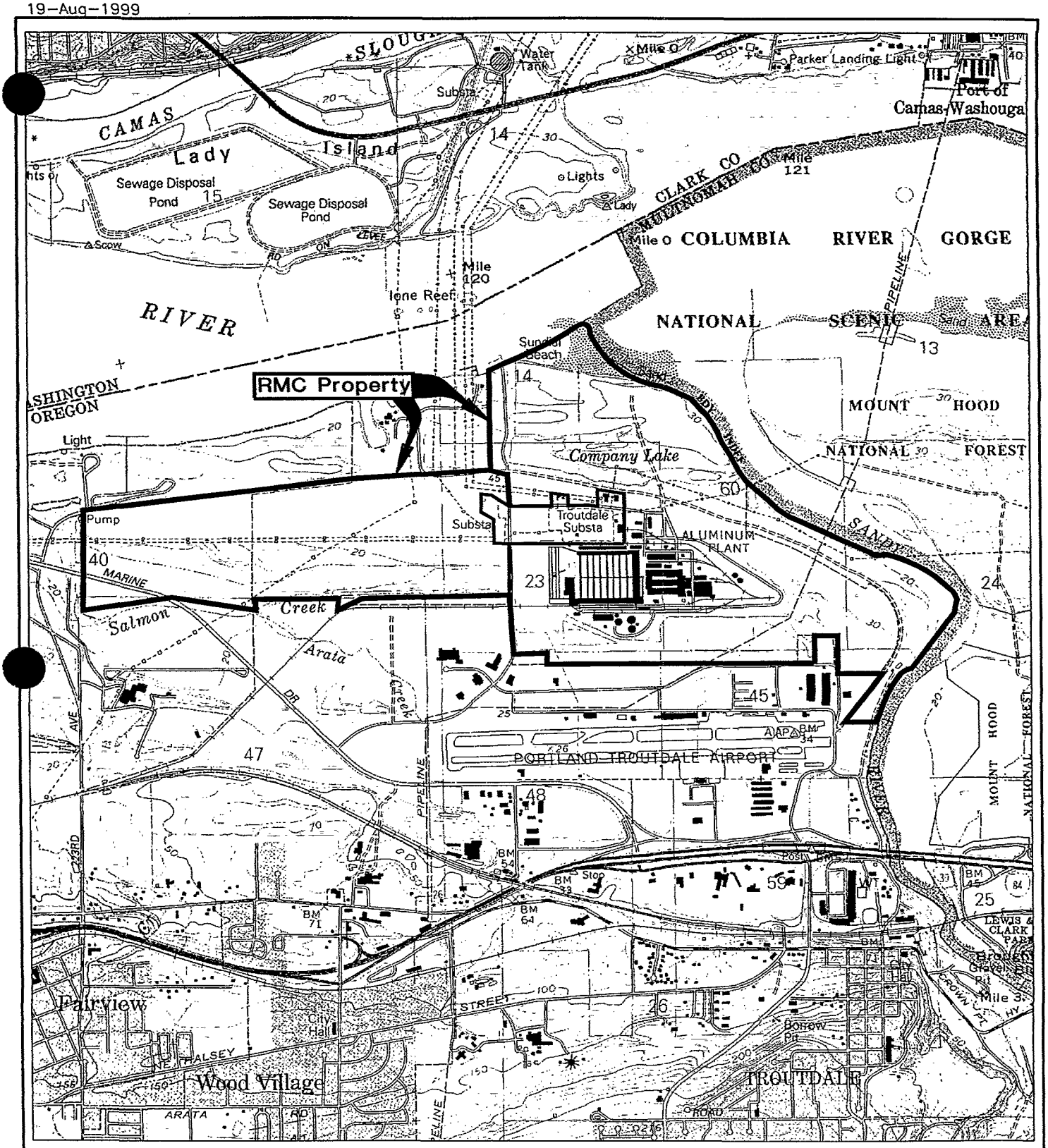
Section 1 Table

Table 1-1
Summary of Early Actions and Maintenance Activities at RMC-Troutdale

Area	Action Taken
Early Actions	
Signage and Access Restrictions	Warning signs posted around Company Lake and north landfill. Fencing was installed at north landfill and along the east side of Company Lake.
East Potliner	Excavation and disposal of more than 11,148 tons of spent potliner (K088) and contaminated soil from east potliner area.
Cryolite Ponds	Removal of approximately 13,900 tons of cryolite material and contaminated soils from unlined impoundments of cryolite, including three recovery ponds located south of the facility.
Bakehouse Sumps	Removal and abandonment of well points at the bakehouse. Removal of approximately 283 tons of contaminated soils from the sumps, and modification of the sumps to bring them into compliance with Oregon Water Resources Department (OWRD) regulations.
PCB Spill Area	Characterization, excavation, and disposal of about 515 tons of PCB-contaminated soil from spill area south of the casthouse. This quantity includes concrete from casthouse area.
Production Well Decommissioning	The following production wells were decommissioned in accordance with OWRD requirements: PW04, PW06, PW09, PW11, PW12, PW14, PW15, PW16, PW17.
South Wetlands	Excavation, characterization, and onsite stockpiling of approximately 60 cubic yards of PCB-containing soil from localized area in northeast south wetlands.
Fairview Farms Debris Piles	Characterization, excavation, and onsite storage of between 50 and 100 cubic yards of miscellaneous debris.
Maintenance Activities	
Electrostatic Precipitator (ESP) Containment Area	Removal of approximately 1,193 tons of material; material replacement adjacent to the ESP tower to contain washdown water; construction of a new butt-can drainage facility; and modification of process piping to capture and reuse water from sumps 16, 17, and 18.
Casthouse	Removal of approximately 36 tons of PCB-containing dust, miscellaneous amounts of concrete (included in totals for the PCB spill area), and 21 tons of roofing and other materials. This work also included concrete decontamination and siding replacement.
South Ditch	Dredging and onsite stockpiling of about 5,400 cubic yards of solids. Dredging was completed for maintenance purposes.
Diesel Oil Spill Area	Excavation and offsite thermal treatment of approximately 2,000 tons of diesel-contaminated soil.

Section 1 Figures

19-Aug-1999



0 1000 2000

SCALE IN FEET

N

LEGEND

APPROXIMATE RMC PROPERTY BOUNDARY

Figure 1-1
VICINITY MAP
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2M HILL

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19-AUG-1999

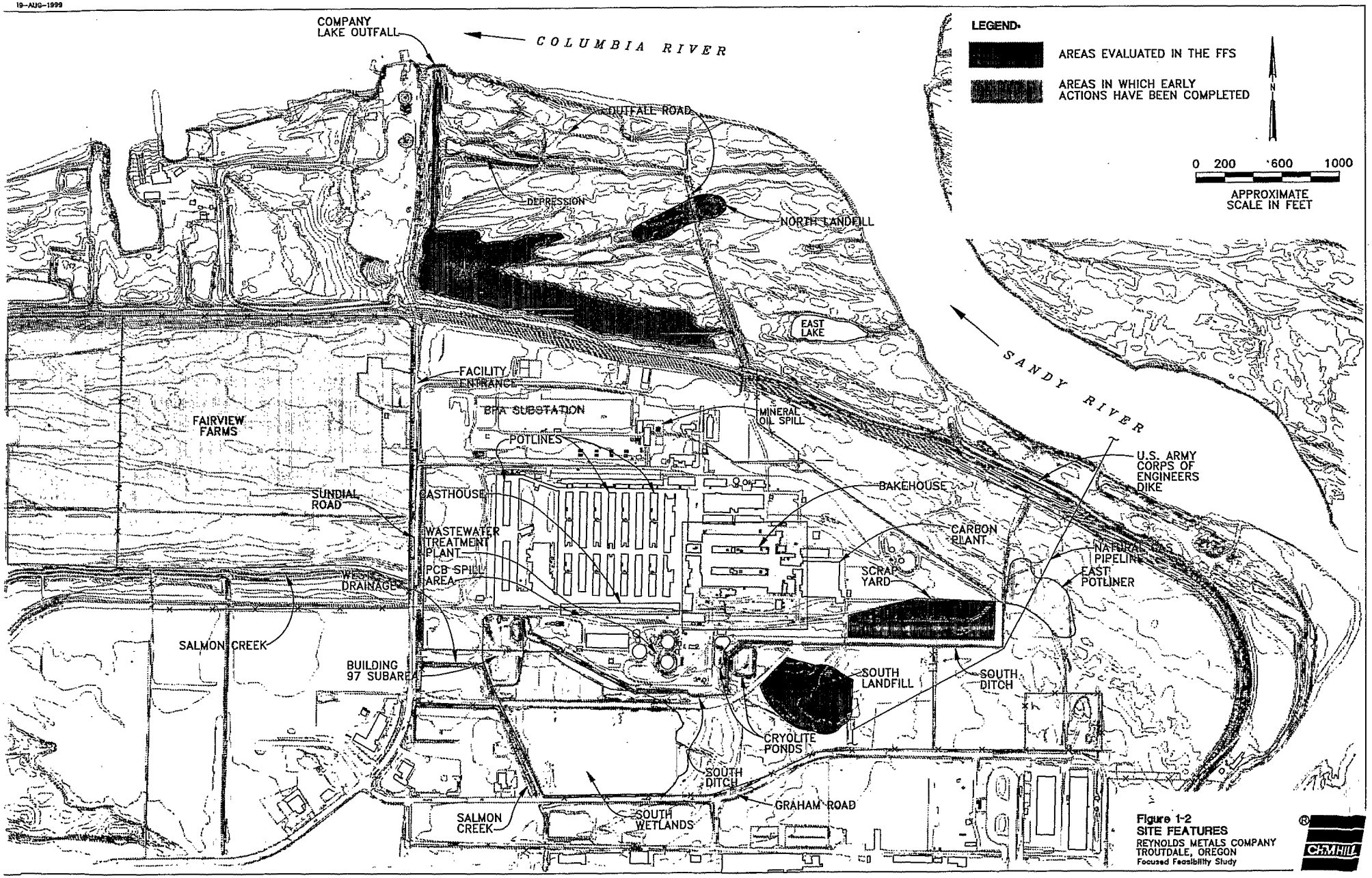

Figure 1-2
SITE FEATURES
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2MHILL

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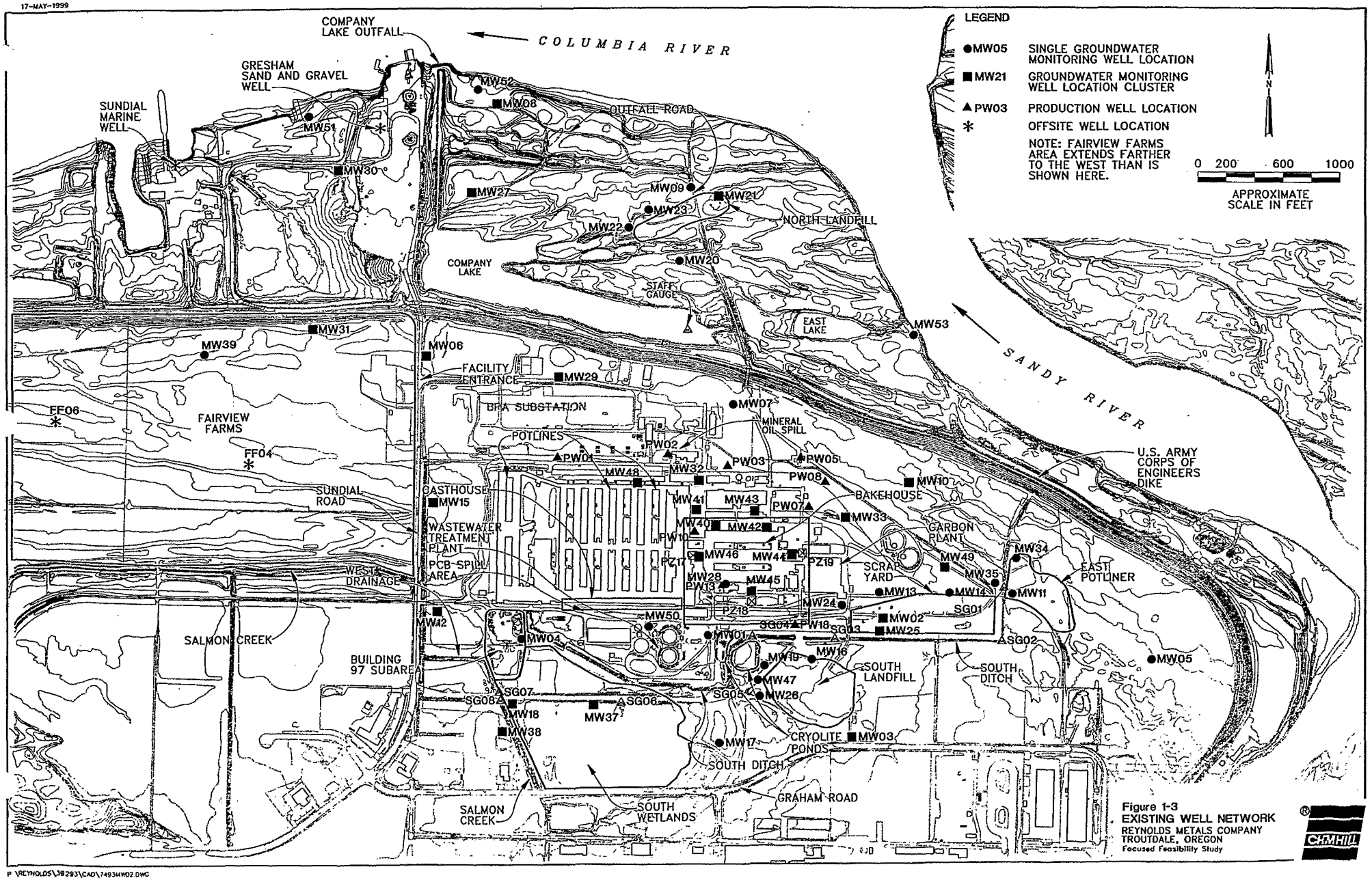

Figure 1-3
EXISTING WELL NETWORK
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2MHILL

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25-Oct-1999

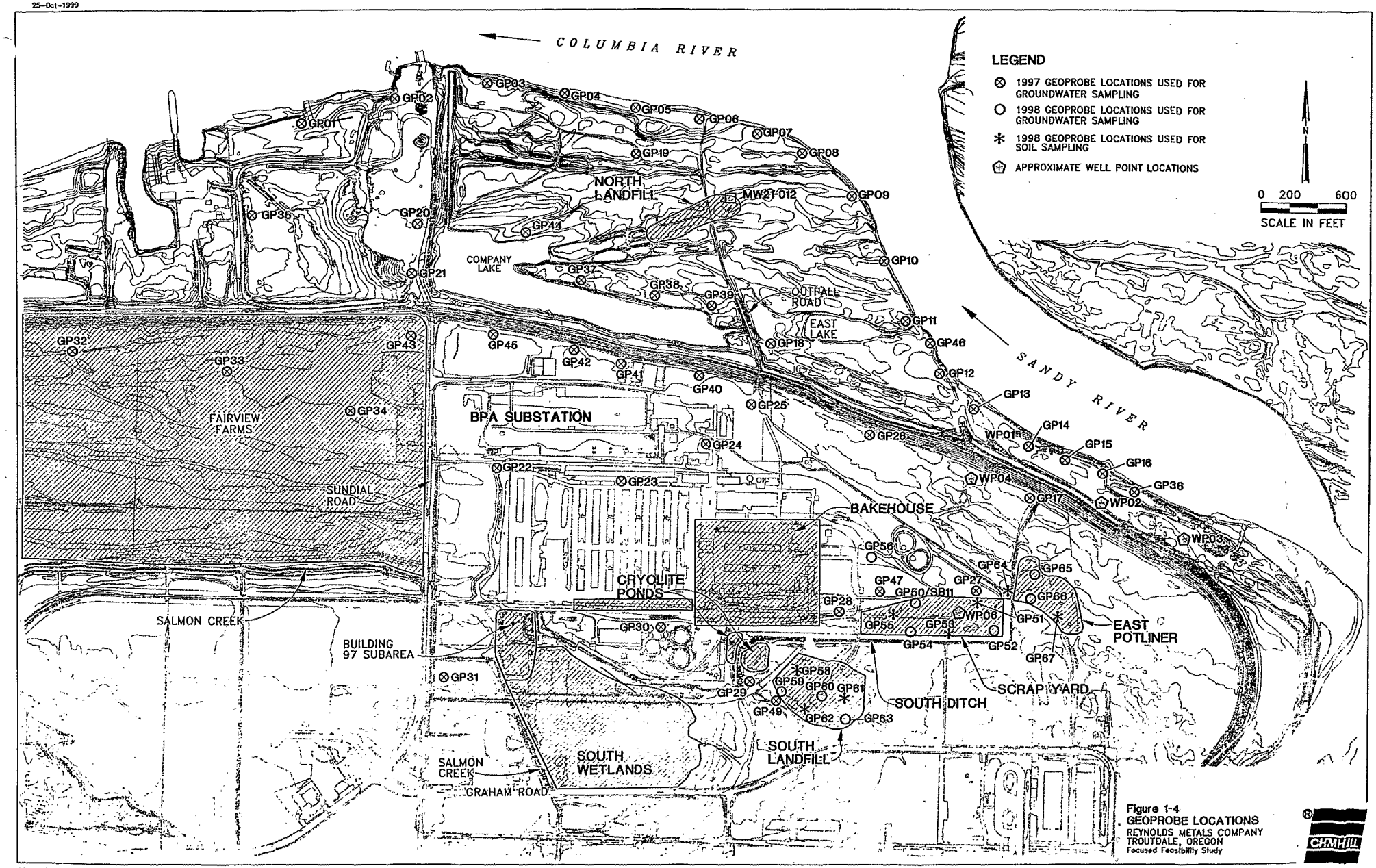

Figure 1-4
GEOPROBE LOCATIONS
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2M HILL

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16-SEPT-1999

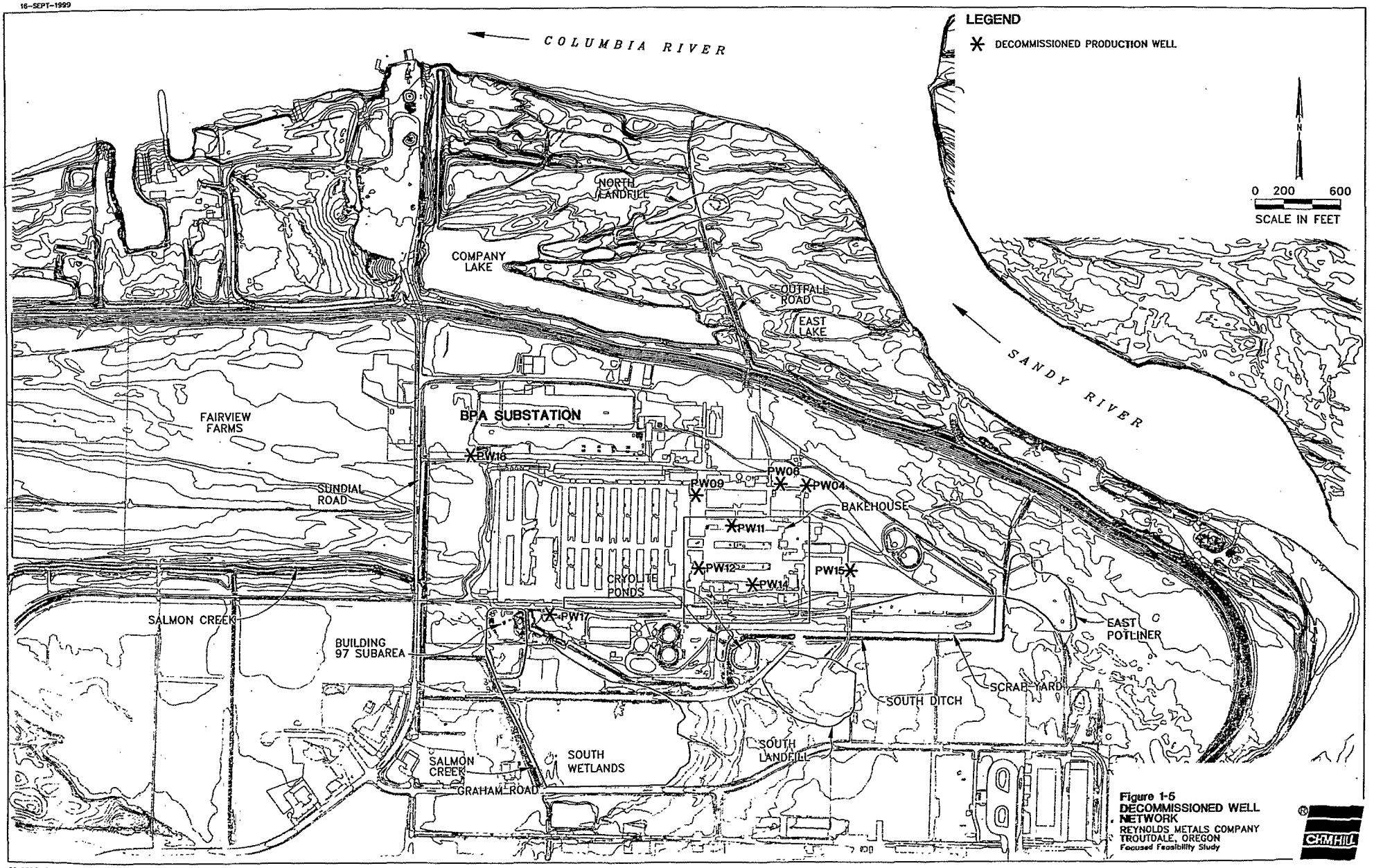

Figure 1-5
DECOMMISSIONED WELL NETWORK
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2M HILL

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R COLOR60.DWG

27-OCT-1999

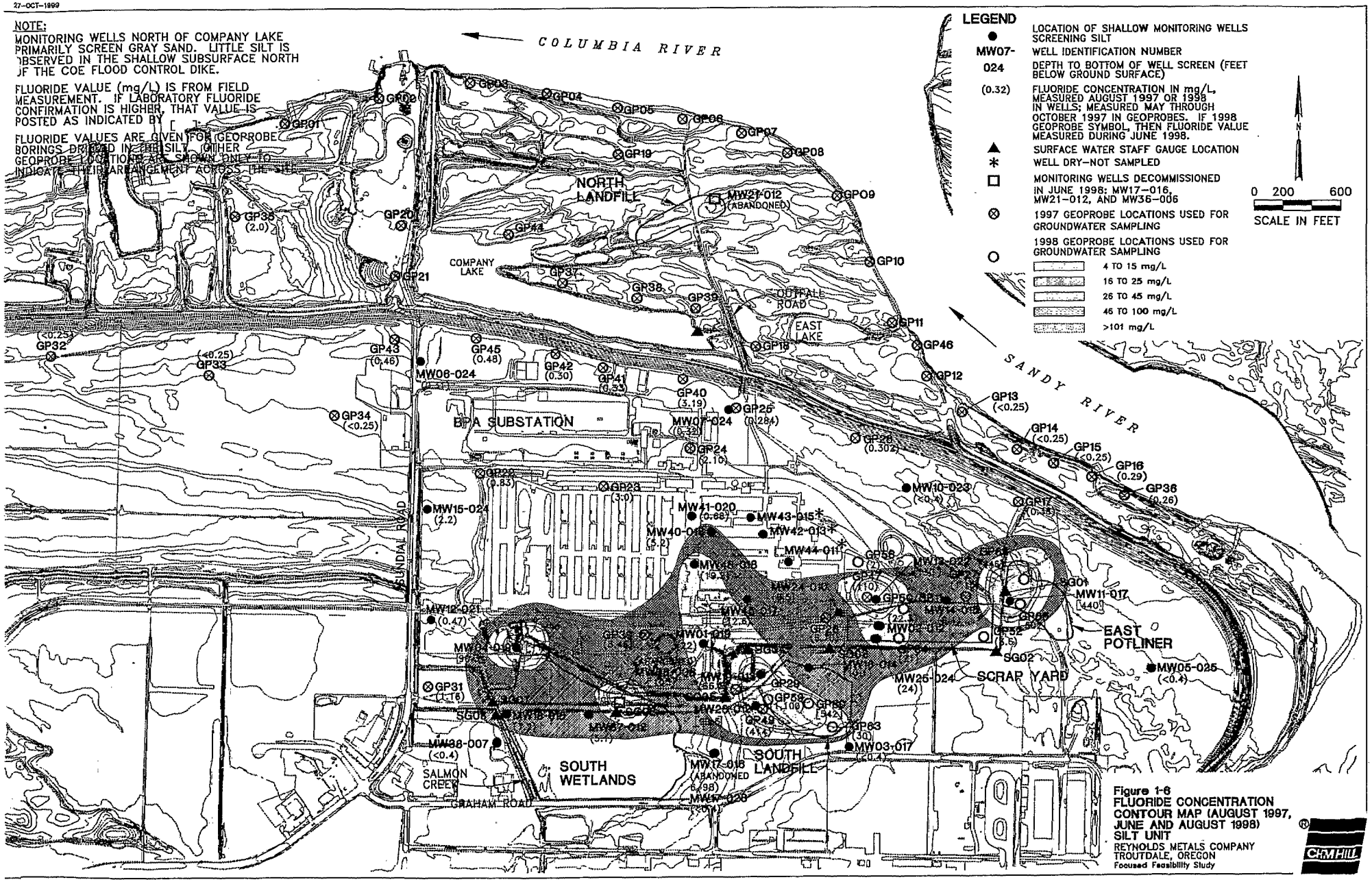

Figure 1-6
FLUORIDE CONCENTRATION CONTOUR MAP (AUGUST 1997, JUNE AND AUGUST 1998) SILT UNIT
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2M HILL

OLOR60.DWG

.R COLOR2D.DWG

27-OCT-1999

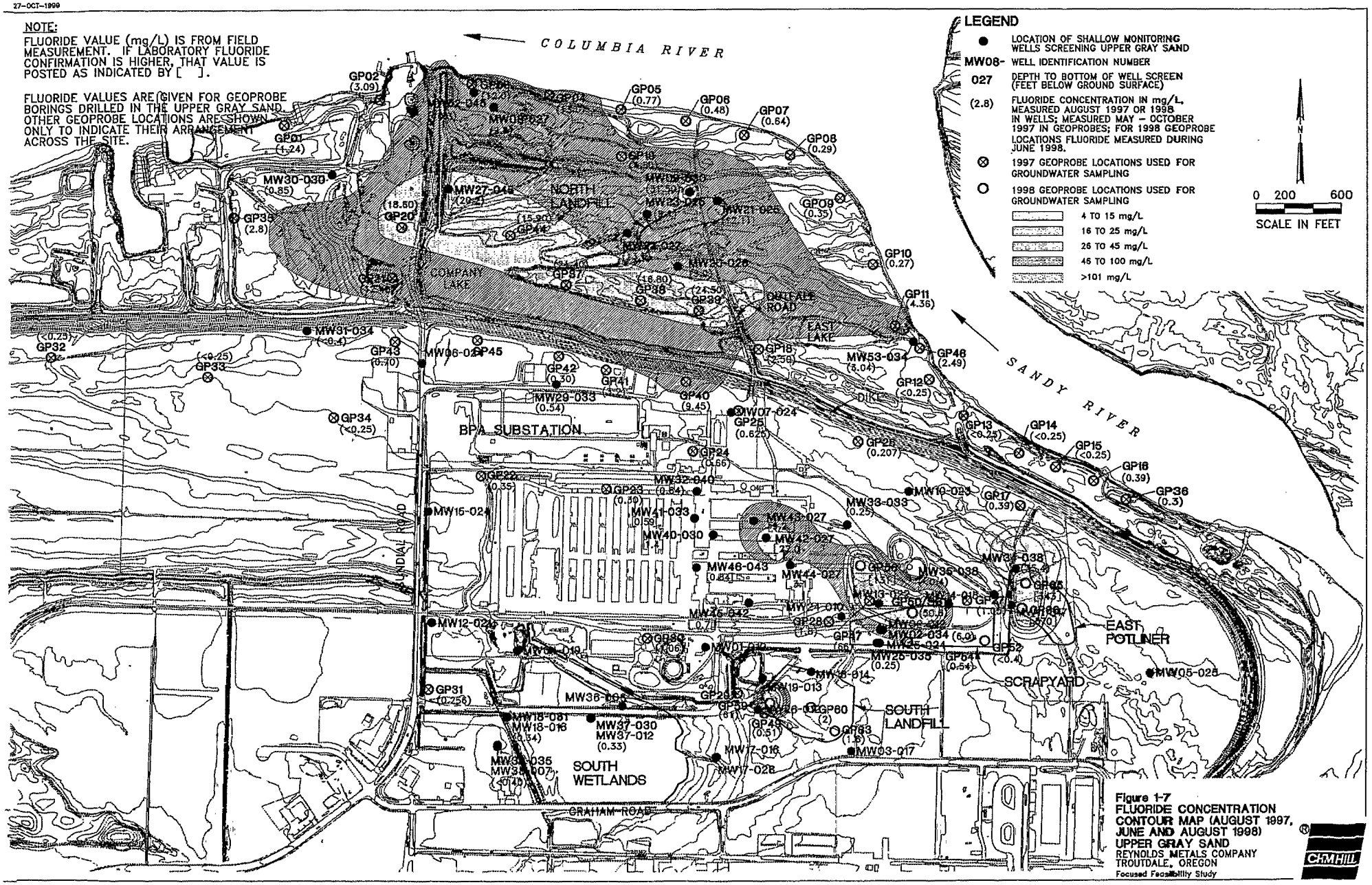

Figure 1-7
FLUORIDE CONCENTRATION CONTOUR MAP (AUGUST 1997, JUNE AND AUGUST 1998)
UPPER GRAY SAND
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2M HILL

OLOR2D.DWG

.R COLOR5E.DWG

27-OCT-1999

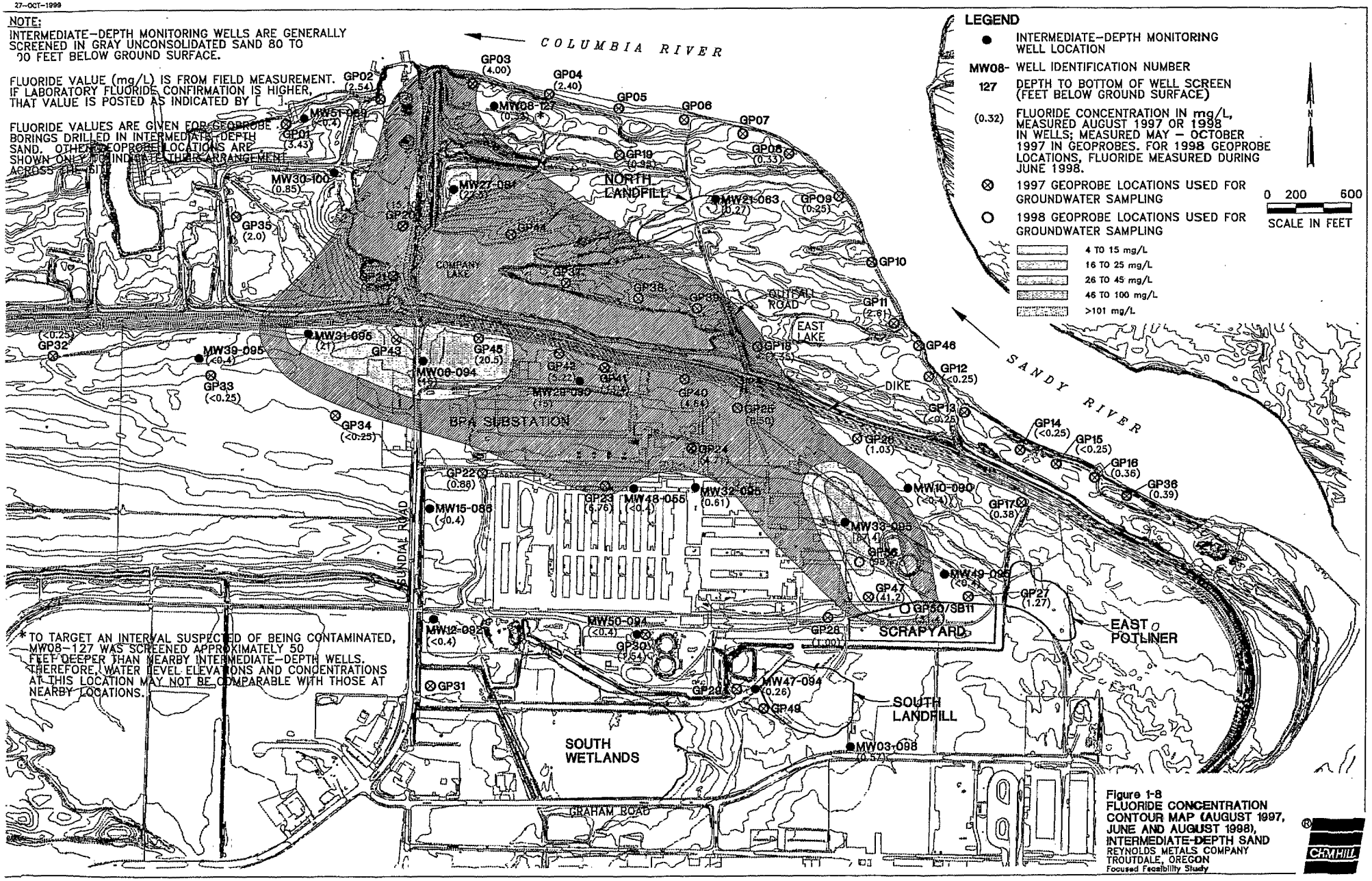

Figure 1-8
FLUORIDE CONCENTRATION CONTOUR MAP (AUGUST 1997, JUNE AND AUGUST 1998), INTERMEDIATE-DEPTH SAND
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2M HILL

COLOR5E.DWG

R COLOR40.DWG

27-OCT-1999

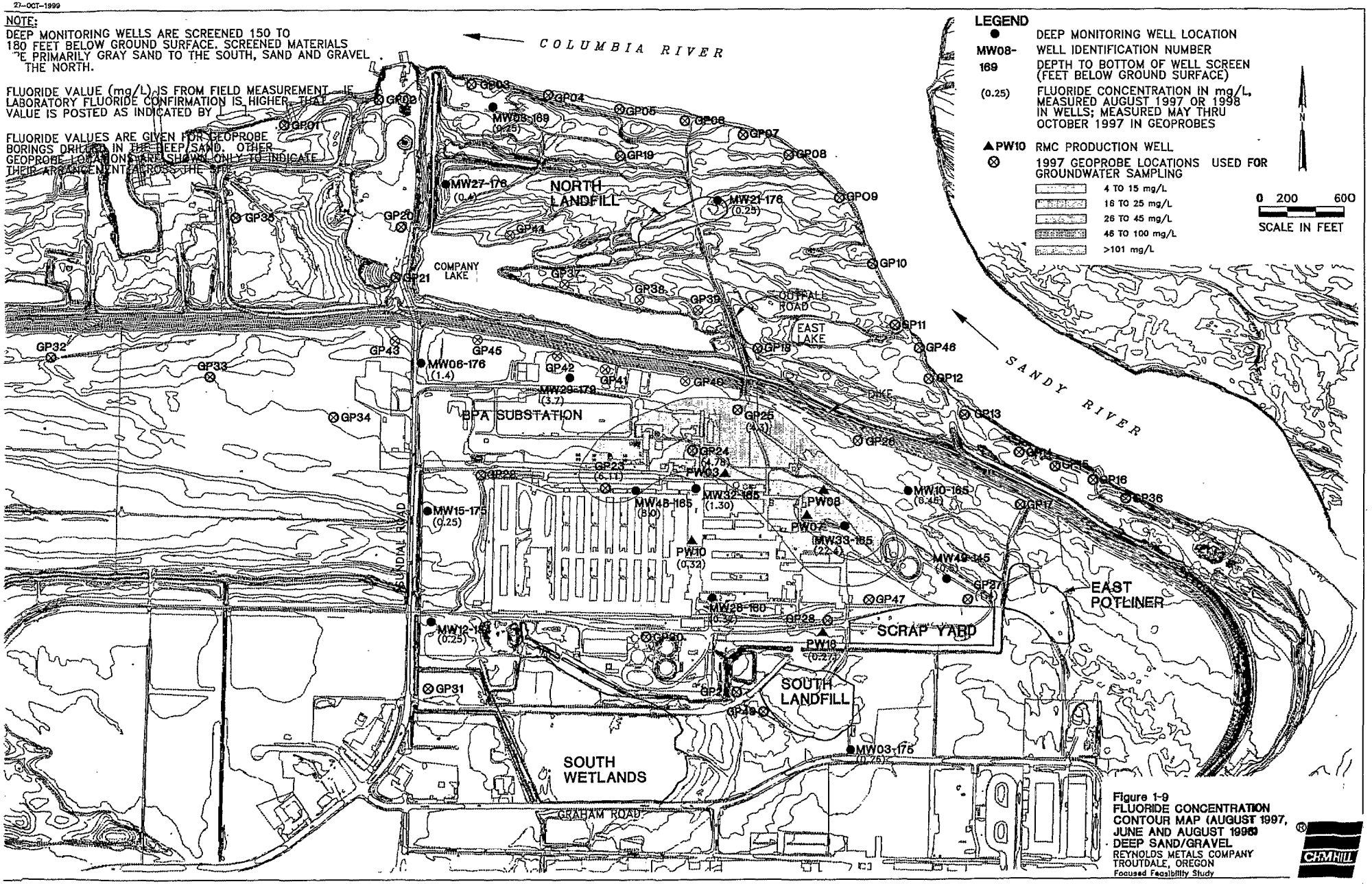

Figure 1-9
FLUORIDE CONCENTRATION CONTOUR MAP (AUGUST 1997, JUNE AND AUGUST 1998) DEEP SAND/GRAVEL
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2M HILL

COLOR40.DWG

SRB
27-OCT-1999

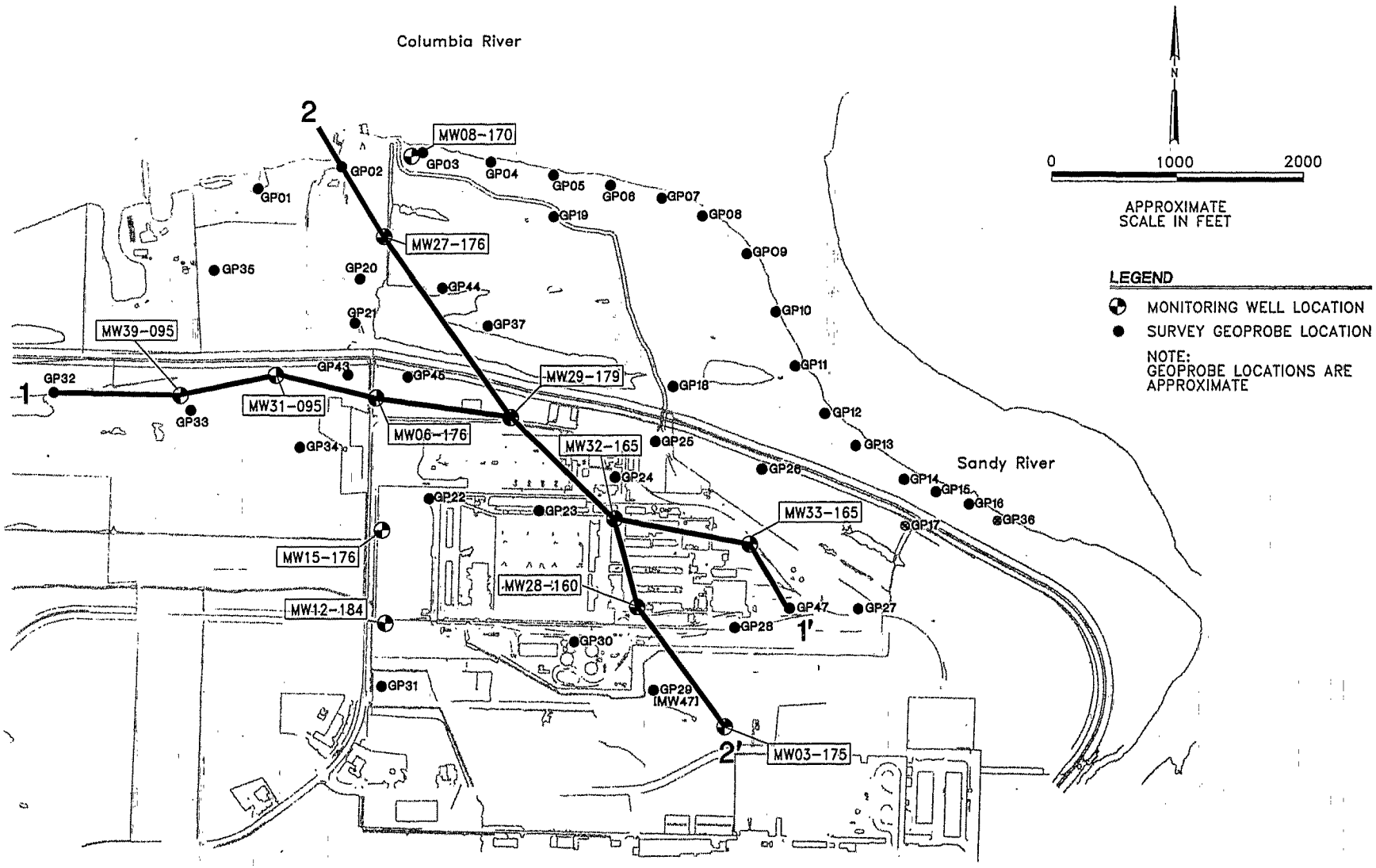

Figure 1-10
SITEWIDE LOCATION MAP FOR CROSS SECTIONS SHOWING VERTICAL DISTRIBUTION OF FIELD-MEASURED FLUORIDE
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2M HILL

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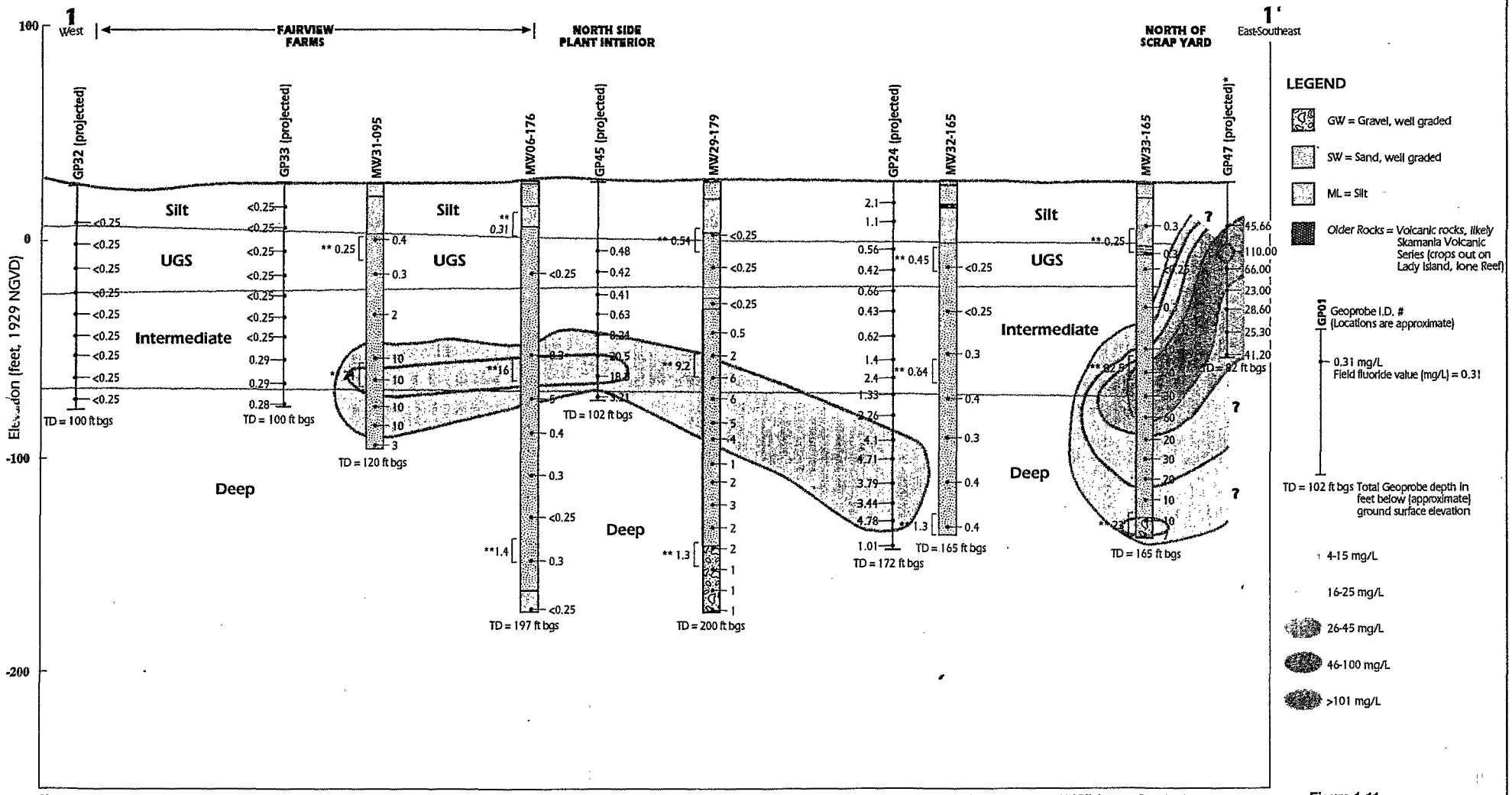


Notes: Values next to well columns indicate fluoride concentrations measured during drilling of the identified well. In most cases the well column represents a composite log, whose screened intervals are shown by a bracket to the left of the column.

Field-measured fluoride concentrations were obtained by screening borehole water samples with an Orion fluoride probe during Phase 1 and Phase 1A drilling (April 1996 to December 1996) and during the Geoprobe investigation (summer 1997).

* Note that the fluoride distribution shown in MW33 and GP47 is localized.

** *August 1997 fluoride concentration data (mg/L).*

Approximate Scales:

Horizontal scale: **1 inch = 500 feet**

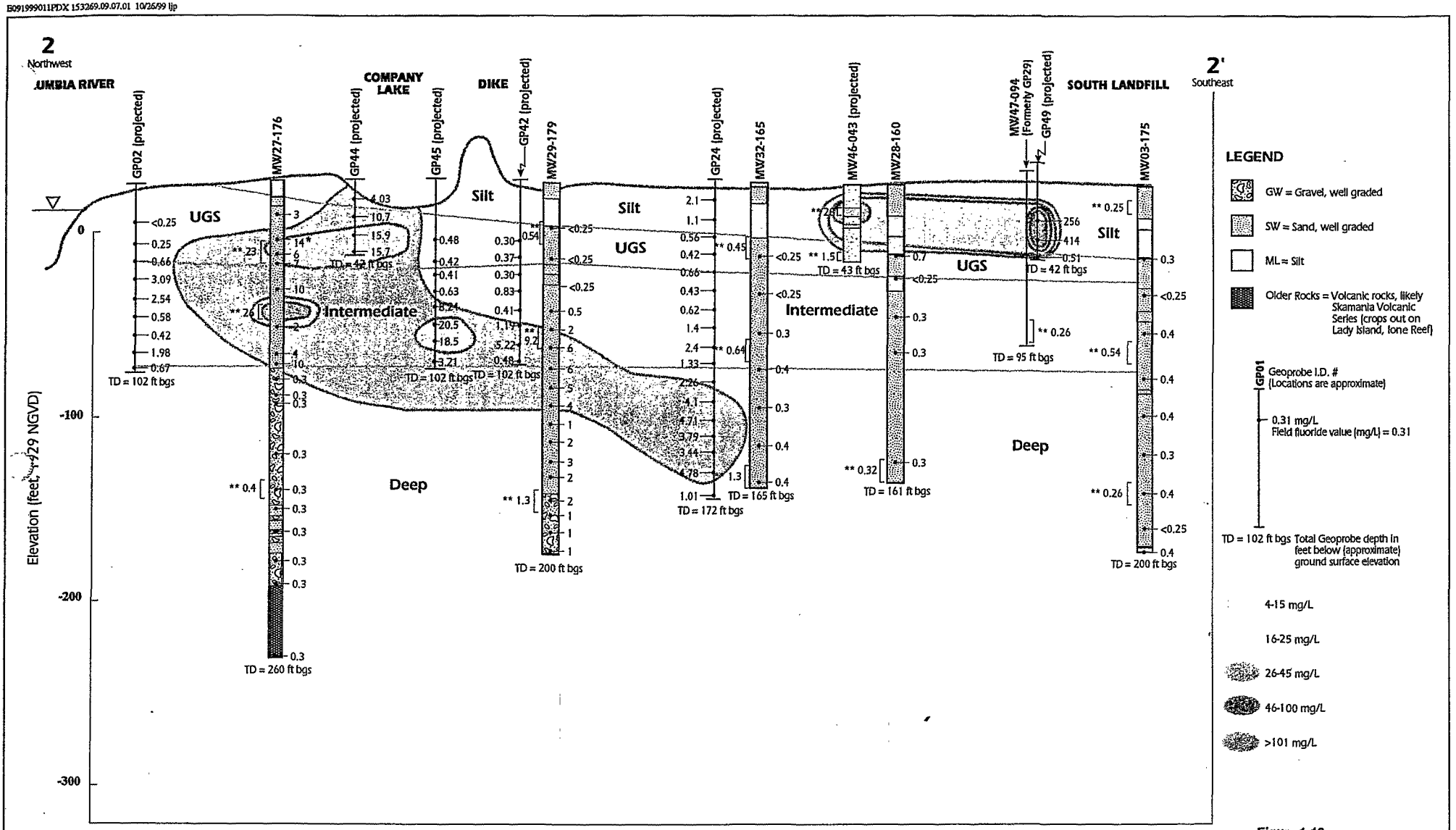
Vertical scale: **1 inch = 45 feet**

Vertical exaggeration: **11x**

Silt, upper gray sand (UGS), intermediate-depth and deep zones represent hydrogeologic units.

Figure 1-11
CROSS SECTION 1-1'
VERTICAL DISTRIBUTION OF FIELD-MEASURED FLUORIDE
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2MHILL



Notes: Values next to well columns indicate fluoride concentrations measured during drilling of the identified well. In most cases the well column represents a composite log, whose screened intervals are shown by a bracket to the left of the column.

Field-measured fluoride concentrations were obtained by screening borehole water samples with an Orion fluoride probe during Phase 1 and Phase 1A drilling (April 1996 to December 1996) and during the Geoprobe investigation (summer 1997).

* November 1996 fluoride concentration from MW27-045 monitoring well.

** August 1997 fluoride concentration data (mg/L).

Approximate Scales:
Horizontal scale: **1 inch = 500 feet**
Vertical scale: **1 inch = 50 feet**
Vertical exaggeration: **10x**

Silt, upper gray sand (UGS), intermediate-depth and deep zones represent hydrogeologic units.

Figure 1-12
CROSS SECTION 2-2'
VERTICAL DISTRIBUTION OF FIELD-MEASURED FLUORIDE
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2MHILL

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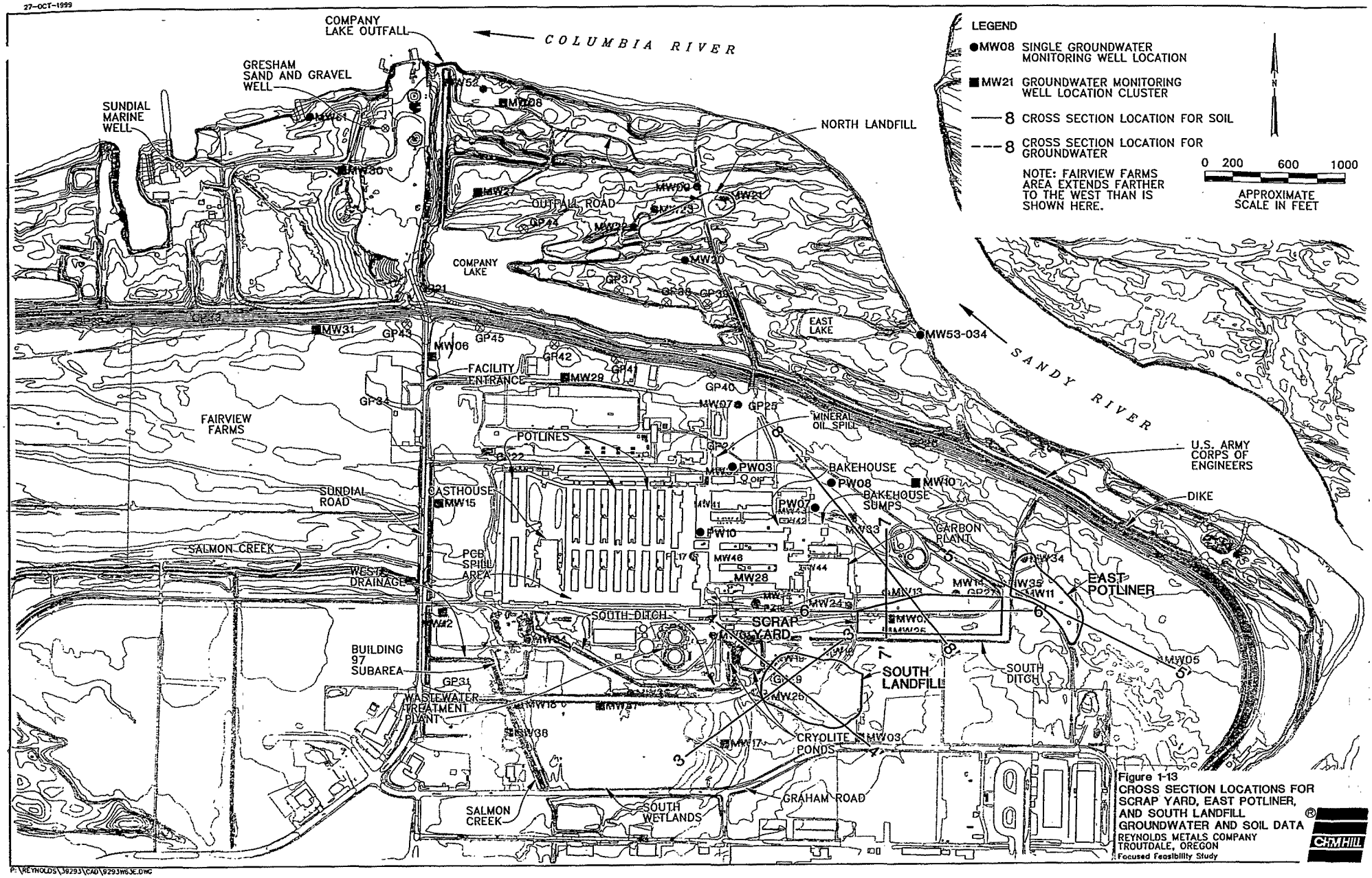

Figure 1-13
CROSS SECTION LOCATIONS FOR SCRAP YARD, EAST POTLINER, AND SOUTH LANDFILL GROUNDWATER AND SOIL DATA
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

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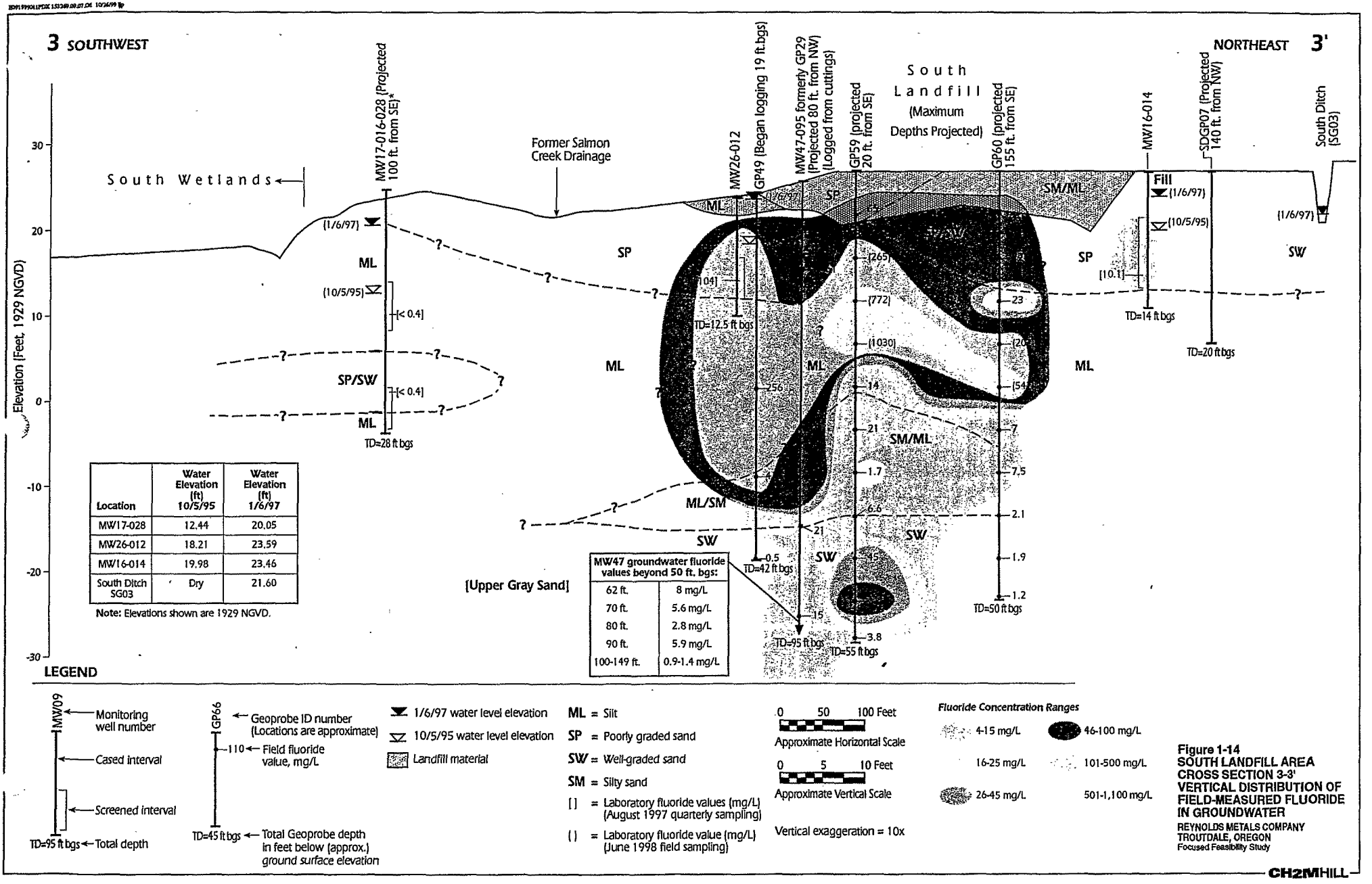


Location	Water Elevation (ft) 10/5/95	Water Elevation (ft) 1/6/97
MW17-028	12.44	20.05
MW26-012	18.21	23.59
MW16-014	19.98	23.46
South Ditch SG03	Dry	21.60

Note: Elevations shown are 1929 NGVD.

MW47 groundwater fluoride values beyond 50 ft. bgs:	
62 ft.	8 mg/L
70 ft.	5.6 mg/L
80 ft.	2.8 mg/L
90 ft.	5.9 mg/L
100-149 ft.	0.9-1.4 mg/L

LEGEND

MW09 — Monitoring well number; Cased interval; Screened interval; TD=95 ft bgs — Total depth

GP66 — Geoprobe ID number (Locations are approximate); 110 — Field fluoride value, mg/L; TD=45 ft bgs — Total Geoprobe depth in feet below (approx.) ground surface elevation

1/6/97 water level elevation

10/5/95 water level elevation

Landfill material

ML = Silt

SP = Poorly graded sand

SW = Well-graded sand

SM = Silty sand

[ ] = Laboratory fluoride values (mg/L) (August 1997 quarterly sampling)

( ) = Laboratory fluoride value (mg/L) (June 1998 field sampling)

0 50 100 Feet — Approximate Horizontal Scale

0 5 10 Feet — Approximate Vertical Scale

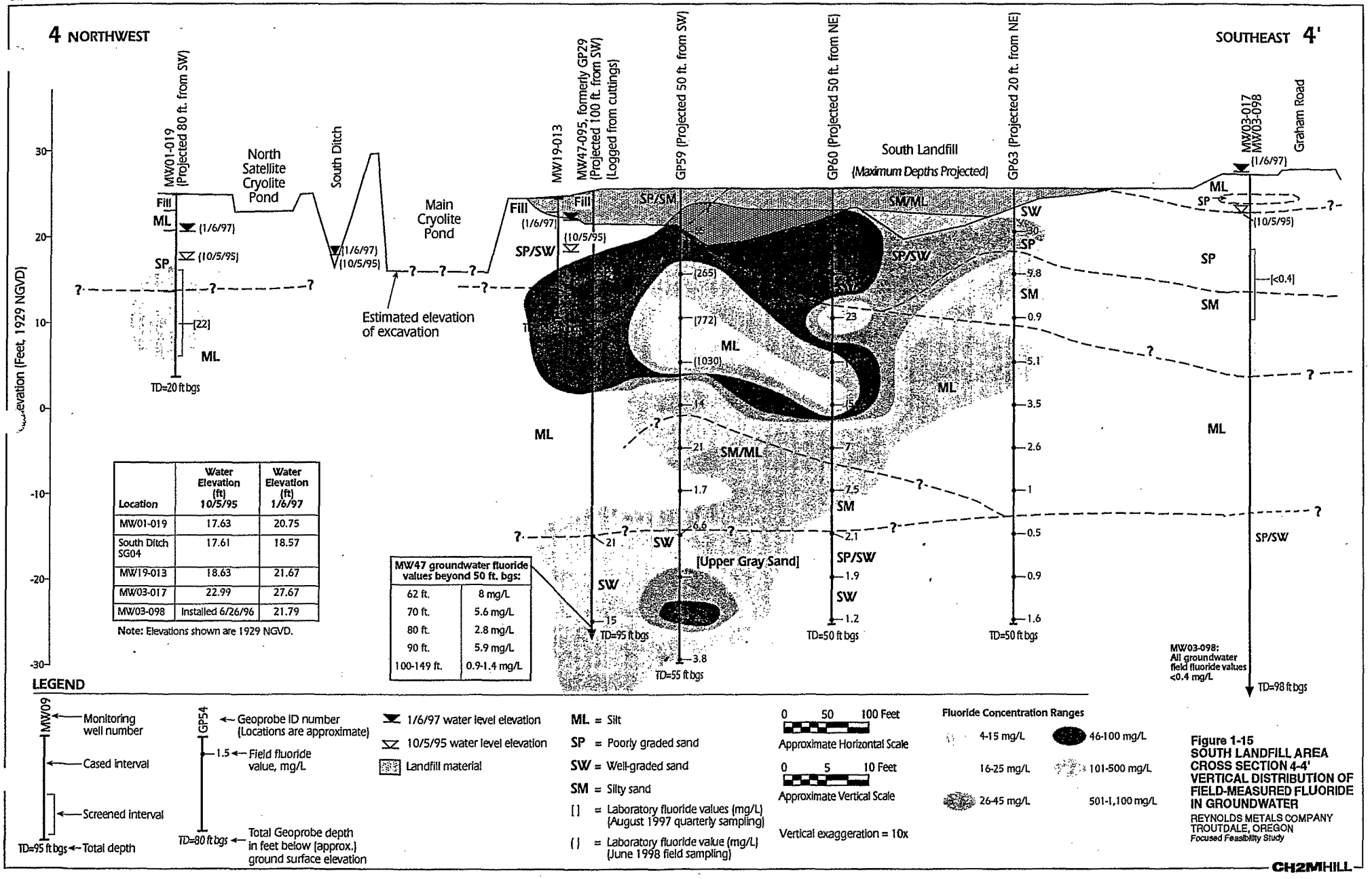
Vertical exaggeration = 10x

Fluoride Concentration Ranges

4-15 mg/L; 16-25 mg/L; 26-45 mg/L; 46-100 mg/L; 101-500 mg/L; 501-1,100 mg/L

Figure 1-14
SOUTH LANDFILL AREA CROSS SECTION 3-3'
VERTICAL DISTRIBUTION OF FIELD-MEASURED FLUORIDE IN GROUNDWATER
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2MHILL



Location	Water Elevation (ft) 10/5/95	Water Elevation (ft) 1/6/97
MW01-019	17.63	20.75
South Ditch SG04	17.61	18.57
MW19-013	18.63	21.67
MW03-017	22.99	27.67
MW03-098	Installed 6/26/96	21.79

Note: Elevations shown are 1929 NGVD.

MW47 groundwater fluoride values beyond 50 ft. bgs:	
62 ft.	8 mg/L
70 ft.	5.6 mg/L
80 ft.	2.8 mg/L
90 ft.	5.9 mg/L
100-149 ft.	0.9-1.4 mg/L

LEGEND

MW09 — Monitoring well number
Cased interval
Screened interval
TD=95 ft bgs — Total depth

GP54 — Geoprobe ID number (Locations are approximate)
1.5 — Field fluoride value, mg/L
TD=80 ft bgs — Total Geoprobe depth in feet below (approx.) ground surface elevation

1/6/97 water level elevation
10/5/95 water level elevation
Landfill material

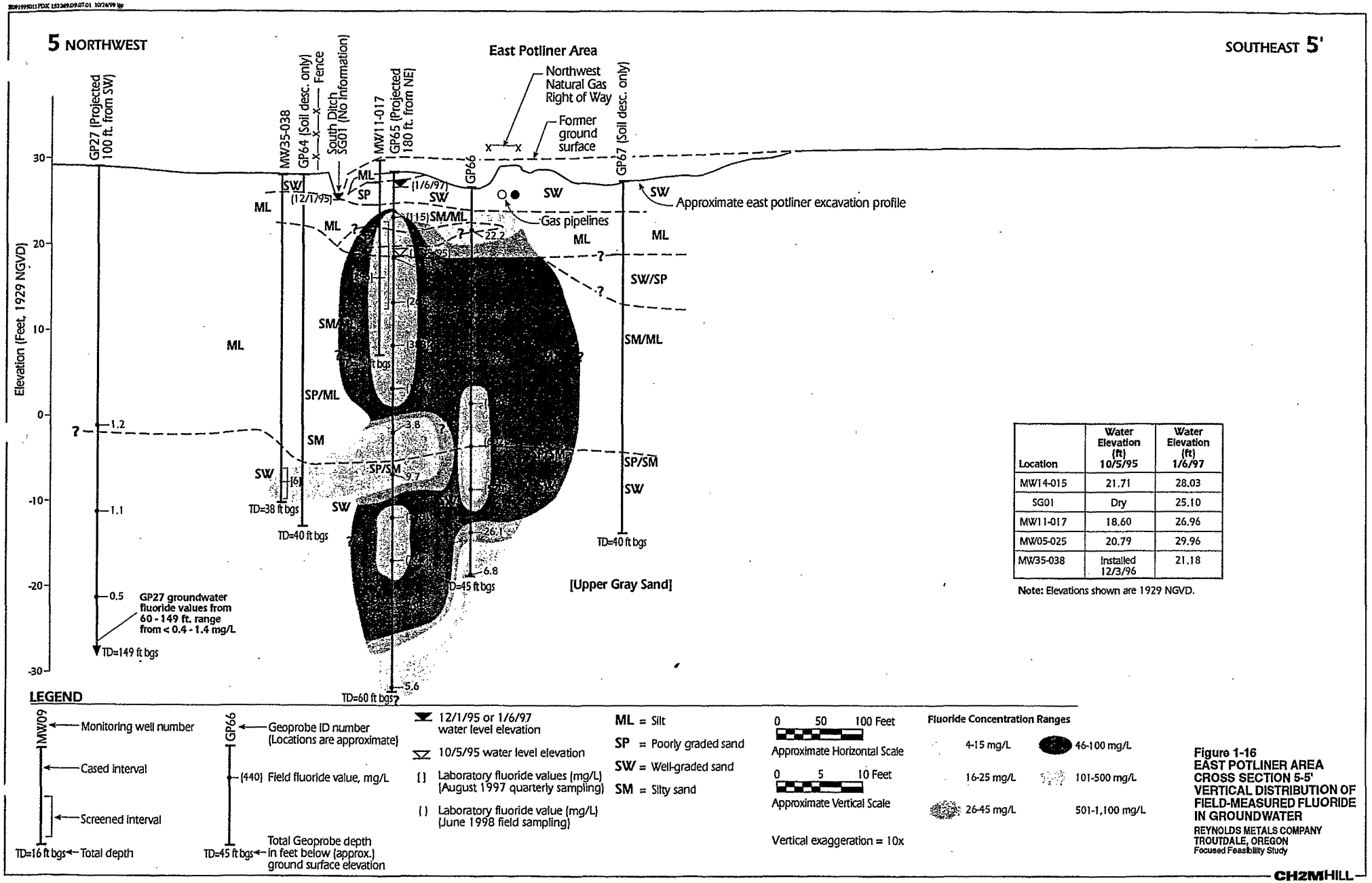
ML = Silt
SP = Poorly graded sand
SW = Well-graded sand
SM = Silty sand
[ ] = Laboratory fluoride values (mg/L) (August 1997 quarterly sampling)
( ) = Laboratory fluoride value (mg/L) (June 1998 field sampling)

0 50 100 Feet
Approximate Horizontal Scale
0 5 10 Feet
Approximate Vertical Scale
Vertical exaggeration = 10x

Fluoride Concentration Ranges
4-15 mg/L
16-25 mg/L
26-45 mg/L
46-100 mg/L
101-500 mg/L
501-1,100 mg/L

Figure 1-15
SOUTH LANDFILL AREA CROSS SECTION 4-4' VERTICAL DISTRIBUTION OF FIELD-MEASURED FLUORIDE IN GROUNDWATER
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2MHILL

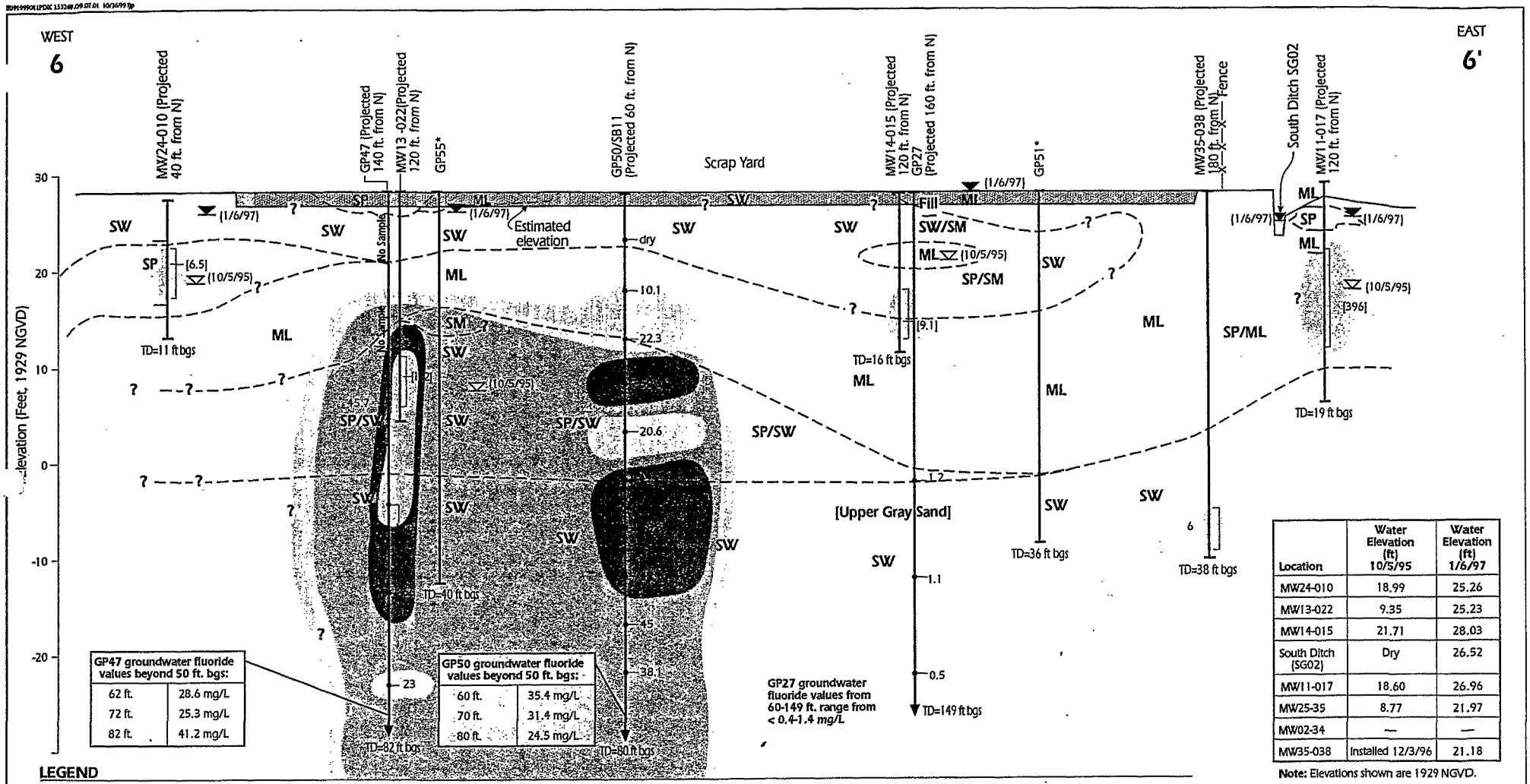


Location	Water Elevation (ft) 10/5/95	Water Elevation (ft) 1/6/97
MW14-015	21.71	28.03
SG01	Dry	25.10
MW11-017	18.60	26.96
MW05-025	20.79	29.96
MW35-038	Installed 12/3/96	21.18

Note: Elevations shown are 1929 NGVD.

Figure 1-16
EAST POTLINER AREA CROSS SECTION 5-5' VERTICAL DISTRIBUTION OF FIELD-MEASURED FLUORIDE IN GROUNDWATER
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2MHILL



Location	Water Elevation (ft) 10/5/95	Water Elevation (ft) 1/6/97
MW24-010	18.99	25.26
MW13-022	9.35	25.23
MW14-015	21.71	28.03
South Ditch (SG02)	Dry	26.52
MW11-017	18.60	26.96
MW25-35	8.77	21.97
MW02-34	—	—
MW35-038	Installed 12/3/96	21.18

Note: Elevations shown are 1929 NGVD.

Figure 1-17
SCRAP YARD
CROSS SECTION 6-6'
VERTICAL DISTRIBUTION OF FIELD-MEASURED FLUORIDE IN GROUNDWATER
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2MHILL

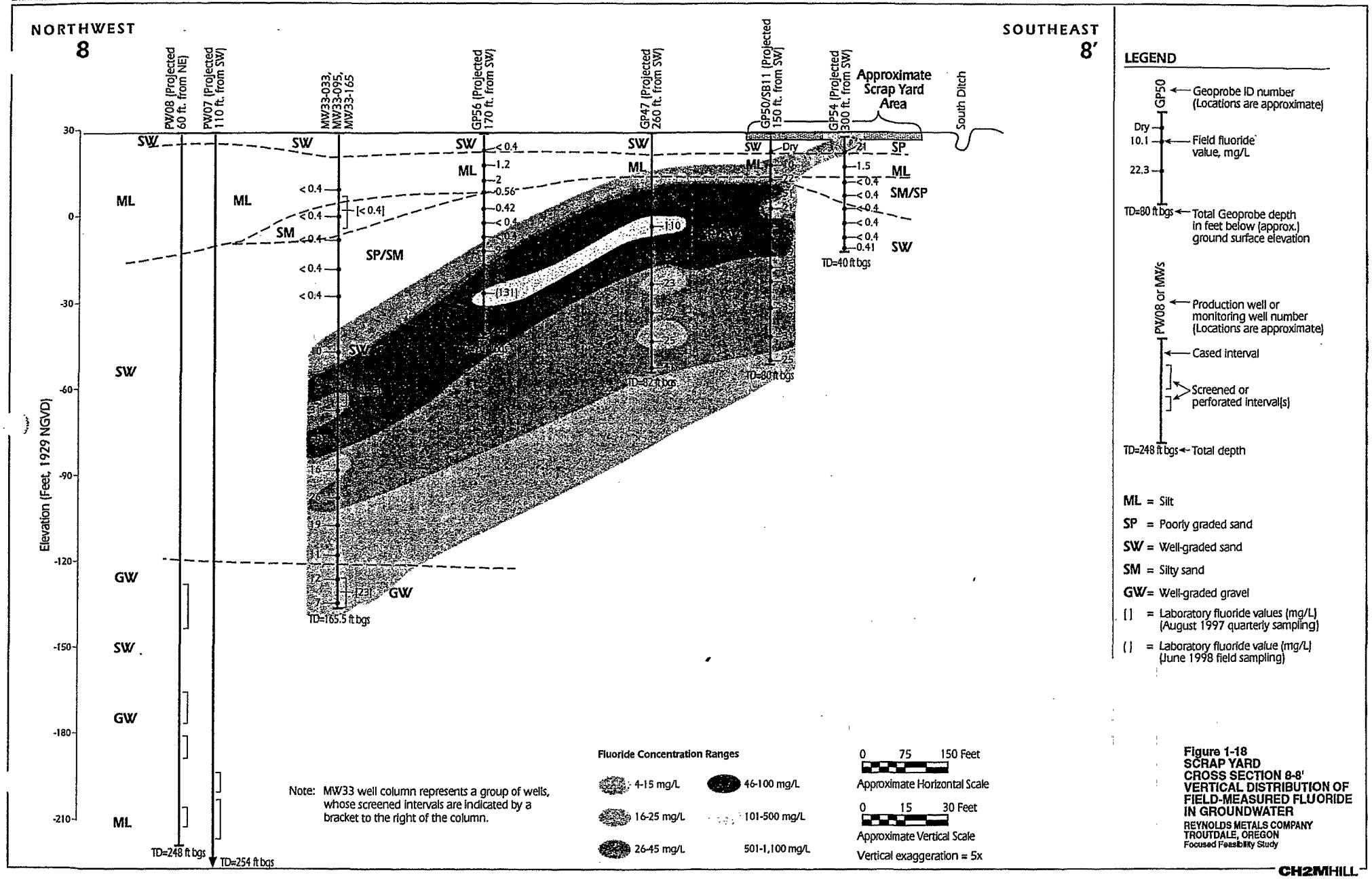


Figure 1-18
SCRAP YARD
CROSS SECTION 8-8'
VERTICAL DISTRIBUTION OF FIELD-MEASURED FLUORIDE IN GROUNDWATER
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2MHILL

SECTION 2

Development of Remedial Action Objectives

SECTION 2

Development of Remedial Action Objectives

This section develops and presents the remedial action objectives (RAOs) for the RMC-Troutdale facility. The primary considerations in deriving the RAOs include:

- Results of the human health and ecological risk assessment
- Applicable or relevant and appropriate requirements (ARARs)
- Fate and transport of constituents of concern

General RAOs for the Troutdale site were developed to address the site as a whole. Area- and media-specific RAOs were developed in order to identify and evaluate remedial options.

Sections 2.1, 2.2, and 2.3 discuss the results of the risk assessment, the evaluation of ARARs, and a summary of fate and transport from the RI, respectively. The RAOs are presented in Section 2.4. The RAOs were used in the evaluation of remedial options and alternatives presented in Sections 4 and 5.

2.1 Summary of Risk Assessment

2.1.1 Human Health Risk Assessment Findings

The human health risk assessment (HHRA) was divided into two parts: nongroundwater media and groundwater. The HHRA findings for both are summarized in the following two subsections.

2.1.1.1 Nongroundwater Media RA Results

The results of the nongroundwater media HHRA are summarized in Table 2-1. This table provides the excess lifetime cancer risk and noncancer hazard index (HI) risk estimates for each area, environmental medium, and exposure scenario evaluated. Also provided in Table 2-1 is a summary of the primary risk contributors and their respective contribution to the total area-specific risk estimate. The primary human health risk contributors in nongroundwater media at RMC are PAHs and PCBs.

Table 2-2 presents the results of the comparison of risk estimates with risk-based regulatory criteria. The results indicate that none of the most conservative RME-case risk estimates for any exposure scenario exceed EPA's target risk levels ($>10^{-4}$ or HI >1.0) at any area of concern. RME risk estimates exceed the DEQ cumulative lifetime cancer risk target of 1×10^{-5} for selected exposure scenarios at the north landfill, the south landfill, the scrap yard, Fairview Farms (residential scenario only), Company Lake, and the eastern portion of South Ditch. As discussed earlier, a residential receptor at Fairview Farms is highly unlikely because of current and anticipated zoning restrictions, the presence of high-voltage power lines, and the proximity to a heavy industrial complex.

RME risk estimates for individual carcinogens exceed the DEQ target of 1×10^{-6} for the north landfill (5 PAHs), the south landfill (5 PAHs), the scrap yard (5 PAHs and PCBs), Fairview Farms (2 PAHs and PCBs for residential scenario only), the Fairview Farms debris piles (1 PAH for residential scenario only), south wetlands Building 97 subarea (PCBs), Company Lake (4 PAHs), and the eastern portion of South Ditch (5 PAHs).

2.1.1.2 Groundwater HHRA Results

Four exposure settings were evaluated in the groundwater risk assessment to reflect current and future water and land use conditions both onsite and offsite. Exposure point concentrations (EPCs) were estimated at the most relevant exposure points at or near the RMC facility. The most relevant exposure points for onsite and offsite groundwater were identified as locations where human use of groundwater is currently occurring, or where future well placements are most feasible. Feasible well placement locations were selected on the basis of consideration of reasonably anticipated future land use, groundwater flow direction, current groundwater concentration data, and review of the results of the regional well survey [see Section 3 of the *Draft Groundwater Remedial Investigation Report* (CH2M HILL, June 1999)]. For future settings (both onsite and offsite), exposure points were conservatively located where the highest potential for migration of COPCs could occur. These exposure points are as follows:

- **Current Onsite Exposure Point.** At the drinking water tap currently supplying production well water to the RMC facility.
- **Future Onsite Exposure Point.** At well PW08, which contains higher concentrations of fluoride than are observed in tap water or other individual production wells at the RMC facility.
- **Current Offsite Exposure Point.** At the drinking water tap supplying well water at Sundial Marine Tug & Barge and Gresham Sand & Gravel. These are identified as the only currently active wells downgradient of RMC.
- **Future Offsite Exposure Point.** At a hypothetical well located in the northeast corner of Fairview Farms, representing high-end concentrations of fluoride in offsite groundwater downgradient of the RMC facility.

The results of the groundwater HHRA, summarized in Table 2-3, indicate that, of the four exposure settings evaluated, only the future offsite residential groundwater use scenario exceeds EPA's target risk level of a hazard quotient greater than 1.0. The estimated future offsite fluoride concentrations also exceed DEQ's target, the MCL of 4 mg/L. All other exposure settings result in risk estimates below regulatory limits.

2.1.2 Ecological Risk Assessment Findings

The ecological risk assessment (ERA) portion of the baseline RA provides an assessment of the potential impacts on wildlife from historical RMC releases to soil, sediment, surface water, and groundwater.

2.1.2.1 Nongroundwater Media ERA Results

For nongroundwater media in combined open water/wetland areas on the RMC site, the total ecological hazard quotients for fluoride (for heron), PAHs (for mink) and PCBs (for heron and mink) exceed corresponding background values by at least 1.0. Company Lake is the highest risk-contributing area of concern for fluoride and PAHs, contributing 86 and 94 percent of the sitewide risk for these COPCs, respectively. For PCBs, more than 99 percent of the sitewide ecological risk is contributed by the south wetlands area. A further evaluation of the home ranges for the mink and heron indicates that, if approximately 250 (for heron) to 336 (for mink) additional acres of offsite habitat exists that is suitable for foraging by these receptors, then it can be concluded that the RMC-related exposures to PCBs and PAHs are not high enough to pose unacceptable risk (ecological HQ >1.0). Evaluation of surrounding areas, including the Sandy River delta and the Columbia River, indicates that this additional habitat for the mink is available The necessary additional acreage for the heron, however, exceeds its home range. For fluoride, the concentrations present at Company Lake pose a potential risk to the heron, and this merits evaluation in this FFS.

For nongroundwater media in the upland areas, only PCBs (for the red-tailed hawk) had a total Tier 2 ecological HQ that exceeded the corresponding background value by at least 1.0. South wetlands is the highest risk-contributing area of concern for PCBs, contributing 78 percent of the sitewide risk for PCBs (calculated prior to the 1999 removal action). A further evaluation of the home range for the hawk indicates that, if approximately 100 additional acres of nearby suitable habitat exists, it can be postulated that the RMC-related exposures to PCBs do not pose unacceptable risk to the hawk. The proximity of the RMC facility to the Sandy and Columbia Rivers, the U.S. Forest Service Sandy River Delta Restoration Project, and Lady Island means that there are several thousand acres of nearby, high-quality habitat. Also, adjacent properties provide usable habitat, such as those along the shorelines of the two rivers and within the unused areas of the RMC property north of the dike. The availability of abundant habitat in these areas makes it unlikely that wildlife will utilize only RMC areas of concern.

On the basis of these ERA results, the COPCs with the highest potential for ecological exposure are fluoride and PAHs (primarily within Company Lake) and PCBs (primarily in south wetlands). The nongroundwater media evaluations of multiple area exposures, habitat suitability, and species home range indicate that the risks posed to wildlife by PCBs are marginal or low. Therefore, remedial action at south wetlands is not warranted. However, the potential risks from fluoride and PAHs at Company Lake are evaluated as part of this FFS.

2.1.2.2 Groundwater ERA Results

The primary ecological assessment endpoint selected for the Columbia and Sandy Rivers is survival and health of fingerling stages of anadromous and resident fish. Of the constituents detected in groundwater, fluoride was determined to be the most important site-related constituent, because of solubility. To assess the potential exposure concentrations in the rivers, calculations were made to estimate the mixing factor experienced by groundwater entering the river, and the resulting fluoride concentrations. The objective of the calculations was to conservatively estimate the feasible in-stream concentrations in the two rivers so that

ecological risk could be evaluated. The magnitude of mixing between groundwater and surface water was calculated as a mixing factor that is a ratio of the sum of groundwater and surface water flows divided by the groundwater flow. This mixing factor was then used with the groundwater fluoride concentrations measured at the temporary Geoprobe locations along the rivers, to estimate the potential in-stream exposure concentration of fluoride. Tables 2-4 and 2-5 summarize the estimated fluoride concentrations in the Columbia and Sandy Rivers.

On the basis of the calculated in-stream fluoride concentrations and available toxicity values, no adverse effect on aquatic organisms is expected under any of the most likely streamflow conditions. An additional comparison of estimated exposure concentrations of nonfluoride constituents with freshwater toxicity benchmarks indicated that all are expected to be well below freshwater toxicity benchmarks and, therefore, well below levels expected to produce an adverse effect to aquatic organisms.

2.2 Applicable or Relevant and Appropriate Requirements

Remedial actions at CERCLA sites must attain, or justify the waiver of, any federal or more stringent state environmental standards, requirements, criteria, or limitations that are determined to be applicable or relevant and appropriate [CERCLA Section 121(d)].

Appendix B contains an evaluation of ARARs that are important in establishing RAOs or in developing remedial action alternatives. The main findings of the ARARs analysis are summarized in this section. An evaluation of ARARs compliance relative to each developed remedial alternative is included in Section 6.

2.2.1 Chemical-Specific ARARs

Chemical-specific requirements are usually promulgated health- or technology/economic-based numerical values or standards that establish the acceptable amount or concentration of a chemical in the ambient environment. Requirements that have been determined to be ARARs for RMC-Troutdale are summarized below.

- Federal MCLs are relevant and appropriate for current or potential sources of drinking water at the site. COPCs for groundwater at RMC-Troutdale and corresponding MCLs are listed in Table 2-6.
- The Toxic Substances Control Act (TSCA) regulates disposal, handling, and cleanup of material contaminated with PCBs at concentrations of generally 50 parts per million (ppm) or greater. PCBs have not been encountered at concentrations that would trigger the applicability of TSCA at the north landfill, the south landfill, the scrap yard, Company Lake, or in sitewide groundwater. TSCA regulations might be applicable if such regulated wastes were encountered during an excavation, depending on the type of material encountered.
- Resource Conservation and Recovery Act (RCRA) hazardous waste handling and disposal requirements govern the management of hazardous wastes from the point of generation through disposal. Hazardous wastes are classified by generation source, as well as by chemical constituents. Consolidation of materials onsite within an area of

concern (AOC) at a CERCLA site is not considered waste generation. Therefore, RCRA is not ARAR to onsite waste consolidation, but it would be applicable to wastes removed from the site.

- The Oregon Environmental Cleanup Law standards at ORS 465.315 and OAR 340-122-040 are applicable to the extent they are more stringent than federal standards in the NCP. Under the Oregon cleanup process, the level of constituents assumed to be protective of human health and the environment is defined as an excess lifetime cancer risk of less than or equal to 10^{-6} for individual carcinogens or 10^{-5} risk for combined carcinogens, and a hazard index of less than or equal to 1.0 for systemic toxicants. The acceptable ecological risk level is the point before significant adverse impacts on populations are expected to occur.

2.2.2 Location-Specific ARARs

Location-specific ARARs are those standards that control actions taken in specific locations. Requirements that have been determined to be ARARs for RMC-Troutdale are summarized below:

- The Sandy River is designated as a recreational and scenic river under the Federal Wild and Scenic Rivers Act (16 USC § 1271 et seq.) and the Oregon Scenic Waterways Act [Oregon Revised Statute (ORS) 390.805 et seq.] This designation would prohibit construction that would have a direct and adverse effect on free-flowing characteristics of a designated river or that would unreasonably diminish the scenic, recreational, and fish and wildlife values present in the river corridor.

- The RMC facility is adjacent to the Columbia River, which is habitat for documented threatened or endangered species, as well as species that are proposed for listing. Requirements for consultation with the U.S. Fish and Wildlife Service and the Oregon Department of Fish and Wildlife would be applicable for response actions that could affect a protected species or its habitat.

- The State Historic Preservation Office has identified the RMC locale as an area with high probability for archaeological sites because of its proximity to the confluence of two rivers. Standards under the National Archaeological and Historic Preservation Act (16 USC § 461 et seq.), Executive Order 11593, implementing regulations and the state statute protecting archaeological sites (ORS 358.905), would be applicable to remedial actions that include construction or excavation located in previously undisturbed areas.

- Federal regulations [40 *Code of Federal Regulations* (CFR) 257.3 and 40 CFR Part 258 Subpart B], as well as state regulations [Oregon Administrative Rule (OAR) 340-95-0030], establish minimal siting criteria for solid waste landfills. These requirements would be applicable to new solid waste land disposal units constructed as part of the remedial action. These requirements may also be relevant and appropriate for in-place containment or closure of areas of concern.

- Encroachments in floodways and floodplains are regulated under state and federal programs, including Executive Order 11988 (40 CFR 6, Appendix A). Conformance with floodplain protection standards may be relevant and appropriate for response actions at

Company Lake or the north landfill that would alter or result in construction within a floodplain.

2.2.3 Action-Specific ARARs

Action-specific ARARs regulate the specific type of action or technology under consideration, or the management of regulated materials.

2.2.3.1 RCRA Solid and Hazardous Waste Management

- RCRA and corresponding state law provide standards for the management of solid and hazardous waste. The regulations are applicable to remedial action activities that result in the generation of waste.
- Under RCRA, the generation of waste is determined by whether the waste would be hazardous or nonhazardous, and whether the waste would be moved outside the AOC. Excavation, processing, and consolidation of waste within the AOC are not considered waste generation.
- EPA has established land disposal restrictions (LDRs) for spent aluminum potliner (K088 waste) in 40 CFR 268.39. The LDRs would be applicable if spent potliner were excavated during remedial activities and moved outside the AOC.
- Substantive RCRA closure standards for land disposal units may be ARARs for remedial actions that involve closure of waste in place, or for remedial actions that involve excavation of areas of concern and disposal in a new onsite landfill. The closure standards apply if the waste is a regulated waste and **either**
  - The waste was initially treated, stored, or disposed of after the effective date of the particular RCRA requirement, **or**
  - The remedial activity constitutes disposal as defined by RCRA.

2.2.3.2 Discharge of Wastewater or Stormwater

- Wastewater generated by remedial activities would be subject to the terms of the RMC-Troutdale NPDES permit, which is currently being renegotiated.
- Discharge of stormwater during construction is regulated by the Clean Water Act and DEQ rules if the remedial action disturbs 5 acres or more.

2.2.3.3 Groundwater

- OWRD regulates the construction, alteration, abandonment, maintenance, and use of water wells and monitoring wells, or other holes through which groundwater can become contaminated.
- OWRD regulates the withdrawal of groundwater through administration of water rights. Extraction of groundwater for remediation would have to be done within RMC's current water rights, or an additional permit would need to be obtained.

2.3 Fate and Transport

Fate and transport is used in conjunction with risk assessment findings and ARARs to develop the RAOs that form the basis for the identification and evaluation of potential remedial actions.

This section focuses on the fate and transport of fluoride in groundwater at the site. Fluoride is the primary COPC in groundwater because of its solubility, distribution, and presence above the MCL. Site COPCs in nongroundwater media also include PAHs and PCBs, which are relatively immobile in the environment.

- Available data indicate that the primary sources of fluoride to the intermediate and deep groundwater zones are the scrap yard and Company Lake. Field data and additional fate and transport analyses presented in the *Draft Groundwater Remedial Investigation Report* (CH2M HILL, June 1999) indicate that fluoride from these two areas has leached into UGS groundwater at levels exceeding the MCL, and that fluoride has migrated to the intermediate and deep zones.

- In contrast, fluoride from the waste at two other soil and debris areas (south landfill and east potliner) has leached into the silt unit and the UGS. The leaching in these areas has not affected the intermediate or deep groundwater zone. Data indicate that the fluoride from north landfill has migrated to the UGS north of the COE dike but not to the intermediate or deep zone.

The principal influences on fluoride transport in site groundwater are the thickness and permeability of the silt unit, where it exists, the RMC production wells, and (to a lesser degree) the ambient groundwater flow patterns. Site data and groundwater flow modeling indicate that fluoride is present in the intermediate and deep zones beneath and downgradient of the scrap yard and Company Lake for two reasons:

- The relative thinning of the silt unit at the scrap yard and its absence at Company Lake

- The creation of strong downward gradients from the UGS into the intermediate and deep zones by pumping from the RMC production wells

The UGS has moderate permeability. The silt unit, which lies above the UGS, is estimated to have vertical permeability approximately one ten-thousandth of that of the UGS and one one-hundred-thousandth of the intermediate and deep zones. Consequently, fluoride is highly mobile in the intermediate and deep zones, much less mobile in the UGS, and relatively immobile in the silt unit.

The degree of immobility of fluoride in the silt unit is demonstrated by the results presented in Section A.7 (in Appendix A). These results indicate that, under existing conditions and without any further action, elevated concentrations of fluoride in the silt unit can be expected to persist for thousands of years because of the low permeability in this zone. Moreover, as explained in Section 4.5 of this FFS, the low permeability of the silt unit also makes it infeasible to remove fluoride mass by pumping in this zone. Therefore, in order to make meaningful distinctions among the remedial actions evaluated in this FFS, the time-to-compliance discussions are focused on the UGS, intermediate, and deep zones. In these zones, feasible actions can make an observable difference within the foreseeable future.

2.4 Remedial Action Objectives

CERCLA [Section 121(d)] states that the general goal of remedial actions is to "attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further release at a minimum, which assures protection of human health and the environment." RAOs are narrative statements describing the desired end result of remedial action. As discussed above, the RAOs developed for RMC-Troutdale are based on the general goals of CERCLA and on the following considerations:

- Risk assessment results
- Compliance with ARARs
- Fate and transport of COPCs

The RAOs, presented in Table 2-7, are organized in three categories: general RAOs, area-specific RAOs, and media-specific RAOs. General RAOs include all media (soil, sediment, and groundwater) and areas (north landfill, south landfill, scrap yard, and Company Lake). Each area-specific RAO targets a specific area, and each media-specific RAO focuses on a single medium (soil, sediment, or groundwater). Metrics to evaluate achievement of each RAO are also provided in the table. Where risk reduction is included in Table 2-7, it represents the difference between the baseline and residual risk estimates.

In Section 4, the RAOs are used as a broad measure to evaluate the effectiveness of potential remedial options for each of the areas of concern and groundwater. The RAOs, along with cost and implementability, are the criteria by which the remedial options are evaluated.

Section 2 Tables

Table 2-1
Human Health Risk Assessment Results Summary

Site	Medium	Potentially Exposed Population	Noncancer Hazard Index RME	Excess Lifetime Cancer Risk Average	Excess Lifetime Cancer Risk RME	Major Excess Lifetime Cancer Risk Contributors (approximate % contribution)
North Landfill	Surface soil	Intermittent Maintenance Worker	0.03	$5x10^{-6}$	$4x10^{-5}$	Benzo(a)pyrene (69%), Dibenz(a,h)anthracene (14%)
		Trench Worker	0.15	$5x10^{-7}$	$7x10^{-5}$	
		Trespasser	0.2	$3x10^{-6}$	$3x10^{-5}$	
South Landfill	Surface soil	Intermittent Maintenance Worker	0.03	$3x10^{-6}$	$3x10^{-5}$	Benzo(a)pyrene (65%), Dibenz(a,h)anthracene (14%)
		Trespasser	0.2	$2x10^{-6}$	$5x10^{-5}$	
	Soil	Future Trench Worker	0.2	$3x10^{-7}$	$1x10^{-4}$	Benzo(a)pyrene (72%), Dibenz(a,h)anthracene (14%)
	Surface water	Trespasser	0.06	ND	ND	
Scrap Yard	Surface soil	Intermittent Maintenance Worker	0.4	$3x10^{-6}$	$1x10^{-4}$	Benzo(a)pyrene (59%), Dibenz(a,h)anthracene (13%), Benzo(b)fluoranthene (13%)
	Soil	Future Trench Worker	0.4	$2x10^{-7}$	$3x10^{-5}$	Benzo(a)pyrene (70%)
Fairview Farms	Surface soil	Future Occupational Worker	0.08	N/C	$3x10^{-6}$	Arsenic (61%)[a], Benzo(a)pyrene (23%)
		Future Residential	0.6	$1x10^{-5}$	$3x10^{-5}$	
	Dredge spoils	Future Occupational Worker	0.06	N/C	$1x10^{-6}$	Arsenic (84%)[a], Total PCBs (13%)
		Future Residential	0.4	$5x10^{-6}$	$1x10^{-5}$	
	Seasonal drainage water	Future Occupational Worker	0.1	ND	ND	
		Future Residential	0.3	ND	ND	
	Berries	Future Residential	0.02	ND	ND	
	Debris piles	Future Occupational Worker	0.07	N/C	$2x10^{-6}$	Arsenic (60%)[a], Benzo(a)pyrene (31%)
		Future Residential	0.6	$9x10^{-6}$	$2x10^{-5}$	
Mineral Oil Spill Area	Surface soil	Future Trench Worker	0.02	N/C	$7x10^{-8}$	
		Future Occupational Worker	0.04	N/C	$6x10^{-7}$	
South Wetlands	Building 97	Future Occupational Worker	0.3	N/C	$7x10^{-6}$	Total PCBs (43%), Arsenic (21%)[a], Benzo(a)pyrene (19%)
	Surface soil--main area	Trespasser	0.6	N/C	$3x10^{-6}$	Total PCBs (36%), Arsenic (26%)[a], Dibenz(a,h)anthracene (14%), Benzo(b)fluoranthene (13%)
	Surface water--main area	Trespasser	0.02	N/C	$5x10^{-9}$	
East Potliner	Surface soil	Intermittent Maintenance Worker	0.02	N/C	$1x10^{-6}$	Arsenic (41%)[a], Benzo(a)pyrene (36%), Dibenz(a,h)anthracene (13%)
		Trespasser	0.03	N/C	$3x10^{-7}$	
Cryolite Ponds	Surface soil	Intermittent Maintenance Worker	0.01	N/C	$9x10^{-8}$	
Company Lake	Surface water	Trespasser	<0.01	ND	ND	
	Sediment	Trespasser	0.4	$2x10^{-6}$	$4x10^{-5}$	Benzo(a)pyrene (71%), Dibenz(a,h)anthracene (10%)
East South Ditch	Surface water	Trespasser	0.03	ND	ND	
	Sediment	Trespasser	0.2	$3x10^{-6}$	$1x10^{-4}$	Benzo(a)pyrene (66%), Dibenz(a,h)anthracene (15%)
East Depression	Surface soil	Trespasser	0.09	N/C	$7x10^{-7}$	
Columbia River	Surface water	Recreational Child	<0.01	N/C	$6x10^{-9}$	
	Sediment	Recreational Child	0.05	N/C	$2x10^{-7}$	
Sandy River	Surface water	Recreational Child	<0.01	ND	ND	
	Sediment	Recreational Child	0.05	ND	$1x10^{-7}$	
Salmon Creek	Surface water	Trespasser	<0.01	N/C	$3x10^{-10}$	
	Sediment	Trespasser	0.07	N/C	$6x10^{-7}$	
East Lake	Surface water	Trespasser	<0.01	ND	ND	
	Sediment	Trespasser	0.1	N/C	$5x10^{-7}$	

Notes:
N/C = Not calculated; the average case risk estimates were calculated only when the RME case estimates exceeded EPA or DEQ thresholds.
ND = Carcinogenic chemicals were not detected.
RME = Reasonable maximum exposure.
[a] Arsenic concentrations are within the range of local background.

Table 2-2
Comparison of Human Health Risk Results with Regulatory Risk Criteria

Area	Exposure Scenario	EPA Target Risk Exceedances for RME		DEQ Target Risk Exceedances for RME			Comments
		Total HI >1.0?	Total ELCR $>10^{-4}$?	Total HI >1.0?	Total ELCR $>10^{-5}$?	Individual Chemicals with ELCR $>10^{-6}$ [a]	
Soil and Debris Areas							
North Landfill	Maintenance Worker	No	No	No	Yes	5 PAHs	Maximum detects used as default
	Trespasser	No	No	No	Yes	5 PAHs	Maximum detects used as default
	Trench Worker	No	No	No	Yes	5 PAHs	Maximum detects used as default
South Landfill	Maintenance Worker	No	No	No	Yes	5 PAHs	Maximum detects used as default
	Trespasser	No	No	No	Yes	5 PAHs	Maximum detects used as default
	Trench Worker	No	No	No	Yes	5 PAHs	Maximum detects used as default
Scrap Yard	Maintenance Worker	No	No	No	Yes	5 PAHs, PCBs	Maximum detects used as default
	Trench Worker	No	No	No	Yes	4 PAHs	Maximum detects used as default
Fairview Farms	Future Occupational	No	No	No	No	None	
	Future Residential	No	No	No	No	2 PAHs, PCBs	Residential unlikely in this area
Mineral Oil Spill Area	Occupational	No	No	No	No	None	
	Trench Worker	No	No	No	No	None	
South Wetlands	Occupational	No	No	No	No	PCBs	Building 97 area only
	Trespasser	No	No	No	No	None	
Completed Early Actions							
Fairview Farms Debris Piles	Future Occupational	No	No	No	No	None	
	Future Residential	No	No	No	No	1 PAH	Residential unlikely in this area
East Potliner	Maintenance Worker	No	No	No	No	None	
	Trespasser	No	No	No	No	None	
Cryolite Ponds	Maintenance Worker	No	No	No	No	None	
Wastewater Discharge Areas							
Company Lake	Trespasser	No	No	No	Yes	4 PAHS	
Depression East of Outfall Ditch	Trespasser	No	No	No	No	None	
East South Ditch	Trespasser	No	No	No	Yes	5 PAHS	Potential matrix interferences
Surface Water and Sediment Areas							
Columbia River	Recreational	No	No	No	No	None	
Sandy River	Recreational	No	No	No	No	None	
Salmon Creek	Trespasser	No	No	No	No	None	
East Lake	Trespasser	No	No	No	No	None	

Notes:
HI = hazard index.
ELCR = excess lifetime cancer risk.
[a] Chemicals exceeding 10^{-6} risk but less than background levels are excluded.

Table 2-3
Summary of Groundwater Risk Estimates for Current and Future Exposure to Groundwater

Exposure Scenario	Exposure Route	Average Exposure		Reasonable Maximum Exposure	
		Noncancer Hazard Index	Excess Lifetime Cancer Risk	Noncancer Hazard Index	Excess Lifetime Cancer Risk
Current Onsite Occupational Worker	Ingestion	N/C	N/C	0.26	N/A
	Dermal	N/C	N/C	0.001	N/A
	Inhalation	N/C	N/C	N/A	N/A
	Total	N/C	N/C	0.26	N/A
Future Onsite Occupational Worker	Ingestion	N/C	N/C	0.34	9×10^{-7}
	Dermal	N/C	N/C	0.002	2×10^{-7}
	Inhalation	N/C	N/C	N/A	5×10^{-6}
	Total	N/C	N/C	0.34	6×10^{-6}
Current Offsite Occupational Worker	Ingestion	N/C	N/C	0.057	N/A
	Dermal	N/C	N/C	0.0003	N/A
	Inhalation	N/C	N/C	N/A	N/A
	Total	N/C	N/C	0.06	N/A
Future Offsite Occupational Worker	Ingestion	N/C	N/C	0.95	N/A
	Dermal	N/C	N/C	0.004	N/A
	Inhalation	N/C	N/C	N/A	N/A
	Total	N/C	N/C	0.95	N/A
Future Offsite Residential	Ingestion	1.8	N/C	3.2	N/A
	Dermal	0.004	N/C	0.007	N/A
	Inhalation	N/A	N/C	N/A	N/A
	Total	**1.8**	N/C	**3.3**	N/A

N/C = Not calculated; the average case risk estimates were calculated only when the RME case estimates exceeded EPA target risk levels [$>10^{-4}$ excess lifetime cancer risk (ELCR); >1.0 hazard index (HI)].

N/A = Exposure is incomplete for this exposure route.

Table 2-4
Estimated Incremental Increase in Fluoride Concentration in the Columbia River, Based on Measured Groundwater Concentrations Adjacent to the River

River Flow Condition	Fluoride Concentration (mg/L) Based on Portion of River Flow Available for Mixing		
	20 Percent	40 Percent	50 Percent
7Q10[1]	0.00005	0.00003	0.00002
Minimum Monthly	0.00004	0.00002	0.00002
Mean Annual	0.00002	0.00001	0.00001

[1] 7Q10 represents the 7-day sustained low flow expected to occur once every 10 years.

Table 2-5
Estimated Incremental Increase in Fluoride Concentration in the Sandy River, Based on Measured Groundwater Concentrations Adjacent to the River

River Flow Condition	Fluoride Concentration (mg/L) Based on Percent of River Flow Available for Mixing		
	10 Percent	25 Percent	50 Percent
7Q10	0.006	0.002	0.001
Minimum Monthly	0.003	0.001	0.0005
Mean Annual	0.0006	0.0002	0.0001

Table 2-6
Relevant and Appropriate MCLs (μg/L)

Inorganics		Volatile Organics	
Arsenic	50	1,1-DCE	7
Beryllium	4	PCE	5
Chromium	100		
Cyanide	200		
Fluoride	4,000		
Lead	15[a]		
Nickel	100[b]		

[a] Action level.
[b] Being remanded.

Table 2-7
Remedial Action Objectives and Metrics

RAOs	Metric
General RAOs	
Reduce exposure of human receptors to COPCs at concentrations that pose unacceptable risk	Residual COPC concentrations applicable to specific exposure scenarios[a]
Reduce exposure of ecological receptors to COPCs at concentrations that pose unacceptable risk	Residual COPC concentrations applicable to specific ecological exposure scenarios
Reduce or control mass loading of fluoride and other COPCs to groundwater in the UGS, intermediate and deep zones.	Fluoride concentrations in UGS, intermediate, and deep zone groundwater[b]
Conduct cost-effective actions that provide overall protection of human and ecological receptors	Cost-benefit analysis
Area-Specific RAOs	
Protect the Columbia River from washout or scour of Company Lake sediments	Qualitative evaluation (Yes/No)
Retain use of Company Lake as an NPDES wastewater treatment pond	Qualitative evaluation (Yes/No)
Retain industrial use of the scrap yard	Qualitative evaluation (Yes/No)
Provide erosion protection for the north landfill waste layer	Qualitative evaluation (Yes/No)
Retain industrial use of the scrap yard	Qualitative evaluation (Yes/No)
Media-Specific RAOs	
Reduce or control offsite migration of fluoride plume and other COPCs in groundwater	Fluoride concentrations in offsite groundwater
Reduce or control mass loading of fluoride and other COPCs in groundwater in the UGS, intermediate, and deep zones.	1) Fluoride concentrations in the UGS, intermediate, and deep zones 2) Size of UGS, intermediate, and deep zone plumes after 5 and 10 years
Restore groundwater to beneficial use criteria	Groundwater quality
Reduce, minimize, or contain loading of fluoride and other COPCs to surface water	Surface water quality

[a] Residual soil fluoride concentrations determined by confirmation sampling for excavation options.
[b] Groundwater fluoride concentrations will serve as a surrogate or indicator of other COPCs.

SECTION 3

Remedial Technology Screening

SECTION 3

Remedial Technology Screening

This section presents general categories of response actions and remedial technologies considered with regard to the RAOs outlined in Section 2.4. The remedial technologies are presented for each area of concern and medium.

3.1 General Response Actions

Response actions can be separated into general categories. The categories of response actions that are being considered at the Troutdale site are summarized in Table 3-1. The general response actions are further subdivided into remedial technologies in Section 3.2.

3.2 Remedial Technology Screening

A number of remedial technologies were considered and screened as part of the early action process for RMC-Troutdale. Because those technologies represent a full range of remedial actions for each area of concern and medium, they were retained for this FFS. The technologies considered under the early action process were evaluated according to the following criteria:

- Must be robust
- Must be well proven
- Must be easily implemented
- Must be able to act as a permanent action

Tables 3-2 through 3-4 present the range of remedial technologies considered for each medium or area of concern as a subset of each general response action category. The check marks indicate the areas for which each technology was considered during the evaluation of potential early actions. Remedial technologies that were eliminated from further consideration for a given area are shaded. The remaining technologies were considered potentially appropriate for the RMC site, following evaluation by the criteria listed above. The remedial options presented and evaluated in Section 4 of this FFS were developed by selecting appropriate technologies from these tables.

Table 3-2 presents the remedial technologies considered for soil (including waste material and debris). Table 3-3 presents the general response actions and remedial technologies for surface water and sediment at Company Lake. Table 3-4 lists the remedial technologies considered for groundwater. Groundwater actions were generally evaluated on a sitewide basis, rather than by area of concern. Technologies such as extraction were evaluated for targeted areas.

Section 3 Tables

Table 3-1
General Response Action Categories for RMC-Troutdale

General Response Action	Description
No Action	No action is evaluated as a baseline scenario for comparison with other response actions, as required by the NCP.
Institutional Controls	Institutional controls (access and use restrictions, deed restrictions) are used to prevent receptor exposure to COPCs.
Containment	Containment actions are intended to limit the horizontal or vertical migration of COPCs and to eliminate receptor exposure to COPCs.
Removal	Removal of affected media (soil, debris, sediment, groundwater, or surface water) by various methods (depending on media and area of concern).
Treatment	Treatment through physical or chemical means via in situ or ex situ technologies that address COPCs at various areas of concern and media.
Disposal	Onsite or offsite disposal of affected media that have been removed from areas of concern.

Table 3-2
Remedial Technologies for Soil at RMC-Troutdale

General Response Action	Remedial Technology	North Landfill	South Landfill	Scrap Yard
No Action	None	✓	✓	✓
Institutional Controls	Industrial control of property	✓	✓	✓
	Access restrictions	✓	✓	✓
	Use restrictions for workers		✓	✓
	Fencing/signage	✓	✓	✓
	Deed restrictions	✓	✓	✓
Containment	Stabilization with cement, flyash, lime, gypsum, or combination/cap	✓	✓	✓
	Capping			
	- Asphaltic concrete	✓	✓	✓
	- Polymer asphalt membrane cap	✓	✓	✓
	- Shotcrete cap	✓		
	- Geotextile/soil cap	✓	✓	✓
	- Gravel/riprap cap	✓		✓
	- Multilayer impermeable cap (flexible membrane liner combination)	✓	✓	✓
	Vertical barriers			
	- Sheet pile	✓	✓	✓
	- Slurry wall	✓	✓	✓
	- Grout curtain	✓	✓	✓
	Horizontal barriers			
	- Grout injection/jet grout	✓	✓	✓
	- Deep soil mixing	✓	✓	✓
	Surface controls			
	- Grading	✓	✓	✓

Table 3-2, continued
Remedial Technologies for Soil at RMC-Troutdale

General Response Action	Remedial Technology	North Landfill	South Landfill	Scrap Yard
Containment (continued)	- Revegetation	✓	✓	✓
	- Stormwater diversion/collection	✓	✓	✓
Removal	Excavation of waste	✓	✓	✓
Disposal	Offsite disposal			
	- Subtitle C	✓	✓	✓
	- Subtitle D	✓	✓	✓
	- Toxic Substances Control Act (TSCA)	✓	✓	✓
	Onsite landfill	✓	✓	✓
Treatment	Solidification			
	- In situ (lime, cement, gypsum)	✓	✓	✓
	- Ex situ (excavate, process, treat, and place back onsite south of dike)	✓	✓	✓
	In situ/ex situ bioremediation (PAHs, PCBs)	✓	✓	✓
	Incineration (PAHs, PCBs)	✓	✓	✓
	Thermal desorption (SVOCs)	✓	✓	✓
	Soil washing/flushing			
	- In situ	✓	✓	✓
	- Ex situ with placement back into area of concern	✓	✓	✓

Note: Shaded boxes represent remedial technologies that were eliminated from consideration in the options presented in Section 4.

Table 3-3
Remedial Technologies for Surface Water and Sediment at Company Lake

Medium	General Response Action	Remedial Technology	Company Lake
Surface Water	No Action	None	✓
	Institutional Controls	Monitoring	✓
		Access restrictions	✓
		Deed restrictions	✓
	Containment	Not applicable	
	Removal/Disposal	Not applicable	
	Treatment/Disposal	NPDES-outside scope of FFS	
Sediment	No Action	None	✓
	Institutional Controls	Monitoring	✓
		Access restrictions	✓
		Fencing	✓
		Signage	✓
		Deed restrictions	✓
	Containment	Capping	
		- Sand	✓
		- Geotextile/sand	✓
		- Geotextile/gravel	✓
		- Geomembrane/sand	✓
		Vertical barrier	✓
	Removal/Disposal	Dredge process residue and/or sediment	✓
		Offsite disposal	
		-Subtitle D	✓

Table 3-3, continued
Remedial Technologies for Surface Water and Sediment at Company Lake

Medium	General Response Action	Remedial Technology	Company Lake
Sediment, continued		Placement in monocell	✓
		Onsite landfill	✓
	Treatment/Disposal	Solidification	
		-In situ	✓
		-Ex situ	
		Solidification with cap	✓
		In situ bioremediation (limnofix)	✓
		Ex situ bioremediation	✓
		Incineration	✓
		Thermal desorption	✓
		Soil washing (brick only)	✓
		Slurry reactor	✓

Note: Shaded boxes represent remedial technologies that were eliminated from consideration in options presented in Section 4.

Table 3-4
Remedial Technologies for Groundwater at RMC-Troutdale

General Response Action	Remedial Technology	Groundwater
No Action	None	✓
Institutional Controls	Monitoring	✓
	Deed restrictions	✓
	Property acquisition	✓
	Provision of alternate water supply	✓
Containment	Passive drain systems—barrier/underdrains (see Appendix H for discussion of silt drains)	✓
	Phytoremediation (for dewatering, some fluoride removal)	✓
	Focused extraction wells—hydraulic containment in areas of concern	✓
	Production well decommissioning—remove potential preferential flow paths for constituent migration	✓
	Production well operation—adjust operation to establish hydraulic containment	✓
	West perimeter injection wells—create a hydraulic divide to reduce offsite constituent migration	✓
Removal/Disposal	Passive drain systems—barrier/underdrains	✓
	Production well operation—mass removal in the intermediate and deep zones	✓
	Focused extraction wells/well points—mass removal at areas of concern in the silt unit, UGS, and intermediate zones	✓
Treatment/Disposal	Ex situ: physical treatment (various)	✓
	Ex situ: chemical treatment (calcium chloride, fluorapatite, granular-activated alumina, activated carbon, reverse osmosis, air stripping VOCs, green sand filter, thiol ion exchange for metals)	✓
	In situ chemical treatment (gypsum or lime)	✓
	Treatment wall (physical/chemical)	✓
	Natural attenuation	✓

Note: Shaded boxes represent remedial technologies that were eliminated from consideration in the options presented in Section 4.

SECTION 4

Remedial Options Evaluation

SECTION 4

Remedial Options Evaluation

The remedial technologies retained from Section 3 have been combined into remedial options for each area of concern and for groundwater. This section evaluates these remedial options on the basis of effectiveness and cost. The remedial technologies retained from Section 3 are all robust, well-proven, and readily implementable. For this reason, no further discussion of implementability is provided for the evaluation of remedial options in this section. A discussion of implementability is included in the detailed evaluation of remedial alternatives (Section 6). The most suitable remedial options identified in this section are assembled into sitewide remedial alternatives in Section 5.

The **effectiveness** of each remedial option for achieving the RAOs presented in Section 2.4 is evaluated in this section. Area-specific remedial goals are provided as benchmarks in determining whether the remedial options meet the remedial action objectives (RAOs).[1] Risk reduction goals are also presented. The risk-based RAOs and goals pertain only to pathways exceeding acceptable risk levels in the baseline risk assessment. In evaluating the effect of remedial actions on groundwater, fluoride is used as an indicator of effectiveness because it is the most prevalent COPC in groundwater. With very few exceptions, all other COPCs are co-located with fluoride.

The **cost** estimates discussed in this section were developed during the early action decisionmaking process and have been refined for incorporation in the FFS. They represent a somewhat greater degree of depth and detail than generally prepared for a feasibility study. Nevertheless, cost estimates should be considered order of magnitude, providing relative estimates of cost for comparative evaluation of options. Appendixes C and D contain supporting documentation and discussion of the cost estimates.

An evaluation of remedial options is presented in Sections 4.1 through 4.4 for the individual areas of concern and in Section 4.5 for groundwater.

The No Action Option serves as a basis for comparative evaluation of the remedial options for each area of concern and for groundwater. The No Action Option has not been assigned a number. The other remedial options for each area of concern or medium have been assigned names by the following convention:

- North Landfill: Options NLF-1 through NLF-5
- South Landfill: Options SLF-1 through SLF-5
- Scrap Yard: Options SY-1 through SY-4
- Company Lake: Options CL-1 through CL-3
- Sitewide Groundwater: Options GW-1 through GW-4

[1] In accordance with EPA usage, "remedial goals" in this document are subsets of "objectives."

4.1 North Landfill

4.1.1 RAOs for North Landfill

Remedial options for the north landfill are evaluated in this section for their effectiveness in meeting the RAOs presented in Table 4-1.

The baseline human health risk assessment for nongroundwater media concluded that none of the RME-case risk estimates for any exposure scenario exceed EPA target risk criteria at north landfill. DEQ target risk criteria, however, are exceeded. The primary risk contributors at the north landfill are PAHs in surface and subsurface soils, and nearly all the risk is attributable to the eastern portion of the site. The RME-case excess lifetime cancer risk (ELCR) estimates are as follows:

- Trespasser: 7×10^{-5}
- Intermittent maintenance worker: 4×10^{-5}
- Trench worker: 7×10^{-5}
- For individual carcinogens, 5 PAHs exceed the DEQ target risk criterion of 1×10^{-6}

In order to meet DEQ human health target risk criteria for the RME case, the following reductions in direct contact exposure to soil COPCs must be achieved:

- 86 percent for an intermittent maintenance worker
- 67 percent for a trespasser
- 86 percent for a trench worker

The baseline ecological risk assessment concluded that ecological risks (based on Tier 2 ecological hazard quotients) posed by the north landfill do not exceed threshold criteria; therefore, reduction of ecological risk is not considered an RAO for the north landfill.

Constituents, primarily fluoride, appear to have migrated from the north landfill to UGS groundwater (note: the silt unit does not exist north of the dike). Prevailing groundwater flow directions are to the north-northeast from the landfill to the Columbia and Sandy Rivers. Groundwater flow model evaluations indicate that, due to upward vertical gradients in the area, constituents in the UGS do not migrate to the intermediate and deep zones. Only a small area of the UGS downgradient of the north landfill is affected by fluoride. Within a short distance downgradient of the landfill, fluoride concentrations in the UGS drop below the MCL. Evaluations of groundwater discharge to the rivers indicate that fluoride in shallow groundwater north of the dike is not causing a measurable effect on surface water in the Columbia or Sandy Rivers.

The remedial goal for shallow groundwater in the vicinity of the north landfill is to meet aquatic protection criteria at the Columbia and Sandy Rivers. Due to present and anticipated zoning restrictions, and the location within the 10-year floodplain, a future groundwater user in the area of the north landfill is highly unlikely. Groundwater north of the COE dike is discussed further in Section 4.5, and its potential effect on the rivers is discussed in Section 1.

4.1.2 Evaluation of Options for the North Landfill

Table 4-2 summarizes the options for north landfill, lists the advantages and disadvantages of each, and presents the costs associated with each option. Figure 4-1 shows the area addressed by these options.

4.1.3 Remedial Options Retained for the North Landfill

Three north landfill options have been retained for further consideration in the sitewide remedial alternatives described in Section 5:

- No Action
- Option NLF-2: Permeable Riprap Cover
- Option NLF-4: Excavation of the Waste Layer

The No Action Option does not meet all the RAOs for the north landfill, but it is retained (as required by the NCP) to serve as a basis for comparison with other options.

Option NLF-2 attains all of the defined RAOs. The permeable riprap cover reduces human health risk by eliminating the direct surface contact exposure pathway for the trespasser and maintenance worker scenarios. Human health risks to future trench workers are reduced by the required use of level D PPE for all trenching activities at the north landfill. The permeable riprap cover does not provide any reduction in the mass loading of fluoride and other COPCs to groundwater; deed restrictions prohibiting groundwater use would be required. However, the north landfill affects groundwater in only a limited area north of the COE dike, and does not pose unacceptable ecological risk at the rivers. Human receptors are unlikely due to zoning restrictions and the floodplain, as discussed above. Deed restrictions prohibiting subsurface construction within the north landfill would also be required.

Option NLF-4 meets all of the RAOs, but at a higher cost. Human health risks are reduced for the trespasser, maintenance worker, and trench worker scenarios by the removal of the waste layer, placement of clean backfill, and the requirement for level D PPE for trench workers. Deed restrictions prohibiting groundwater use would be required until COPC concentrations in groundwater were reduced to MCLs. Option NLF-4 reduces mass loading of fluoride and other COPCs to groundwater through waste removal. However, this benefit to groundwater does not significantly reduce risk, since groundwater in the vicinity of the north landfill is not adversely affecting the river or posing a risk to human receptors. Erosion of the waste layer in an extreme flood event is eliminated by excavation.

The following north landfill remedial options were not retained for further consideration in sitewide remedial alternatives:

- Option NLF-1—Institutional controls
- Option NLF-3—Multilayer low-permeability cap
- Option NLF-5—Excavation of waste layer and surficial sand

Although institutional controls in NLF-1 are effective in reducing human direct contact exposure, they do not meet the other RAOs listed in Table 4-1. Option NLF-1 does not reduce mass loading of fluoride and other COPCs to groundwater and does not prevent erosion of the waste layer at north landfill in an extreme flood event.

Option NLF-3, the multilayer, low-permeability cap with a riprap cover, does not provide a significant reduction in mass loading of fluoride and other COPCs to groundwater due to the high seasonal water table. Option NLF-3 is effectively equivalent to Option NLF-2 (riprap cover) but is significantly more costly.

Option NLF-5, excavation of the waste layer plus 2 feet of the surficial sand unit, is significantly more costly than Option NLF-4 , and provides only a marginal increase in risk reduction for the trench worker scenario, which is a highly unlikely exposure. Removal of a portion of the underlying sand results in a reduction in the mass loading of fluoride and other COPCs to groundwater. However, groundwater in the vicinity of the north landfill is affected in only a limited area and is not presenting a risk to the river or to human receptors. Like NLF-3 and 4, NLF-5 provides protection from loading of constituents to the river during an extreme flood event.

4.2 South Landfill

4.2.1 RAOs for the South Landfill

The remedial options for the south landfill are evaluated in this section against the RAOs presented in Table 4-3.

The baseline human health risk assessment for nongroundwater media at the south landfill concluded that none of the RME-case risk estimates for any exposure scenario exceed EPA target risk criteria. DEQ target risk criteria, however, are exceeded for each exposure scenario. The primary risk contributors at the south landfill are PAHs in surface and subsurface soils. The baseline RME-case ELCR estimates for surface and subsurface soils are as follows:

- Intermittent maintenance worker: 3×10^{-5}
- Trespasser: 5×10^{-5}
- Trench worker: 1×10^{-4}
- For individual carcinogens, 5 PAHs exceed the DEQ target risk criterion of 1×10^{-6}

In order to meet DEQ human health target risk criteria for the RME case, the following reductions in direct contact exposure to soil COPCs must be achieved:

- 67 percent for the intermittent maintenance worker scenario
- 80 percent for the trespasser scenario
- 90 percent for the trench worker scenario

The baseline ecological risk assessment concluded that ecological risks (based on Tier 2 ecological hazard quotients) posed by the south landfill do not exceed the required threshold criteria; therefore, reduction of ecological risk is not considered an RAO for the south landfill.

Constituents, primarily fluoride, have migrated from the south landfill to silt zone groundwater. Low soil permeability in the silt unit limits the ability of constituents to migrate to the underlying groundwater zones. Available data indicate that the south landfill is not a significant source of constituent migration to the UGS, intermediate, and deep groundwater zones.

The remedial goal for groundwater in the vicinity of the south landfill is to achieve compliance with the MCLs in the UGS, intermediate, and deep zones. UGS groundwater at the south landfill exceeds the MCL but only in a limited area and there is no evidence of downgradient fluoride migration to either the intermediate or deep groundwater zones.

4.2.2 Evaluation of Options for the South Landfill

Table 4-4 summarizes the options for the south landfill, lists the advantages and disadvantages of each, and presents the costs associated with each option. Figure 4-2 shows the area addressed by these options.

4.2.3 Remedial Options Retained for the South Landfill

Four south landfill options have been retained for further consideration in the sitewide remedial alternatives described in Section 5:

- No Action
- Option SLF-1: Institutional Controls
- Option SLF-2: Soil and Vegetation Cap
- Option SLF-4: Excavation of the Waste Layer

The No Action Option does not meet the RAOs for the south landfill but is retained, as required by the NCP, to serve as a basis for comparison with other options.

Option SLF-1 reduces human health risk by restricting access to and use of the area, thus reducing the direct surface contact exposure pathway for the trespasser and maintenance worker scenarios. Institutional controls for this option would include deed restrictions prohibiting use of groundwater until MCLs are attained. Institutional controls do not reduce mass loading of fluoride and other COPCs to groundwater. However, it appears that concentrations of fluoride currently leaching from the landfill are lower than concentrations that leached in the past. This is suggested by the detection of higher fluoride concentrations in the silt unit approximately 10 to 15 feet below the waste layer. While the UGS groundwater at the south landfill has been affected by fluoride in the silt layer, the area is not a significant source of fluoride or other COPCs to the intermediate and deep groundwater zones. Groundwater issues at the south landfill could also be addressed directly by groundwater actions retained in the sitewide remedial alternatives. Restrictions on subsurface construction and industrial use would also be required. Human health risk is reduced for the trench worker scenario through the requirement of level D PPE for all trenching activities at the south landfill.

The soil and vegetation cap in Option SLF-2 attains many of the defined RAOs at a low cost. The cap provides a reduction in human exposure to COPCs at the south landfill by eliminating the direct surface contact pathway. The cap does not significantly reduce mass loading of fluoride and other COPCs to groundwater. However, as discussed above, while the UGS groundwater at the south landfill has been affected by fluoride in the silt layer, the area is not a significant source of fluoride or other COPCs to the intermediate and deep groundwater zones. Groundwater issues at the south landfill could also be addressed directly by groundwater actions retained in the sitewide remedial alternatives.

Option SLF-4, excavation of the waste layer, meets nearly all of the RAOs, at a higher cost. Removal of the waste layer provides a reduction in human exposure to COPCs, as well as reducing mass loading of fluoride and other COPCs to groundwater. Excavation does not provide significant risk reduction compared with the institutional control or capping options. South landfill is not a significant source of fluoride and other COPCs to the intermediate and deep groundwater zones.

Two south landfill options were eliminated from further consideration in sitewide remedial alternatives:

- Option SLF-3—Multilayer low-permeability cap
- Option SLF-5—Excavation of waste layer and surficial sand

Option SLF-3, the multilayer, low-permeability cap, does not significantly reduce mass loading of fluoride and other COPCs to groundwater because of the high seasonal water table. Option SLF-3 is effectively equivalent to Option SLF-2 (permeable cap) but is significantly more costly.

Option SLF-5, excavation of the waste layer plus 2 feet of the surficial sand unit, is significantly more costly than Option SLF-4 (excavation of the waste layer). The estimated mass of fluoride present in an 8-foot-thick layer of sand below the waste is less than one-fifth the estimated mass of fluoride in the waste material. As discussed in Section 1, the silt unit below the south landfill is thicker and less permeable than it is at the scrap yard, resulting in minimal mass loading of fluoride or other COPCs from the silt unit to the UGS, intermediate, or deep zone groundwater. Therefore, SLF-5 provides only a marginal or negligible increase in reduction of risk and mass loading of fluoride and other COPCs to groundwater, compared with SLF-4.

4.3 Scrap Yard

The remedial options for the scrap yard are evaluated against the RAOs and presented in Table 4-5.

The baseline human health risk assessment for nongroundwater media at the scrap yard concluded that none of the RME-case risk estimates for any exposure scenario exceed EPA target risk criteria. DEQ target risk criteria, however, are exceeded for each exposure scenario. The primary risk contributors at the scrap yard are PAHs and PCBs in surface soils, and PAHs in subsurface soils. The RME-case ELCR estimates are as follows:

- 1×10^{-4} for an intermittent maintenance worker
- 3×10^{-5} for a trench worker
- For individual carcinogens, PCBs and 5 PAHs exceed the DEQ target risk criterion of 1×10^{-6}

In order to meet DEQ human health target risk criteria for the RME-case, the following reductions in total exposure to soil COPCs must be achieved:

- 90 percent for the intermittent maintenance worker scenario
- 67 percent for the trench worker scenario

Ecological risk was not evaluated for the scrap yard because it is inside the plant fence.

Constituents, primarily fluoride, have migrated from the scrap yard to shallow groundwater. Plume mapping completed as part of the groundwater RI depicts downward constituent migration from the scrap yard to the intermediate and deep zones. Groundwater flow modeling indicates that pumping of the production wells is the primary cause of fluoride migration from the scrap yard.

The remedial goal for groundwater in the vicinity of the scrap yard is to achieve compliance with the MCLs in the UGS, intermediate, and deep zones. Due to significant constituent migration from the scrap yard, groundwater action in this area is evaluated as part of the sitewide groundwater options discussed in Section 4.5.

4.3.2 Evaluation of Options for the Scrap Yard

Table 4-6 summarizes the options for the scrap yard, lists the advantages and disadvantages of each, and presents the costs associated with each option. Figure 4-2 shows the area addressed by these options.

4.3.3 Remedial Options Retained for the Scrap Yard

Four scrap yard options have been retained for further consideration in sitewide remedial alternatives:

- No Action
- Option SY-1: Institutional controls
- Option SY-2: Permeable gravel cap over the north area
- Option SY-3: Excavation of the north area waste layer

The No Action Option does not meet the RAOs defined, but it is retained (as required by the NCP) to serve as a basis of comparison with other options.

The institutional controls option, SY-1, reduces human health risk by restricting access and industrial use of the area, thus reducing direct-contact exposure to COPCs in surface soils. Some minor disruptions (use restrictions and required use of personal protective equipment) will result from the implementation of this option. Deed restrictions would be required to prohibit groundwater use where MCLs are exceeded. Groundwater issues at the scrap yard could also be addressed directly by groundwater actions retained in the sitewide remedial alternatives.

The gravel cap in Option SY-2 attains many of the defined RAOs at a low cost. The cap provides a reduction in human exposure to COPCs at the scrap yard by eliminating direct surface contact to COPCs in the north area of the scrap yard. Institutional controls and use restrictions would be required to achieve risk reduction in the south area of the scrap yard. The cap also preserves future industrial use of the area. It does not reduce mass loading of COPCs to groundwater. Deed restrictions would be required to prohibit groundwater use where MCLs are exceeded. Groundwater issues at the scrap yard could also be addressed directly by groundwater actions retained in the sitewide remedial alternatives.

Option SY-3, excavation of the waste layer in the north scrap yard area, meets most of the RAOs at a moderate cost. It provides a reduction in human exposure to COPCs detected in

the north area of the scrap yard, as well as significantly reducing further mass loading of COPCs to groundwater. Institutional controls and use restrictions would be required to achieve risk reduction in the south area of the scrap yard. Industrial use of the area is retained under this option. Deed restrictions would be required to prohibit groundwater use until MCLs are met. Groundwater issues at the scrap yard may also be addressed directly by groundwater actions retained in the sitewide remedial alternatives.

Option SY-4, excavation of the waste layer in the north area and of selected areas of the underlying surficial sand in the north area, is not retained for further consideration in the sitewide remedial alternatives. Option SY-4 is significantly more costly than Option SY-3, and it provides only a marginal increase in risk reduction. Option SY-4 would provide an additional reduction in mass loading of fluoride and other COPCs to groundwater; however, the amount of materials that must be removed to achieve the additional reduction (approximately four times the volume removed in Option SY-3) is cost prohibitive.

4.4 Company Lake

4.4.1 RAOs for Company Lake

The remedial options for Company Lake are evaluated against the RAOs presented in Table 4-7.

The baseline human health risk assessment for nongroundwater media at Company Lake concluded that none of the RME-case risk estimates for any exposure scenarios exceed EPA target risk criteria. DEQ target risk criteria, however, are exceeded for sediment in the trespasser scenario. The primary risk contributors at Company Lake are PAHs in sediment. The RME-case ELCR estimate for a trespasser is 4×10^{-5}. RME-case risk estimates for individual carcinogens (4 PAHs) exceed the DEQ target risk criterion of 1×10^{-6}.

In order to meet DEQ human health target risk criteria for the RME case, a 75 percent reduction in total exposure to sediment COPCs must be achieved for the trespasser scenario.

The baseline ecological risk assessment for nongroundwater media concluded that, for open water/wetland areas, the total Tier 2 ecological HQs for fluoride (for mallard and heron) and PAHs (for mink) exceed corresponding background levels by at least 1.0. Company Lake contributes 86 percent of the sitewide fluoride risk and 94 percent of the sitewide risk for PAHs. Based on the Tier 2 ERA, Company Lake-related ecological exposure to fluoride for the great blue heron may pose unacceptable risk, even when available offsite habitat is considered. Consideration of available offsite habitat for the mallard and mink reduces the significance of the onsite risk.

Groundwater both north and south of Company Lake has been affected by the leaching of constituents from the process residue. Leaching estimates indicate that Company Lake is the primary source of fluoride to groundwater surrounding the lake. Elevated fluoride concentrations in the UGS north of Company Lake migrate north and northwest to the Columbia River. Evaluations of groundwater discharge to the river indicate that this fluoride does not have a measurable effect on surface water quality in the river. Groundwater flow modeling results, supported by field data, indicate that production well pump-

ing has caused a southerly migration of fluoride from Company Lake to the intermediate and deep zone groundwater.

The remedial goal for groundwater in the vicinity of Company Lake is to achieve compliance with the MCLs in the UGS, intermediate, and deep zones. Due to significant constituent migration from Company Lake, groundwater action in this area is evaluated as part of the sitewide groundwater options discussed in Section 4.5.

4.4.2 Evaluation of Remedial Options for Company Lake

Table 4-8 summarizes the options for Company Lake, lists the advantages and disadvantages of each, and presents the costs associated with each option. Figure 4-5 shows the area addressed by these options.

4.4.3 Remedial Options Retained for Company Lake

All four Company Lake options have been retained for further consideration in the sitewide remedial alternatives described in Section 5:

- No Action
- Option CL-1: Institutional Controls
- Option CL-2: Permeable Cap
- Option CL-3: Dredge Process Residue

The No Action Option does not meet the RAOs defined for Company Lake but is retained as required by the NCP.

The institutional controls in Option CL-1 provide a human health risk reduction to COPCs by restricting access to and use of the area, thus reducing direct exposure. Deed restrictions would also be required to prohibit groundwater use where MCLs are exceeded. This option does not attain all the RAOs, since it does not address ecological exposure or actively address groundwater. Groundwater issues could be addressed by groundwater actions retained in the sitewide remedial alternatives.

Option CL-2 attains some of the defined RAOs at a moderate cost. The permeable cap provides a reduction in human and ecological exposure to COPCs at Company Lake by eliminating direct contact with process residue. The cap does not reduce mass loading of COPCs to groundwater. Groundwater issues could be addressed by groundwater actions retained in the sitewide remedial alternatives.

Option CL-3, dredging the process residue, meets all of the RAOs, although at a higher cost. Removal of the process residue reduces human and ecological exposure to the highest concentrations of COPCs, as well as minimizing further mass loading of COPCs to groundwater and significantly improving groundwater cleanup times for the contaminant plume surrounding the lake. This option would require implementation of deed restrictions prohibiting groundwater use until COPC concentrations are reduced below MCLs.

4.5 Sitewide Groundwater

4.5.1 RAOs for Sitewide Groundwater

The remedial actions for sitewide groundwater are evaluated against the RAOs presented in Table 4-9.

The baseline risk assessment evaluated five exposure scenarios, as shown in Table 4-10. Of the five, only the future potential offsite use of groundwater as drinking water (for occupational and residential scenarios) exceed EPA's target risk criteria of a hazard quotient greater than 1.0. These exposure scenarios also exceed the MCL for fluoride (4 mg/L). All the other exposure settings result in risk estimates below both EPA and DEQ regulatory limits.

4.5.2 Evaluation of Remedial Options for Sitewide Groundwater

Table 4-11 summarizes the options for sitewide groundwater, lists the advantages and disadvantages of each, and presents the costs associated with each option. The following paragraphs provide additional explanation of Options GW-1 through GW-4.

4.5.2.1 Option GW-1: Production Well Optimization

Production well optimization (PWO) is the process of managing production well pumping schedules in a manner that provides for the plant's water supply needs while preventing offsite migration of fluoride present in the intermediate and deep zones. Under this option, the plant's water supply needs are met by operating production wells PW07 and PW08 (see Figure 4-6). Dredging Company Lake or excavating the waste layer of the scrap yard would enhance the effectiveness of this option by eliminating or reducing the primary sources of constituents to groundwater.

Analyses indicate that PW07 and PW08 would need to operate at a minimum pumping rate of 600 gpm each (for a total of 1,200 gpm) in order to provide onsite containment of the south plant intermediate and deep zone fluoride plume, and critical portions of the UGS. The portions of the fluoride plume captured in the UGS by pumping at this minimum rate are in the western two-thirds of the scrap yard and in the area between the production wells and the southern and eastern perimeters of Company Lake (see Figure A-9 in Appendix A of this report). This is the area of the UGS that has been identified as the primary source of COPCs migrating to the intermediate and deep zone groundwater.

The normal, long-term pumping rate for the production wells when the plant is in full operation is on the order of 1,800 gallons per minute (gpm). At this higher pumping rate, the production wells provide additional containment. At a pumping rate of 1,800 gpm, PWO will prevent offsite migration of the south plant plume in the intermediate and deep zones, as well as provide capture of the fluoride plume in the UGS and intermediate zone at the scrap yard, the UGS at the south landfill and east potliner, and the fluoride migrating from the southern and eastern perimeters of Company Lake. PWO is discussed in greater detail in Appendix A.

If plant demand drops below the minimum rate necessary to contain the plume, pumping will be maintained at the minimum rate until fluoride concentrations drop below the MCL

in the portion of the intermediate and deep zones lying between the production wells and the scrap yard. In this event, excess water (beyond process needs) would be discharged to Company Lake.

GW-1 alone does not reduce the mass loading of fluoride or other COPCs to groundwater in the UGS. Consequently, on its own, GW-1 has no effect on reducing future offsite risk or restoring groundwater to MCLs anywhere on the plant site (see Appendix A, Table A-1). GW-1 in combination with Company Lake dredging is, however, expected to result in achievement of MCLs in as little as 15 years for much of the area surrounding Company Lake; the time to MCL achievement in the intermediate and deep zones southwest of Company Lake is estimated to be 50 to 100 years. GW-1 has no effect on times to achievement of the MCLs in the south plant area. Deed restrictions would be required in certain areas to prohibit the use of groundwater exceeding the MCLs.

4.5.2.2 Option GW-2: Production Well Optimization with Focused Extraction

Option GW-2 builds on the PWO (Option GW-1) by adding a focused extraction system, including two UGS extraction wells. One extraction well is located along the north side of the scrap yard, the other in the western portion of the east potliner area (see Figure 4-7). Each well is pumped at a rate of 20 gpm. The purpose of the two extraction wells is to intercept the plume of fluoride that is migrating from the UGS to the intermediate and deep zones under the influence of the production wells. The extraction wells provide mass removal, limit or prevent migration of COPCs from the UGS in the scrap yard and east potliner area, and provide a measure of protection to the water quality of the production wells. Dredging Company Lake or excavating the waste layer of the scrap yard would enhance the effectiveness of this option by eliminating or reducing the primary sources of constituents to groundwater.

The extracted groundwater from the two UGS focused extraction wells is conveyed to the wet electrostatic precipitator (ESP) for use as makeup water. The 40 gpm of extracted groundwater replaces 40 gpm of production well water currently used for ESP makeup water. The ESP bleed stream is directed to the plant wastewater treatment system (WWTS) for removal of fluoride by calcium fluoride precipitation. The treated wastewater is directed to South Ditch, where it is pumped to Company Lake for final equalization, polishing, and discharge into the Columbia River through the NPDES outfall (see Figure 4-8). In the event of a long-term shutdown of the ESP system, the potential need for alternative treatment would be evaluated.

The current production well water used as makeup water to the ESP contains less than 2 mg/L fluoride. The UGS makeup water in this option contains approximately 75 mg/L fluoride. At 75 mg/L and 40 gpm, the UGS makeup water would contribute 36 pounds of fluoride per day. This fluoride in the makeup water would increase the total pounds and concentration of fluoride entering the WWTS. It is not known whether the current operation of the WWTS would maintain the current effluent fluoride concentration. It is assumed that the current effluent concentration and flow rate could be maintained, and that no increase in fluoride discharge would occur.

By itself, GW-2 does not reduce the mass loading of fluoride or other COPCs to groundwater in the UGS. Consequently, in the area surrounding Company Lake, GW-2 alone has

no effect on reducing future offsite risk or restoring groundwater to MCLs (see Appendix A, Table A-1). GW-2 in combination with Company Lake dredging is expected to result in achievement of MCLs in as little as 15 years for much of the area surrounding Company Lake; the time to MCL achievement in the intermediate and deep zones southwest of Company Lake is estimated to be 50 to 100 years. GW-2 reduces the time to achievement of MCLs in the south plant area to 10 years. Deed restrictions would be required in certain areas to prohibit the use of groundwater exceeding MCLs.

4.5.2.3 Option GW-3: Production Well Optimization with Enhanced Focused Extraction

Option GW-3 builds on the components of GW-2 by adding additional focused extraction at the south landfill and southwest of Company Lake. The purpose of GW-3 is to provide onsite containment of COPCs in the intermediate and deep groundwater using PWO, to contain and restore groundwater quality in the southwest corner of Company Lake and the northeast corner of Fairview Farms using focused extraction, and to contain COPCs in the UGS beneath the scrap yard, east potliner, and south landfill using focused extraction. Dredging Company Lake or excavating the waste layer of the scrap yard would enhance the effectiveness of this option by eliminating or reducing the primary sources of constituents to groundwater.

Groundwater extracted from the three focused extraction wells southwest of Company Lake and the focused extraction well in the south landfill (see Figure 4-9) is pumped to a new groundwater treatment system (GWTS) located near the current plant WWTS. The estimated combined extraction rate is 60 gpm at an estimated average concentration of 30 mg/L fluoride.

A groundwater treatability study conducted in 1998 indicated that site groundwater containing fluoride concentrations less than 100 mg/L was not effectively treated by calcium fluoride precipitation, the technology used at the RMC-Troutdale WWTS and the most common and cost-effective system for removing fluoride in an industrial setting. (See Appendix F.) If the extracted groundwater from the wells added in this option were discharged to the Columbia River without any treatment, the added fluoride mass loading to the river would be approximately 22 pounds per day, which would require an increase in the fluoride allowance in the NPDES permit.

To avoid an increase in the mass fluoride loading to the river, an additional GWTS is required. The GWTS in Option GW-3 uses reverse osmosis (RO) to remove the fluoride from the extracted groundwater. This produces a concentrated brine stream of approximately 15 gpm with a fluoride concentration of approximately 117 mg/L. The brine stream could be effectively treated by calcium fluoride precipitation. (See Figure 4-10.)

The RO system in this option consists of prefiltration for particulate removal, pH adjustment, raw water storage, the RO membrane unit, chemical feed storage, product water storage, and concentrate storage. The extracted groundwater is pH adjusted with hydrochloric acid when placed into the raw water storage tank. The water would be filtered to remove particles before entering the RO membrane unit. Product water from the RO is collected in the product storage tank and the concentrate is collected in the concentrate storage tank. The RO concentrate (brine) is then sent to the calcium fluoride precipitation

system for removal of fluoride. The treated water from the RO system is assumed to have a fluoride concentration less than 2 mg/L.

The precipitation portion of the treatment system adds calcium chloride to precipitate calcium fluoride. The theoretical solubility of calcium fluoride is 8 mg/L. However, the practical limit of this treatment system is approximately 20 to 30 mg/L. Major process equipment includes a rapid mix tank, a flocculator, a clarifier, a media filter, a solids thickening tank, and a plate and frame filter press (see Figure C-17 in Appendix C).

Both the RO treated water stream and the effluent from the precipitation system are discharged into South Ditch. From South Ditch, the water is pumped to Company Lake prior to discharge into the Columbia River via the NPDES outfall (see Figure 4-10).

By itself, GW-3 does not reduce the mass loading of fluoride or other COPCs to groundwater in the UGS. Consequently, in the area surrounding Company Lake, GW-3 alone has no effect on restoring groundwater to MCLs (see Appendix A, Table A-1). GW-3 does, however, reduce the potential for constituents to migrate offsite to the Fairview Farms area. GW-3 in combination with Company Lake dredging is expected to result in achievement of MCLs in as little as 15 years for much of the area surrounding Company Lake, including the intermediate and deep zones southwest of Company Lake. GW-3 is estimated to result in south plant MCL achievement in about 10 years, the same as for GW-2. Deed restrictions would be required in certain areas to prohibit the use of groundwater exceeding the MCLs.

4.5.2.4 Groundwater Option GW-4: Production Well Optimization with Enhanced Focused Extraction and Silt Unit Extraction

Option GW-4 adds low-flow extraction from the silt unit to Option GW-3. Therefore, GW-4 provides:

- Onsite containment of COPCs in the intermediate and deep groundwater using PWO
- Containment and restoration of groundwater quality in the southwest corner of Company Lake and the northeast corner of Fairview Farms using focused extraction
- Containment of COPCs and partial restoration of the UGS beneath the scrap yard, east potliner, and south landfill using focused extraction
- Containment of COPCs in the silt unit at the east potliner area and the south landfill

Extracted groundwater management would include use of 40 gpm from the scrap yard and east potliner extraction wells as makeup for the wet ESP and treatment of extracted UGS groundwater from the south landfill and Company Lake by RO. In addition, groundwater extracted from the silt unit in east potliner and scrap yard will be combined with the RO concentrate and treated using calcium fluoride precipitation. Dredging Company Lake or excavating the waste layer of the scrap yard would enhance the effectiveness of this option by eliminating or reducing the primary sources of constituents to groundwater.

Silt unit extraction was evaluated at the south landfill and the east potliner area, where elevated fluoride concentrations are present in the silt unit soil and groundwater and where the silt unit is greater than 10 feet thick (see Figure 4-11). Silt unit extraction was not considered at scrap yard because the silt unit there is less than 10 feet thick, and fluoride

concentrations in the silt are one to two orders of magnitude lower than concentrations in the overlying waste and surficial sand.

The objective of silt unit extraction is to prevent fluoride loading to the UGS from the silt unit. Modeling analyses were conducted to evaluate the spacing and pumping rates of a system of well points at both south landfill and east potliner. The model was run to identify the system parameters that would create an upward gradient within the lower portion of the silt unit without causing excessive drawdown in individual extraction wells. At the east potliner area, extraction well points were limited to areas outside of the right-of-way of a high-pressure natural gas pipeline, which runs southwest-northeast through the middle of the east potliner area.

The modeling analyses indicated that containment of east potliner groundwater in the silt unit (including beneath the natural gas line right-of-way) could be achieved by a system of approximately 25 well points each pumping 0.15 gpm (for a total of 3.75 gpm). The total pumping rate of 3.75 gpm is equivalent to an infiltration rate of 20 inches per year over the 150,000 ft^2 footprint of east potliner. The actual feasible extraction rate within the silt unit is limited by the long-term average annual precipitation infiltration rate, which is estimated to be less than 20 inches per year.

The west central portion (60,000 ft^2) of the south landfill was selected for silt extraction because it is the only location at south landfill where fluoride migration to the base of the silt unit and into the UGS has been observed. The modeling analysis indicated that at least 60 well points, and possibly as many as 75, would be required in order to contain the 60,000 ft^2 target area. Each well point would pump on the order of 0.1 gpm, for a total of between 6 and 7.5 gpm. Actual pumping rates could be on the order of 0.05 gpm or lower, depending on the permeability of the silt unit at each well point location. As with the east potliner area, pumping of the silt unit at the south landfill would be limited by infiltration from precipitation.

The groundwater extraction system in this option consists of four 15-horsepower (hp) jet pumping units equipped with 24 ports each. For costing purposes, it was assumed that 24 well points would be installed for the east potliner area, and 72 well points for the south landfill. Intake piping is routed from each of the extraction wells to the jet pumping units. Three jet pumping units are located at the south landfill area and one at the east potliner area. Each pumping unit consists of a pump control panel, a flow meter, and a 1-hp transfer pump.

The groundwater from the 24 east potliner silt extraction wells and the 72 south landfill silt extraction wells is pumped to a groundwater treatment system for removal of fluoride (see Figure 4-12). The total estimated flow is approximately 11 gpm at a concentration of approximately 470 mg/L fluoride. Due to the higher fluoride concentrations in silt unit, it is assumed that a calcium fluoride precipitation system could be installed to handle this groundwater. If discharged to the Columbia River untreated, this groundwater would contribute approximately 62 pounds per day of fluoride.

By itself, GW-4 does not reduce the mass loading of fluoride or other COPCs to groundwater in the UGS. This means that without removal of the process residue from Company Lake, GW-4 would prevent offsite migration of some affected groundwater south of

Company Lake but would have little effect on restoring groundwater in this area to the MCL (see Appendix A, Table A-1). GW-4 in combination with Company Lake dredging is expected to result in achievement of MCLs in as little as 15 years for much of the area surrounding Company Lake, including the intermediate and deep zones southwest of Company Lake. In this regard, GW-4 is about as effective as GW-3. In the south plant UGS, GW-4 is estimated to result in south plant MCL achievement in about 10 years, the same as for GW-2. The silt unit extraction wells in GW-4 might reduce the potential for constituents to migrate from the silt to UGS groundwater, but are not expected to have any impact on the time for groundwater in the silt unit to achieve the MCLs. Deed restrictions would be required in certain areas to prohibit the use of groundwater exceeding MCLs.

4.5.3 Options Retained for Sitewide Groundwater

Four groundwater options were retained for further consideration:

- No Action
- Option GW-1: Production Well Optimization
- Option GW-2: Production Well Optimization and Focused Extraction

The No Action option does not meet the RAOs defined for sitewide groundwater but is retained as required by the NCP to serve as a basis for comparison with other options.

Option GW-1 is retained because it controls the offsite migration of fluoride and other COPCs. It contains 100 percent of fluoride exceeding the MCL in the intermediate and deep zones south of the production wells, and between 50 and 100 percent of the groundwater exceeding the MCL in the UGS in the south plant, depending on pumping rates. It also captures all of the plume migrating southward from Company Lake toward the production wells in the intermediate and deep zones. If Option GW-1 is combined with Company Lake dredging, it improves groundwater quality between Company Lake and the production wells.

Option GW-2 is retained because it improves on the results of GW-1 by containing COPCS moving vertically out of the silt unit into the UGS in the scrap yard and east potliner areas. It controls offsite migration of fluoride and other COPCS by capturing essentially all the fluoride exceeding the MCL in the UGS underlying the scrap yard and east potliner, and all the fluoride exceeding the MCL in the intermediate and deep zones.

Option GW-3 is retained because it contains fluoride exceeding the MCL in the UGS beneath the entire footprint of the scrap yard, the east potliner area, and the south landfill, the intermediate zone underlying the scrap yard, and fluoride in the UGS migrating from the southern and eastern perimeters of Company Lake. However, the NPV cost of GW-3 is nearly four times that of GW-2. The volume of extracted groundwater requires additional treatment and an extensive conveyance system, and the effectiveness of reverse osmosis under site-specific conditions is not proven because it has not undergone pilot testing.

Option GW-4 is not retained because the effectiveness of the silt unit extraction is uncertain and costly. The NPV cost of GW-4 is approximately 150 percent of GW-3, but does not provide a commensurate benefit.

Section 4 Tables

Table 4-1
North Landfill Remedial Action Objectives, Metrics, and Remedial Goals

Remedial Action Objective	Metric	Remedial Goal
Reduce exposure of human receptors to COPCs at concentrations that pose unacceptable risk	Residual COPC concentrations applicable to specific exposure scenarios[1]	EPA and DEQ target risk criteria for the maintenance worker, trespasser, and trench worker scenarios: • Total ELCR less than 10^{-5} • ELCR less than 10^{-6} for any single COPC • Hazard index less than 1
Reduce or control mass loading of fluoride and other COPCs to surface water and to groundwater in the UGS, intermediate, and deep zones.	Fluoride and other COPC concentrations in surface water and in the UGS, intermediate-, and deep-zone groundwater[2]	Compliance with aquatic protection criteria in the rivers
Provide erosion protection for north landfill waste layer	Qualitative evaluation (Yes/No)	Protect north landfill soil and waste from erosion during an extreme flood event

[1] Residual soil fluoride concentrations determined by confirmation sampling for excavation options.
[2] Groundwater fluoride concentrations will serve as a surrogate or indicator of other COPCs.

Table 4-2
Evaluation of Remedial Options for North Landfill

Option	Description/Purpose	Effectiveness Evaluation: Advantages	Effectiveness Evaluation: Disadvantages	Order-of-Magnitude Costs: Capital Cost	Order-of-Magnitude Costs: Annual O+M	Order-of-Magnitude Costs: NPV[1]
No Action	No remedial actions taken at north landfill.	• No cost associated with this option.	• Does not address human exposure to COPCs above DEQ target risk criteria. • Does not provide any reduction in mass loading of COPCs to groundwater. • Does not protect north landfill from erosion.	NA	NA	NA
Option NLF-1: Institutional Controls	Deed restrictions, fencing and signage, use restrictions, personal protective equipment (PPE) requirements. The purpose of Option NLF-1 is to: • Limit the use of the area by future owners • Restrict access to site for potential trespassers • Restrict use of site to authorized personnel and visitors only • Rely on the use of appropriate personal protective equipment for potential trench workers	• Provides a reduction in human health exposure at north landfill by reducing the potential for direct contact with COPCs through access, use, and deed restrictions and the use of personal protective equipment. These restrictions are expected to reduce human exposures to levels below DEQ target risk criteria based on the required risk reduction percentages noted above. • Low costs.	• Does not reduce or control mass loading of COPCs to groundwater; however, there is no indication that this pathway poses unacceptable risk at NLF, so this disadvantage is not significant. • Does not provide erosion protection.	$71,000	$1,600	$91,000
Option NLF-2: Permeable Riprap Cap	Construct a permeable riprap cover over the waste layer, implement institutional controls. The purpose of Option NLF-2 is to: • Reduce human and ecological exposure to COPCs in surface soils • Provide erosion protection in case of an extreme flood event	• Reduces or eliminates maintenance worker and trespasser exposure by eliminating the pathway for direct surface contact to COPCs in surface soils and the waste layer, thus meeting DEQ target risk criteria. Trench worker scenario to be addressed by institutional controls, • Protects waste layer from potential erosion, minimizing migration of COPCs to surface water.	• Does not reduce or control mass loading of COPCs to groundwater; however, there is no indication that this pathway poses unacceptable risk at NLF, so this disadvantage is not significant.	$449,000	$20,000	$697,000
Option NLF-3: Multilayer Low-Permeability Cap, Including Riprap Cover	Construct multilayer low-permeability cap, implement institutional controls. The purpose of Option NLF-3 is to: • Reduce human and ecological exposure to COPCs in surface soils • Minimize infiltration of precipitation through the waste material, thus reducing COPC mass loading to groundwater • Provide erosion protection in case of an extreme flood event	• Reduces or eliminates maintenance worker and trespasser exposure by eliminating the pathway for direct surface contact to COPCs in surface soils and the waste layer, thus meeting DEQ target risk criteria. Trench worker scenario to be addressed by institutional controls, • Protects waste layer from potential erosion, minimizing migration of COPCs to surface water.	• Provides minimal reduction in migration of COPCS to groundwater because of high seasonal groundwater elevations. This option would reduce fluoride mass loading to groundwater in a limited area north of the landfill by approximately 20 percent; the overall duration of fluoride loading to groundwater would still be on the order of hundreds of years. However, there is no indication that this pathway poses unacceptable risk at NLF, so this disadvantage is not significant.	$910,000	$31,000	$1,299,000
Option NLF-4: Excavation of Waste Layer	Excavate waste material, place clean backfill, allow natural revegetation, implement institutional controls. The purpose of Option NLF-4 is to: • Reduce human and ecological exposure to COPCs to levels below DEQ target risk criteria, prevent erosion of the waste layer, and reduce COPC mass loading to the groundwater by removal of the waste layer, and placement of clean backfill	• Reduces or eliminates maintenance worker and trespasser exposure by eliminating direct surface contact with COPCs in surface soils and the waste layer, thus meeting DEQ target risk criteria. Trench worker scenario to be addressed by institutional controls, if necessary depending on residual soil COPC concentrations. • Reduce the migration of COPCs to groundwater and surface water through removal of the waste layer.	• Does not prevent migration of COPCs to groundwater from the surficial sand unit, although the bulk of fluoride mass in the waste layer would be removed. There is no indication that this pathway poses unacceptable risk at NLF, so this disadvantage is not significant.	$10,845,000	$5,000	$10,908,000
Option NLF-5: Excavation of Waste Layer and Upper 2 Feet of Surficial Sand	Excavate waste layer and upper 2 feet of the surficial sand unit, place clean backfill, allow natural revegetation, implement institutional controls. The purpose of Option NLF-5 is to: • Reduce human and ecological exposure to COPCs to levels below DEQ target risk criteria by removal of the waste layer and an additional 2 feet of the surficial sand unit, and placement of clean backfill • Prevent erosion of the waste layer by excavating • Reduce COPC mass loading to groundwater by removal of the waste layer and upper 2 ft of surficial sand	• Reduces or eliminates human health risk by eliminating exposure to the waste layer and the upper 2 ft of the surficial sand unit. Placement of clean fill will further reduce risks to near background levels. Trench worker scenario may need to be addressed by institutional controls depending on residual soil concentrations. • Reduces the migration of fluoride and other COPCS to groundwater through removal of the waste layer and additional fluoride mass that is potentially adsorbed to the top 2 feet of the surficial sand unit.	• Does not prevent migration of COPCs to groundwater from the remaining surficial sand, although the bulk of fluoride mass is found in the waste layer that would be removed. There is no indication that this pathway poses unacceptable risk at NLF, so this disadvantage is not significant. • Higher cost for management and disposal of additional excavated soils. • Higher cost of excavation and material disposal is not balanced by a proportional reduction of risk.	$14,111,000	$5,000	$14,174,000

[1] 7 percent over 30 years.

Table 4-3
South Landfill Remedial Action Objectives, Metrics, and Remedial Goals

Remedial Action Objective	Metric	Remedial Goal
Reduce exposure of human receptors to COPCs at concentrations that pose unacceptable risk	Residual COPC concentrations applicable to specific exposure scenarios[1]	EPA and DEQ target risk criteria for the maintenance worker, trespasser, and trench worker scenarios: • Total ELCR less than 10^{-5} • ELCR less than 10^{-6} for any single COPC • Hazard index less than 1
Reduce or control mass loading of fluoride and other COPCs to groundwater in the UGS, intermediate, and deep zones	Fluoride concentrations in the UGS, intermediate-, and deep-zone groundwater[2]	Compliance with MCLs in UGS, intermediate, and deep zone

[1] Residual soil fluoride concentrations determined by confirmation sampling for excavation options.
[2] Groundwater fluoride concentrations will serve as a surrogate or indicator of other COPCs.

Table 4-4
Evaluation of Remedial Options for South Landfill

Option	Description/Purpose	Effectiveness Evaluation: Advantages	Effectiveness Evaluation: Disadvantages	Order-of-Magnitude Costs: Capital Cost	Order-of-Magnitude Costs: Annual O+M	Order-of-Magnitude Costs: NPV[1]
No Action	No remedial actions taken at south landfill.	• No cost associated with this option.	• Does not reduce human health risk to a level below DEQ target risk criteria. • Does not reduce or control mass loading of COPCs to groundwater.	NA	NA	NA
Option SLF-1: Institutional Controls	Deed restrictions, fencing and signage, use restrictions, PPE requirements. The purpose of Option SLF-1 is to reduce human exposure to COPCs in surface soils to levels below DEQ target risk criteria by : • Limiting the use of the property by future owners, • Restricting access to site by potential trespassers • Restricting use of site to authorized personnel and visitors only • Requiring use of appropriate personal protective equipment for potential future trench workers	• Provides a reduction in human exposure at south landfill by reducing the potential for direct contact with COPCs through access, use, and deed restrictions. These restrictions are expected to reduce human exposures from direct contact to below DEQ target risk criteria based on the required risk reduction percentages noted above. • Low cost associated with this option.	• Does not reduce or control mass loading of COPCs to groundwater. However, the south landfill is not considered to be a major contributor of constituents migrating sitewide, so this is not considered a significant disadvantage.	$81,000	$2,000	$106,000
Option SLF-2: Permeable Soil and Vegetated Cap	Construct a permeable, vegetated soil cap over the waste layer; implement institutional controls. The purpose of Option SLF-2 is to: • Reduce human exposure to COPCs in surface soils to levels below DEQ target risk criteria	• Reduces maintenance worker and trespasser exposure to COPCs by eliminating the pathway for direct surface contact to COPCs in surface soils and waste layer, thus meeting DEQ target risk criteria. The trench worker scenario would be addressed by institutional controls.	• Does not reduce or control mass loading of COPCs to groundwater. However, the south landfill is not considered to be a major contributor of constituent migration, so this is not considered a significant disadvantage.	$724,000	$24,000	$1,026,000
Option SLF-3: Multilayer Low Permeability Cap	Construct multilayer, low-permeability cap; implement institutional controls. The purpose of Option SLF-3 is to: • Reduce human exposure to COPCs in surface soils to levels below DEQ target risk criteria • Reduce infiltration of precipitation through waste material, thus reducing COPC mass loading to groundwater	• Reduces maintenance worker and trespasser exposure to COPCs by eliminating the pathway for direct surface contact to COPCs in surface soils and waste layer, thus meeting DEQ target risk criteria. The trench worker scenario would be addressed by institutional controls.	• Provides limited reduction in mass loading of COPCs to groundwater because of seasonally high groundwater table. However, the south landfill is not considered to be a major contributor of constituents migrating sitewide, so this is not considered a significant disadvantage.	$1,698,000	$52,000	$2,337,000
Option SLF-4: Excavation of Waste Layer	Excavate waste material; place clean backfill; allow natural revegetation; implement institutional controls. The purpose of Option SLF-4 is to: • Reduce human exposure to COPCs to levels below DEQ target risk criteria by removal of the waste layer and placement of clean backfill. • Reduce COPC mass loading to groundwater by removal of the waste layer	• Provides a reduction in risk by removal of the waste layer at south landfill. The highest total PAH concentrations at south landfill were within the top 6 feet of the waste layer. PAHs are also known to have very low solubilities and tend not to migrate into subsurface soil. Three test pit samples were collected at south landfill at the interface between the waste layer and the surficial sand unit during September 1994. The samples were collected at depths ranging between 6 and 8 feet bgs and are considered representative of conditions at south landfill following waste removal. PAHs were not detected in two of the samples; four PAHs were detected in the third sample. Based on this data, the post-excavation residual risk would not be expected to exceed 3x10-10 for the trespasser scenario, 2x10-10 for the maintenance worker scenario, and 3x10-10 for the trench worker scenario. These reductions would meet DEQ target risk criteria. • Backfill and natural revegetation would further reduce trespasser and maintenance worker exposure to residual COPC concentrations in the surficial sand unit by eliminating the pathway for direct contact through. • Reduces the migration of COPCs to groundwater through removal of the waste layer.	• Does not prevent mass loading of COPCs adsorbed to soils in the surficial sand and silt units to groundwater in the UGS. However, the south landfill is not considered to be a major contributor of constituents migrating sitewide, so this is not considered a significant disadvantage.	$14,599,000	$4,000	$14,652,000
Option SLF-5: Excavation of Waste Layer and Surficial Sand	Excavate waste material and upper 2 feet of the surficial sand unit; place clean backfill; allow natural revegetation; implement institutional controls. The purpose of Option SLF-5 is to: • Reduce human exposure to COPCs to levels below DEQ target risk criteria by removal of the waste layer and an additional 2 feet of the surficial sand unit and placement of clean backfill • Reduce COPC mass loading to groundwater by removal of the waste layer and an additional 2 feet of the surficial sand unit	• Provides risk reduction by eliminating exposure to the waste layer and an additional 2 feet of the surficial sand unit. Additional excavation of surficial sand may further reduce risk for the trench worker scenario compared to Option SLF-4, depending on residual soil COPC concentrations. These reductions are expected to meet DEQ target risk criteria for the trespasser, maintenance worker, and potentially the trench worker. • Reduces the mass loading of COPCs to groundwater through removal of the waste layer and additional 2 feet of the surficial sand unit.	• Does not prevent mass loading of COPCs adsorbed to the soils in the remaining surficial sand and silt units to groundwater in the UGS. Excavation of an additional 2 feet of surficial sand would remove additional fluoride mass, but would not provide a significant reduction of fluoride mass loading to groundwater compared to Option SLF-4. • Higher cost for excavation and material disposal is not offset by proportionate risk reduction.	$21,212,000	$4,000	$21,266,000

[1] 7 percent over 30 years.

Table 4-5
Scrap Yard Remedial Action Objectives, Metrics, and Remedial Goals

Remedial Action Objective	Metric	Remedial Goal
Reduce exposure of human receptors to COPCs at concentrations that pose unacceptable risk	Residual COPC concentrations applicable to specific exposure scenarios[1]	EPA and DEQ target risk criteria for the maintenance worker and trench worker scenarios: • Total ELCR less than 10^{-5} • ELCR less than 10^{-6} for any single COPC • Hazard index less than 1
Reduce or control mass loading of fluoride and other COPCs to groundwater in the UGS, intermediate, and deep zones.	Fluoride concentrations in the UGS, intermediate-, and deep-zone groundwater[2]	Compliance with MCLs in the UGS, intermediate, and deep zones
Retain industrial use of the scrap yard	Qualitative evaluation (Yes/No)	Minimal disturbance to scrap yard operations

[1]Residual soil fluoride concentrations determined by confirmation sampling for excavation options.
[2]Groundwater fluoride concentrations will serve as a surrogate or indicator of other COPCs.

Table 4-6
Evaluation of Remedial Options for Scrap Yard

Option	Description/Purpose	Effectiveness Evaluation: Advantages	Effectiveness Evaluation: Disadvantages	Order-of-Magnitude Costs: Capital Cost	Order-of-Magnitude Costs: Annual O+M	Order-of-Magnitude Costs: NPV[1]
No Action	No remedial actions taken at scrap yard.	• No cost associated with No Action. • No disruption of industrial operations.	• Does not address human exposure to COPCs above DEQ target risk criteria. • Does not reduce or control mass loading of COPCs to groundwater.	NA	NA	NA
Option SY-1: Institutional Controls	Deed restrictions, fencing and signage, use restrictions, PPE requirements. The purpose of Option SY-1 is to reduce human exposure to COPCs in surface soils above DEQ target risk criteria by: • Limiting the use of the area by future owners • Restricting access to site to potential trespassers • Restricting use of site to authorized personnel and visitors only • Requiring use of appropriate personal protective equipment for all potential future trench workers	• Reduces maintenance and trench worker exposure by reducing the potential for direct contact with COPCs in the waste layer through the deed, use, and access restrictions. • Does not significantly limit continued industrial use of the property. • Low cost associated with this option.	• Does not reduce or control mass loading of COPCs to groundwater.	$31,000	$0	$31,000
Option SY-2: Permeable Gravel Cap Over North Area	Construct a permeable gravel cap over north area waste layer; implement institutional controls. The purpose of Option SY-2 is to: • Reduce human exposure to COPCs in surface soils in the north area below DEQ target risk criteria • Preserve the suitability of the scrap yard for industrial use	• Reduces maintenance worker exposure to COPCs by eliminating the pathway for direct surface contact with COPCs detected in surface soil in the north area of scrap yard, thus meeting DEQ target risk criteria. • Trench worker exposure throughout the scrap yard, and maintenance worker exposure in the south area, would be addressed by institutional controls and use restrictions. • Preserves industrial use of property with only temporary disruptions to the use of the scrap yard during construction activities.	• Does not reduce or control mass loading of COPCs to groundwater. • Does not reduce human exposure to COPCs in the south area which will require institutional controls and use restrictions.	$376,000	$18,000	$597,000
Option SY-3: Excavation of Waste Layer in North Area	Excavate the waste layer in the north scrap yard area; place and grade clean gravel; implement institutional controls. The purpose of Option SY-3 is to: • Reduce human exposure to the highest concentrations of COPCs in the north area of scrap yard to levels below DEQ target risk criteria by removal of the waste layer and placement of clean gravel • Significantly reduce COPC mass loading to groundwater by removal of the waste layer in the north area of scrap yard • Preserve the suitability of scrap yard for industrial use	• Provides risk reduction by removal of the waste layer at the north area of scrap yard. Total PAHs were detected at higher concentrations in discrete surface soil samples than in composite subsurface soil. PAHs have very low solubilities and tend not to migrate into subsurface soil. PAHs would not be expected at depths below the waste layer. Therefore, it is likely the post-excavation residual risk would meet DEQ target risk criteria for the maintenance worker and trench worker scenarios in the north area. In addition, placement of clean gravel backfill would further reduce exposure to remaining COPCs. • Trench worker and maintenance worker exposures in the south area would be addressed by institutional controls and use restrictions. • Reduces the migration of COPCs to groundwater through removal of the waste layer for the north area of scrap yard. This action would reduce the duration of fluoride loading by approximately 50 percent (See Appendix A, Section A.7). • Removes 243,000 pounds of fluoride mass in the waste layer. (See Appendix E for a summary of fluoride mass estimations.) • Retains use of scrap yard for continued industrial use.	• This option does not prevent further mass loading of COPCs adsorbed to soils in the surficial sand and silt units to groundwater in the UGS. Does not reduce human exposure to COPCs in the south area which will require institutional controls and use restrictions	$1,916,000	$7,000	$1,999,000

Table 4-6 (continued)
Evaluation of Remedial Options for Scrap Yard

Option	Description/Purpose	Effectiveness Evaluation		Order-of-Magnitude Costs		
		Advantages	Disadvantages	Capital Cost	Annual O+M	NPV[1]
Option SY-4: Excavation of Waste Layer and Partial Excavation of Surficial Sand in North Area	Excavate the waste layer in the north scrap yard area; excavate middle and western thirds of the surficial sand unit in the north scrap yard area; place clean gravel backfill ; implement institutional controls. *The purpose of Option SY-4 is to:* • Reduce human exposure to COPCs to levels below DEQ target risk criteria by removal of the waste layer in the north area, and placement of clean backfill • Reduce COPC mass loading to groundwater by removal of the waste layer and partial removal of sand in the north scrap yard area • Preserve the suitability of scrap yard for industrial use	• Provides a reduction in risk by eliminating exposure to the waste layer and selected areas of the surficial sand unit. Total PAHs were detected at higher concentrations in discrete surface soil samples than in composite subsurface soil. PAHs have very low solubilities and tend not to migrate into subsurface soil. PAHs would not be expected at depths below the waste layer. Therefore, it is likely the post-excavation residual risk would meet DEQ target risk criteria for the maintenance worker and trench worker scenarios in the north area with or without sand removal. In addition, placement of clean gravel backfill would further reduce exposure to remaining COPCs. • Trench worker and maintenance worker exposures in the south area would be addressed by institutional controls and use restrictions. • Significantly reduces the migration of COPCs to groundwater through removal of the waste layer for the north and south areas of scrap yard, and the highest concentrations of COPCs in surficial sands of the middle and western thirds of the north area of scrap yard. This action would reduce the duration of fluoride loading by approximately 90 percent. Further discussion is provided in Appendix A. • Removes 612,000 lb of fluoride mass in the waste layer and soil above the silt unit. • Retains use of the scrap yard for continued industrial use.	• This option does not prevent further mass loading of COPCs adsorbed to soils primarily in the north area silt unit to groundwater in the UGS. However, the silt contains only a small fraction of the fluoride present in the waste and surficial sand. • Does not reduce human exposure to COPCs in the south area which will require institutional controls and use restrictions. • Higher cost for excavation and material disposal is not offset by a proportionate reduction of risk.	$7,206,000	$7,000	$7,289,000

[1] 7 percent over 30 years.

Table 4-7
Company Lake Remedial Action Objectives, Metrics, and Remedial Goals

Remedial Action Objective	Metric	Remedial Goal
Reduce exposure of human receptors to COPCs at concentrations that pose unacceptable risk	Residual COPC concentrations applicable to specific human health exposure scenarios	EPA and DEQ target risk criteria for the trespasser scenario: • Total ELCR less than 10^{-5} • ELCR less than 10^{-6} for any single COPC • Hazard index less than 1
Reduce exposure to ecological receptors to COPCs at concentrations that pose unacceptable risk	Residual COPC concentrations applicable to specific ecological exposure scenarios	Tier 2 ecological hazard quotient less than 1
Reduce or control mass loading of fluoride and other COPCs to groundwater in the UGS, intermediate, and deep zones	Fluoride concentrations in UGS, intermediate-, and deep-zone groundwater[1]	Compliance with MCLs in the UGS, intermediate, and deep zones
Protect Columbia River from washout or scour of Company Lake sediments	Qualitative evaluation (Yes/No)	Prevent washout in case of an extreme flood event
Retain use of Company Lake as an NPDES system	Qualitative evaluation (Yes/No)	Minimal disturbance to wastewater discharge

[1] Groundwater fluoride concentrations will serve as a surrogate or indicator of other COPCs.

Table 4-8
Evaluation of Remedial Options for Company Lake

Option	Description/Purpose	Effectiveness Evaluation		Order-of-Magnitude Costs		
		Advantages	Disadvantages	Capital Cost	Annual O+M	NPV[1]
No Action	No remedial actions taken at Company Lake.	• No disruption in use of Company Lake as part of the NPDES system. • No cost associated with this option.	• Does not address human exposure to COPCs above DEQ target risk criteria. • Does not address ecological exposure above ecological target risk criteria. • Does not reduce potential for washout or scour of Company Lake process residue in an extreme flood event. • Does not reduce or control mass loading of COPCs to groundwater.	NA	NA	NA
Option CL-1: Institutional Controls	Deed restrictions, fencing and signage, use restrictions. The purpose of Option CL-1 is to reduce human exposure to COPCs in Company Lake sediment (primarily process residue) at concentrations that exceed DEQ target risk criteria by: • Limiting use of the area by future owners • Restricting access to site to potential trespassers • Restricting use of site to authorized personnel and visitors only • Retaining use of Company Lake as part of the NPDES system	• Reduces trespasser exposure to COPCs in sediment to levels below DEQ target risk criteria by reducing the potential for direct contact with COPCs through deed and access restrictions. • Relatively low cost associated with this option. • No disruption to use of Company Lake as part of the NPDES system.	• Does not reduce or control mass loading of COPCs to groundwater. • Does not address ecological exposure to COPCs above ecological target risk criteria. • Does not reduce potential for washout or scour of Company Lake process residue in an extreme flood event.	$229,000	$8,000	$328,000
Option CL-2: Permeable Cap Over Process Residue	Construct permeable cap over process residue (Geotextile layer, 12-inch layer of gravel, 12-inch layer of rock); implement institutional controls. The purpose of Option CL-2 is to: • Reduce human exposure to COPCs in Company Lake sediment (primarily process residue) at concentrations that exceed DEQ target risk criteria • Reduce ecological exposure to COPCs in Company Lake sediment (primarily process residue) at concentrations that exceed ecological target risk criteria • Reduce the potential for washout or scour of Company Lake process residues in an extreme flood event	• Reduces human ecological exposure to COPCs to levels below DEQ target risk criteria by eliminating direct contact with process residues in Company Lake. • Minimizes potential for washout or scour of Company Lake process residue in an extreme flood event.	• Temporary disruption of NPDES discharge and additional cost associated with temporary diversion of NPDES discharge. • Does not reduce or control mass loading of COPCs to groundwater.	$5,111,000	$17,000	$5,317,000
Option CL-3: Dredging Process Residue	Hydraulically dredge process residue; mechanically dewater dredged material; dispose of dried sediments; implement institutional controls. The purpose of Option CL-3 is to: • Reduce human exposure to COPCs in Company Lake sediment (primarily process residue) at concentrations that exceed DEQ target risk criteria • Reduce ecological exposure to COPCs in Company Lake sediment (primarily process residue) at concentrations that exceed ecological target risk criteria • Reduce the potential for washout or scour of Company Lake process residues in an extreme flood event • Reduce mass loading of COPCs from process residue in Company Lake to groundwater	• Reduces human and ecological exposure to COPCs in Company Lake sediment to levels below DEQ target risk criteria by removing the process residue. Reduces the mass loading of COPCs to groundwater through removal of process residue at Company Lake. The process residue contains the majority of fluoride mass in Company Lake; the underlying native sediments contain a relatively small fluoride mass. Dredging is expected to be highly effective in improving groundwater quality surrounding Company Lake. This option could reduce groundwater cleanup time in the UGS to 20 years or less. • Eliminates potential for washout or scour of Company Lake process residue in an extreme flood event.	• Temporary disruption of NPDES discharge and additional cost associated with temporary diversion of NPDES discharge. • Engineering controls required to prevent possible releases of process residue to the Columbia River during dredging.	$10,817,000	$18,000	$10,865,000

[1] 7 percent over 30 years.

Table 4-9
Sitewide Groundwater Remedial Action Objectives, Metrics, and Remedial Goals

RAOs	Metric	Goal
Reduce or control offsite migration of fluoride plume and other constituents of concern (COPCs) in groundwater	Fluoride concentrations in offsite groundwater	Onsite containment of existing plume that has concentrations exceeding MCLs except for a limited area north of the dike
Reduce or control mass loading of fluoride and other COPCs to groundwater in the UGS, intermediate, and deep zones	1) Fluoride concentrations in the UGS, intermediate, and deep zones 2) Size of the UGS, intermediate-, and deep-zone plumes after 5 and 10 years	1) Statistically significant downward trend in fluoride concentrations in the UGS, intermediate, and deep zones over time 2) Reduction of plume size in the UGS, intermediate, and deep zones
Restore groundwater to beneficial use criteria	Groundwater quality	MCLs or concentrations that protect AWQC at the rivers

Table 4-10
Summary of Baseline Risk Estimates for Current and Future Potential Exposure to Groundwater

Exposure Scenario	Exposure Route	Average Exposure		Reasonable Maximum Exposure	
		Noncancer Hazard Index	Excess Lifetime Cancer Risk	Noncancer Hazard Index	Excess Lifetime Cancer Risk
Current Onsite Occupational Worker	Ingestion	N/C	N/C	0.26	N/A
	Dermal	N/C	N/C	0.001	N/A
	Inhalation	N/C	N/C	N/A	N/A
	Total	N/C	N/C	0.26	N/A
Future Potential Onsite Occupational Worker	Ingestion	N/C	N/C	0.34	9×10^{-7}
	Dermal	N/C	N/C	0.002	2×10^{-7}
	Inhalation	N/C	N/C	N/A	5×10^{-6}
	Total	N/C	N/C	0.34	6×10^{-6}
Current Offsite Occupational Worker	Ingestion	N/C	N/C	0.057	N/A
	Dermal	N/C	N/C	0.0003	N/A
	Inhalation	N/C	N/C	N/A	N/A
	Total	N/C	N/C	0.06	N/A
Future Potential Offsite Occupational Worker	Ingestion	N/C	N/C	0.95	N/A
	Dermal	N/C	N/C	0.004	N/A
	Inhalation	N/C	N/C	N/A	N/A
	Total	N/C	N/C	0.95	N/A
Future Potential Offsite Residential	Ingestion	1.8	N/C	3.2	N/A
	Dermal	0.004	N/C	0.007	N/A
	Inhalation	N/A	N/C	N/A	N/A
	Total	**1.8**	N/C	**3.3**	N/A

N/C = Not calculated; the average-case risk estimates were calculated only when the RME case estimates exceeded EPA target risk levels [$>10^{-4}$ excess lifetime cancer risk (ELCR); > 1.0 hazard index (HI)].
N/A = Exposure is incomplete for this exposure route.

Table 4-11
Evaluation of Remedial Options for Sitewide Groundwater

Groundwater Option	Description/Purpose	Effectiveness Evaluation		Order-of-Magnitude Costs		
		Advantages	Disadvantages	Capital Cost	Annual O&M	NPV[1]
No Action	Operate production wells as required by plant water demands and wellfield operational needs without consideration of fluoride containment or capture.	• No cost associated with this option. • Does not disrupt current industrial operations.	• Does not reduce or control offsite migration of fluoride plume and other COPCs in groundwater. • Does not reduce mass loading of fluoride and other COPCs to groundwater in the UGS, intermediate, and deep zones or restore groundwater to beneficial use criteria.	NA	NA	NA
Option GW-1: Production Well Optimization (PWO)	Optimize Production well operation to provide containment: pump PW07 and PW08 at a minimum of 600 gpm each. Implement institutional controls. *The purpose of GW-1 is to:* • Control offsite migration of fluoride and other COPCs in the intermediate and deep zones • Prevent exposure of human receptors to COPCs above MCLs	• Pumping production wells PW07 and PW08 at 600 gpm each is expected to contain 100 percent of the fluoride exceeding the MCL in the intermediate and deep zones south of the production wells. This pumping rate will contain approximately 50 percent of the UGS groundwater exceeding the MCL in the south plant, including the UGS groundwater that is migrating to the intermediate and deep zones. Pumping at a higher rate from PW07 and PW08 or adding pumping from well PW03 to meet plant needs would contain all of the UGS groundwater that exceeds the MCL beneath the scrap yard, east potliner, and south landfill. • Expected to capture 100 percent of the plume migrating south and southeast from Company Lake. • GW-1 in combination with Company Lake dredging is expected to result in achievement of MCLs in as little as 15 years for much of the area surrounding Company Lake; the time to MCL achievement in the intermediate and deep zones southwest of Company Lake is estimated to be 50 to 100 years.	• Does not contain fluoride that is migrating north from Company Lake to the Columbia River. However, the preliminary risk evaluation and mixing calculations for groundwater discharges into the Columbia and Sandy Rivers indicates that fluoride migrating to the Columbia River from the north side of Company Lake does not present an unacceptable risk to human health or ecological receptors or measurably increase in-stream fluoride concentrations. For a detailed discussion of these issues, see Section 3 and Appendix D of the *Draft Surface Water and Sediment Areas Addendum to the RI/FS Work Plan* (CH2M HILL, April 3, 1998). • Pumping the production wells at 600 gpm each does not prevent offsite migration of fluoride and other COPCS in groundwater from the eastern third of the scrap yard or the area beneath east potliner. However, fluoride does not appear to be present in the intermediate and deep zones in these areas and is not present in the UGS near the Sandy River (which is the downgradient discharge location). • Does not reduce mass loading of fluoride and other COPCS to groundwater in the UGS, intermediate, and deep zones.	$0	$128,000	$1,057,000
Option GW-2: PWO and Focused Extraction (FE)	Components of GW-1 (PWO); 1 UGS extraction well on north side of scrap yard pumping at 20 gpm; and 1 UGS extraction well on western portion of east potliner area pumping at 20 gpm; institutional controls. The purpose of Option GW-2 is to: • Control offsite migration of fluoride and other COPCs in the intermediate and deep zones • Contain COPCs migrating from the UGS to the intermediate zone in the south plant area • Prevent exposure of human receptors to COPCs above MCLs	In addition to the advantages described for GW-1 above: • Controls offsite migration of fluoride and other COPCs in groundwater. Two UGS focused extraction wells, each pumping at 20 gpm, will effectively contain groundwater in the UGS beneath the scrap yard and the east potliner area (see Figure A-11 in Appendix A of this report). Groundwater containing fluoride above the MCL in the intermediate and deep zones will be contained by the production wells. • Focused extraction prevents loading from the UGS to the intermediate zone in areas where fluoride concentrations currently exceed MCLs. This offers the following benefits: – Concentrations will drop below the MCL in the portion of the intermediate zone and the deep zone situated between scrap yard and the production wells; reduced concentration could occur within 10 years. Excavation of waste in the scrap yard would enhance this process. – Reduces the required duration of production well pumping at the minimum rate (600 gpm each from PW07 and PW08) compared to Option GW-1. – Reduces fluoride concentrations below the MCL within the UGS beneath scrap yard and east potliner. – Combined effects of PWO and focused extraction will result in restoration of intermediate and deep zone groundwater to beneficial use south of the U.S. Army Corp of Engineers (COE) flood control dike. Restoration of groundwater to beneficial use criteria north of the dike depends on Company Lake being dredged . • Limiting the total pumping rate of the focused extraction wells to 40 gpm or less allows discharge of the extracted groundwater to the ESP, eliminating the need for a new wastewater treatment plant.	• Does not contain fluoride that is migrating north from Company Lake to the Columbia River. However, the preliminary risk evaluation and mixing calculations for groundwater discharges into the Columbia and Sandy Rivers indicates that fluoride migrating to the Columbia River from the north side of Company Lake does not present an unacceptable risk to human health or ecological receptors or measurably increase in-stream fluoride concentrations. For a detailed discussion of these issues, see Section 3 and Appendix D of the *Draft Surface Water and Sediment Areas Addendum to the RI/FS Work Plan* (CH2M HILL, April 3, 1998). • Focused extraction wells may need to operate indefinitely, if the silt unit continues to load fluoride to the UGS; could be most significant beneath scrap yard if the waste in this area is not excavated. • If Company Lake dredging is not performed, then Option GW-2 does not restore UGS groundwater quality in the vicinity of Company Lake. • Focused extraction may result in increased discharge of fluoride to Company Lake and the NPDES outfall.	$375,000	$151,000	$1,763,000

Table 4-11 (continued)
Evaluation of Remedial Options for Sitewide Groundwater

Groundwater Option	Description/Purpose	Effectiveness Evaluation		Order-of-Magnitude Costs		
		Advantages	Disadvantages	Capital Cost	Annual O&M	NPV[1]
Option GW-3: PWO with Enhanced FE	Components of GW-2; 1 UGS extraction well at south landfill pumping at 15 gpm; 3 intermediate-depth extraction wells southwest of Company Lake each pumping at 15 gpm; institutional controls. The purpose of Option GW-3 is to: • Control offsite migration of fluoride and other COPCs in the intermediate and deep zones • Contain COPCs migrating from the UGS to the intermediate zone in the south plant area • Restore UGS groundwater quality southwest of Company Lake • Prevent exposure of human receptors to COPCs above MCLs	In addition to the advantages described for GW-2 above: • Focused extraction wells at the south landfill will capture the small, localized fluoride plume in the UGS at the western portion of south landfill (near GP59) within a 10-year period. Under this option, fluoride in the UGS would decline below the MCL within 10 years. • If Company Lake is dredged, installation of three intermediate-zone extraction wells southwest of Company Lake decreases fluoride concentrations in this area to below the MCL in 10-15 years.	• Does not contain fluoride that is migrating north from Company Lake to the Columbia River. However, the preliminary risk evaluation and mixing calculations for groundwater discharges into the Columbia and Sandy Rivers indicates that fluoride migrating to the Columbia River from the north side of Company Lake does not present an unacceptable risk to human health or ecological receptors or measurably increase in-stream fluoride concentrations. For a detailed discussion of these issues, see Section 3 and Appendix D of the *Draft Surface Water and Sediment Areas Addendum to the RI/FS Work Plan* (CH2M HILL, April 3, 1998). • Focused extraction wells may need to operate indefinitely, if the silt unit continues to load fluoride to the UGS; could be most significant beneath scrap yard if the waste in this area is not excavated. • If Company Lake is not dredged, focused extraction southwest of the pond would only provide containment but would not reduce fluoride concentrations in this area below the MCL in the foreseeable future. • No RO pilot testing has been conducted to establish that RO can be successfully used to concentrate fluoride in the extracted groundwater at the site. • Increased fluoride discharge to the Columbia River will result from the extracted groundwater directed to the ESP and the RO/fluoride precipitation treatment system.	$3,316,000	$297,000	$6,818,000
Option GW-4: PWO with Enhanced FE and Silt Unit Extraction[2]	Components of GW-3; 24 well points each pumping at 0.15 gpm at east potliner ; 72 well points each pumping at 0.05 to 0.1 gpm at south landfill; institutional controls. The purpose of GW-4 is to: • Control offsite migration of fluoride and other COPCs in the intermediate and deep zones • Contain COPCs migrating from the UGS to the intermediate zone in the south plant area • Restore UGS groundwater quality southwest of Company Lake • Prevent exposure of human receptors to COPCs above MCLs • Prevent fluoride loading to UGS from silt unit at the south landfill and east potliner areas.	In addition to the advantages for GW-3: • Prevents further migration of fluoride from the silt unit at the south landfill and the east potliner area to the UGS.	• Does not contain fluoride that is migrating north from Company Lake to the Columbia River. However, the preliminary risk evaluation and mixing calculations for groundwater discharges into the Columbia and Sandy Rivers indicates that fluoride migrating to the Columbia River from the north side of Company Lake does not present an unacceptable risk to human health or ecological receptors or measurably increase in-stream fluoride concentrations. For a detailed discussion of these issues, see Section 3 and Appendix D of the *Draft Surface Water and Sediment Areas Addendum to the RI/FS Work Plan* (CH2M HILL, April 3, 1998). • Focused extraction wells may need to operate indefinitely, if the silt unit continues to load fluoride to the UGS; could be most significant beneath scrap yard if the waste in this area is not excavated. • If Company Lake is not dredged, focused extraction southwest of the pond would only provide containment but would not reduce fluoride concentrations in this area below the MCL in the foreseeable future. • No RO pilot testing has been conducted to establish that RO can be successfully used to concentrate fluoride in the extracted groundwater at the site. • Increased fluoride discharge to the Columbia River will result from the extracted groundwater directed to the ESP and the RO/fluoride precipitation treatment system. • Groundwater extraction from silt unit does not effectively reduce the time required to achieve the MCL in the UGS, because time required to flush fluoride from silt unit soils is a function of precipitation infiltration rates, not groundwater extraction rates. Consequently, the soil options and not the groundwater options affect the time to compliance in the silt unit. In addition, the effectiveness of extraction from the silt unit is questionable.	$4,121,000	$478,000	$10,236,000

[1] 7 percent over 30 years.
[2] An evaluation of drainage trenches is provided in Appendix H.

Section 4 Figures

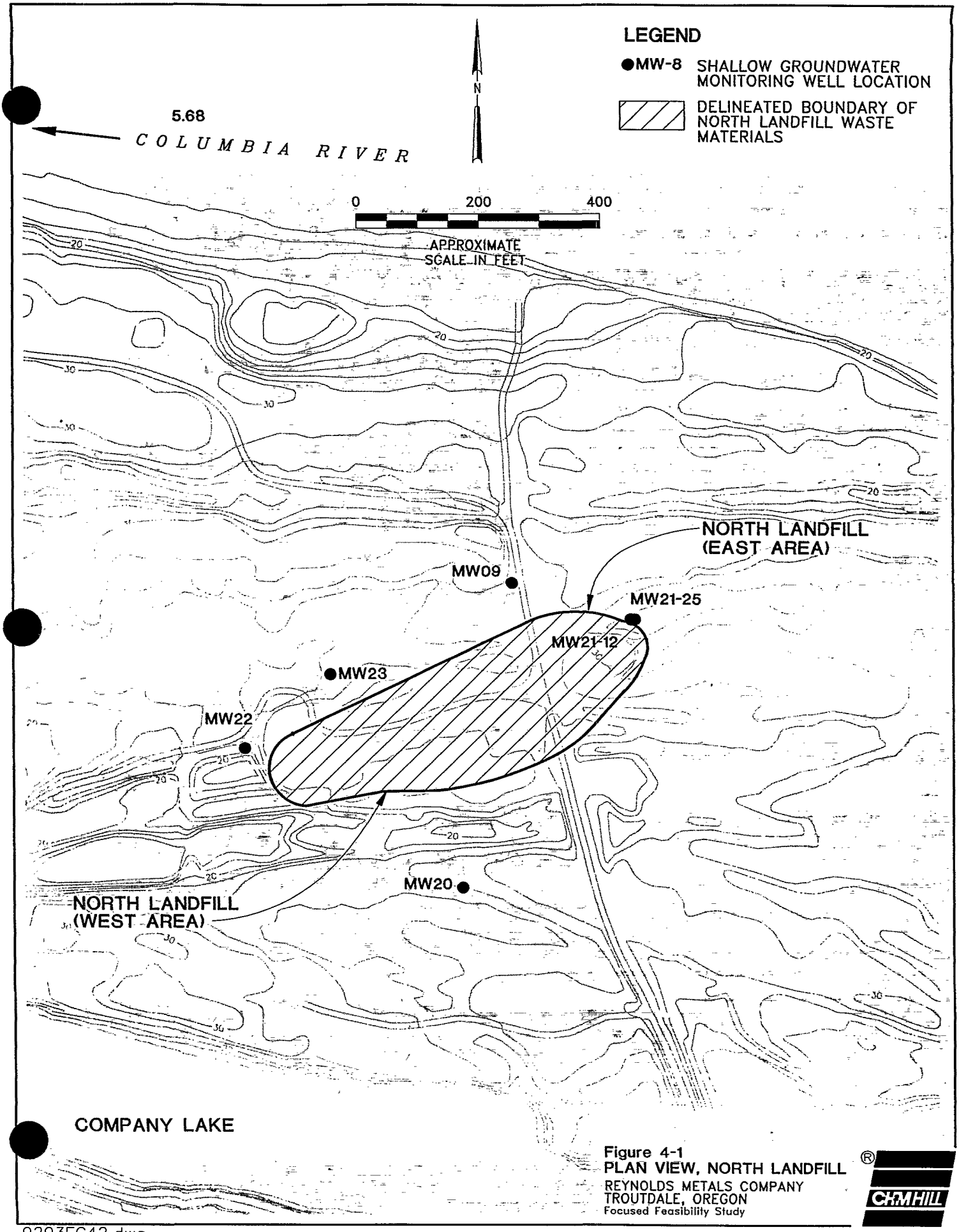


Figure 4-1
PLAN VIEW, NORTH LANDFILL
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2M HILL

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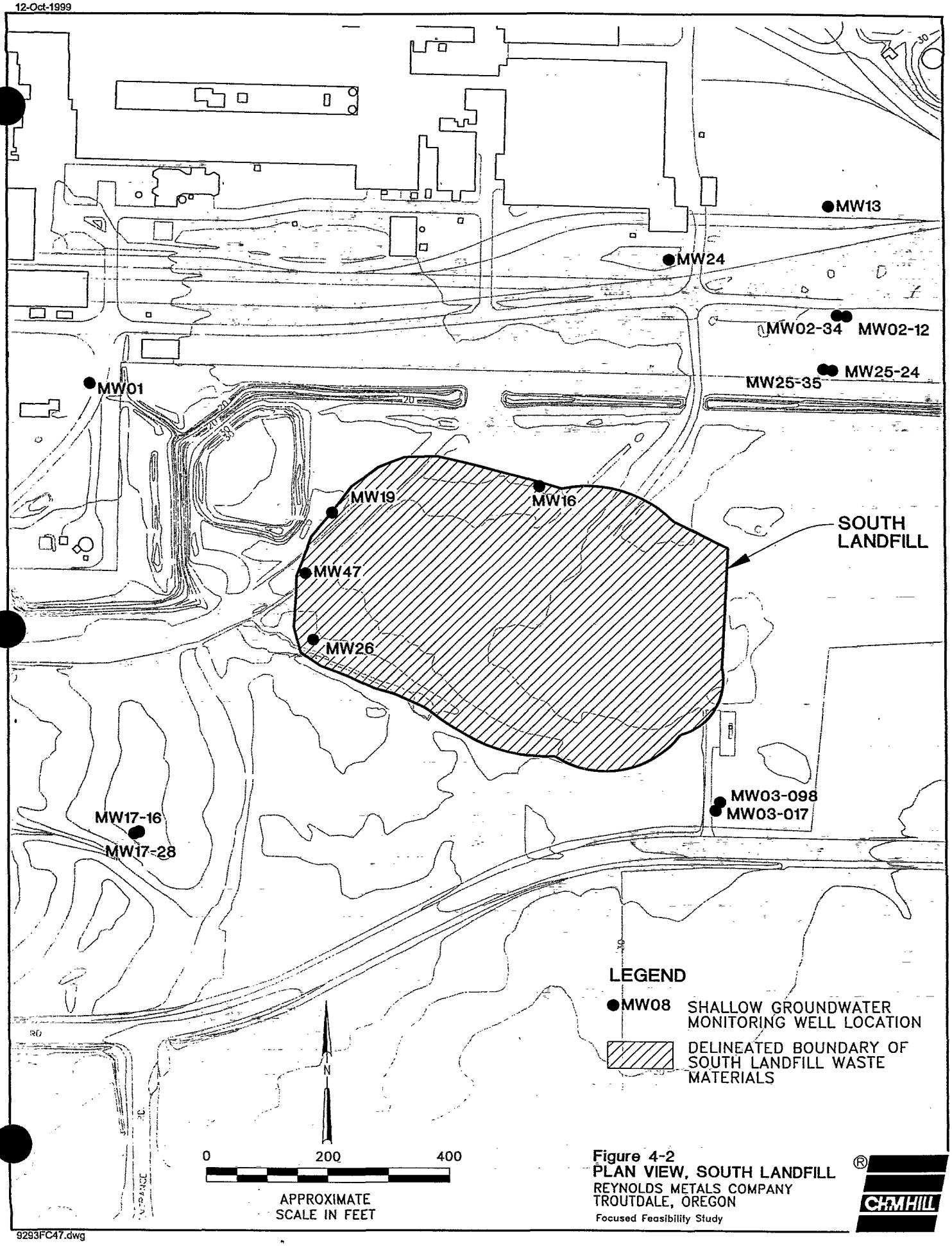

Figure 4-2
PLAN VIEW, SOUTH LANDFILL
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2M HILL

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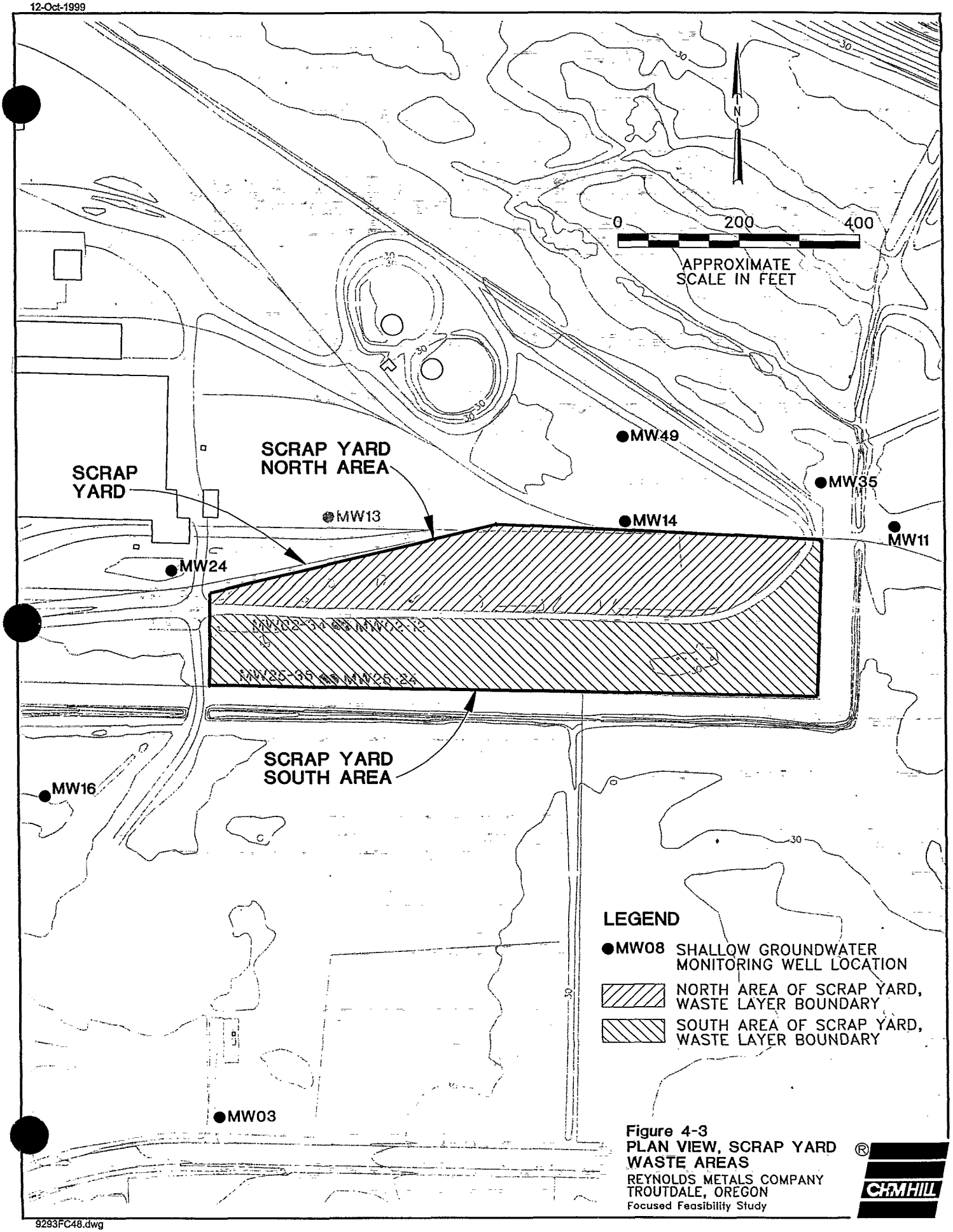

Figure 4-3
PLAN VIEW, SCRAP YARD WASTE AREAS
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2M HILL

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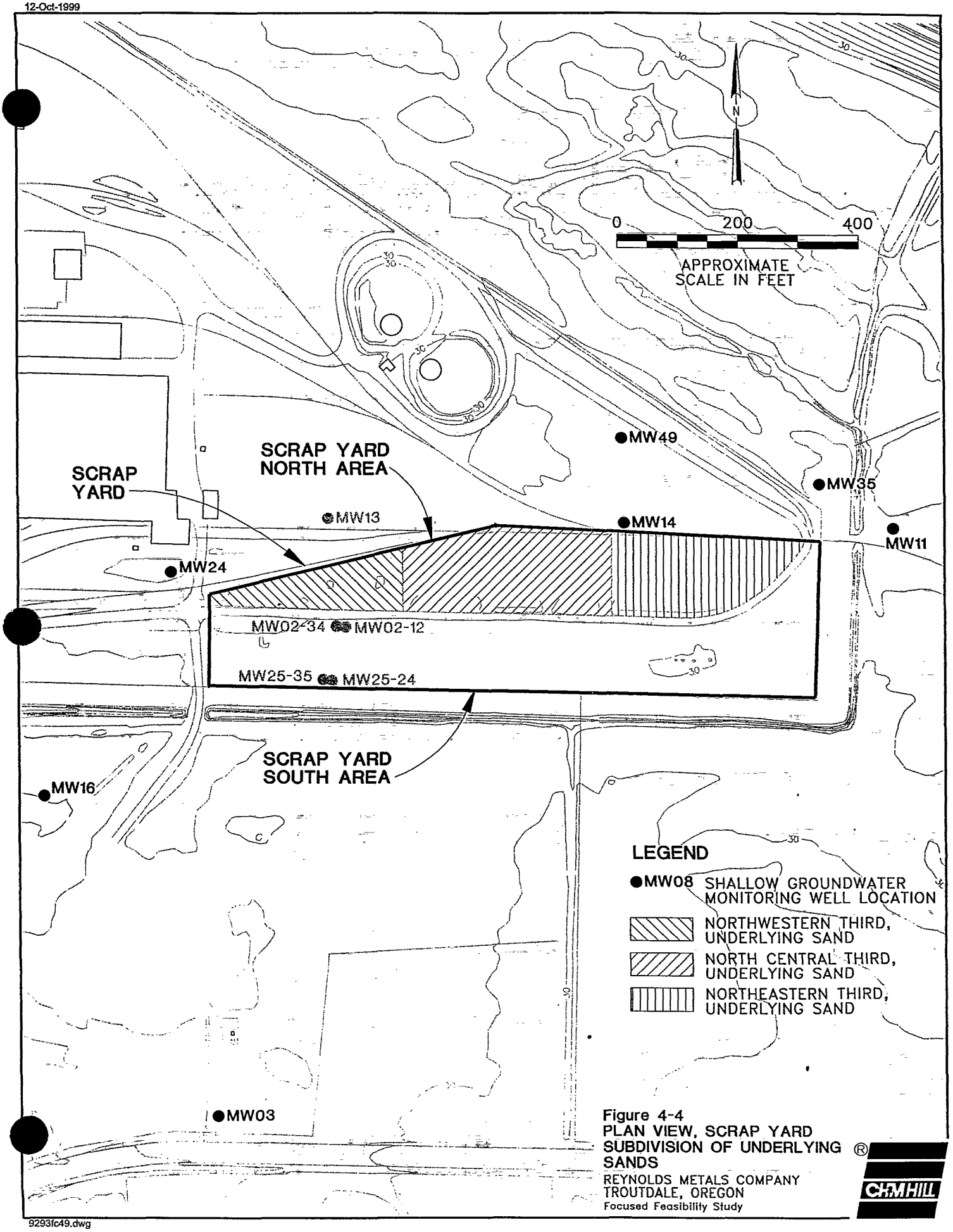

Figure 4-4
PLAN VIEW, SCRAP YARD SUBDIVISION OF UNDERLYING SANDS
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2M HILL

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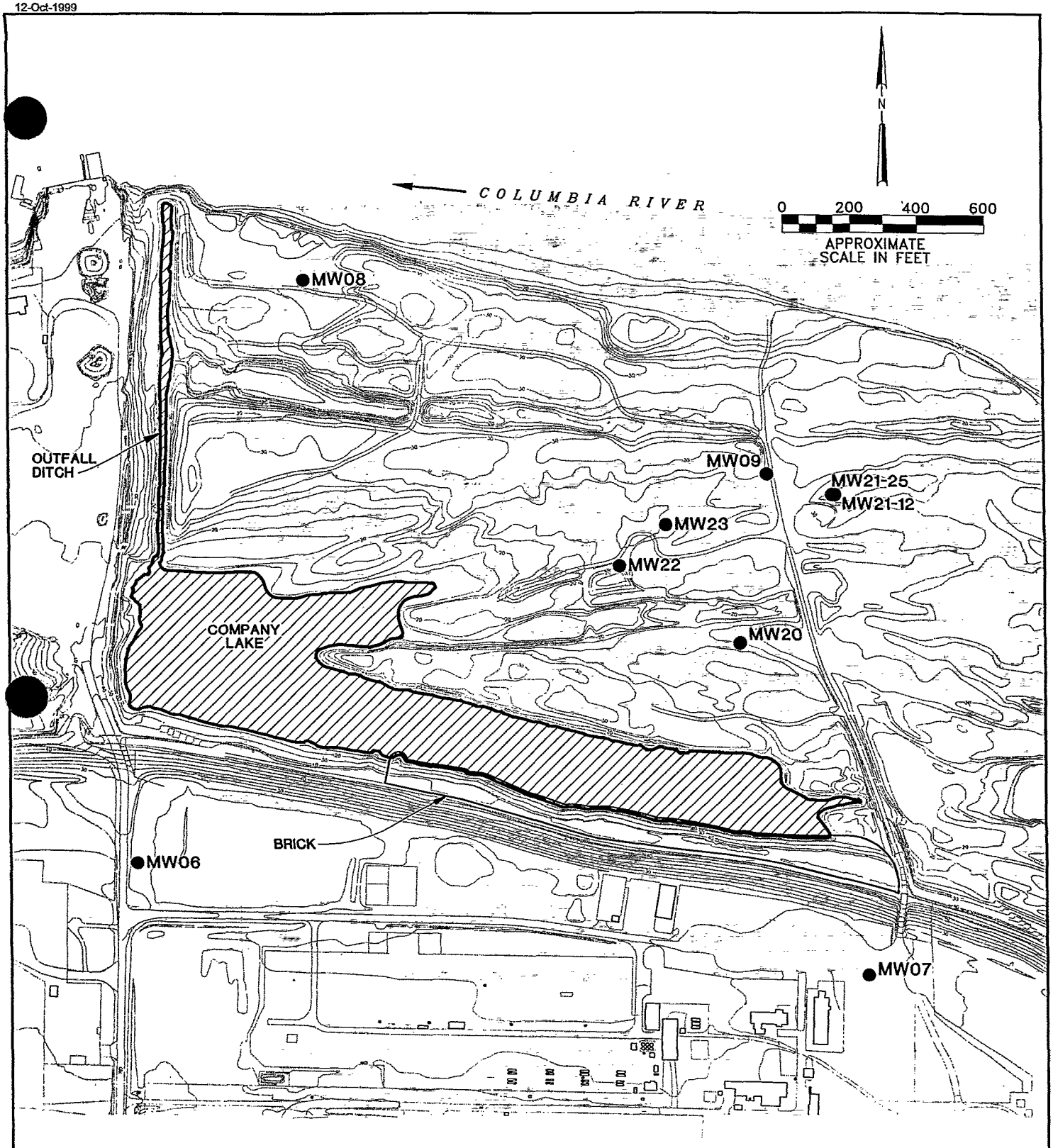

LEGEND

●MW-8 SHALLOW GROUNDWATER MONITORING WELL LOCATION

COMPANY LAKE AND OUTFALL DITCH AREAS

Figure 4-5
PLAN VIEW, COMPANY LAKE
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2M HILL

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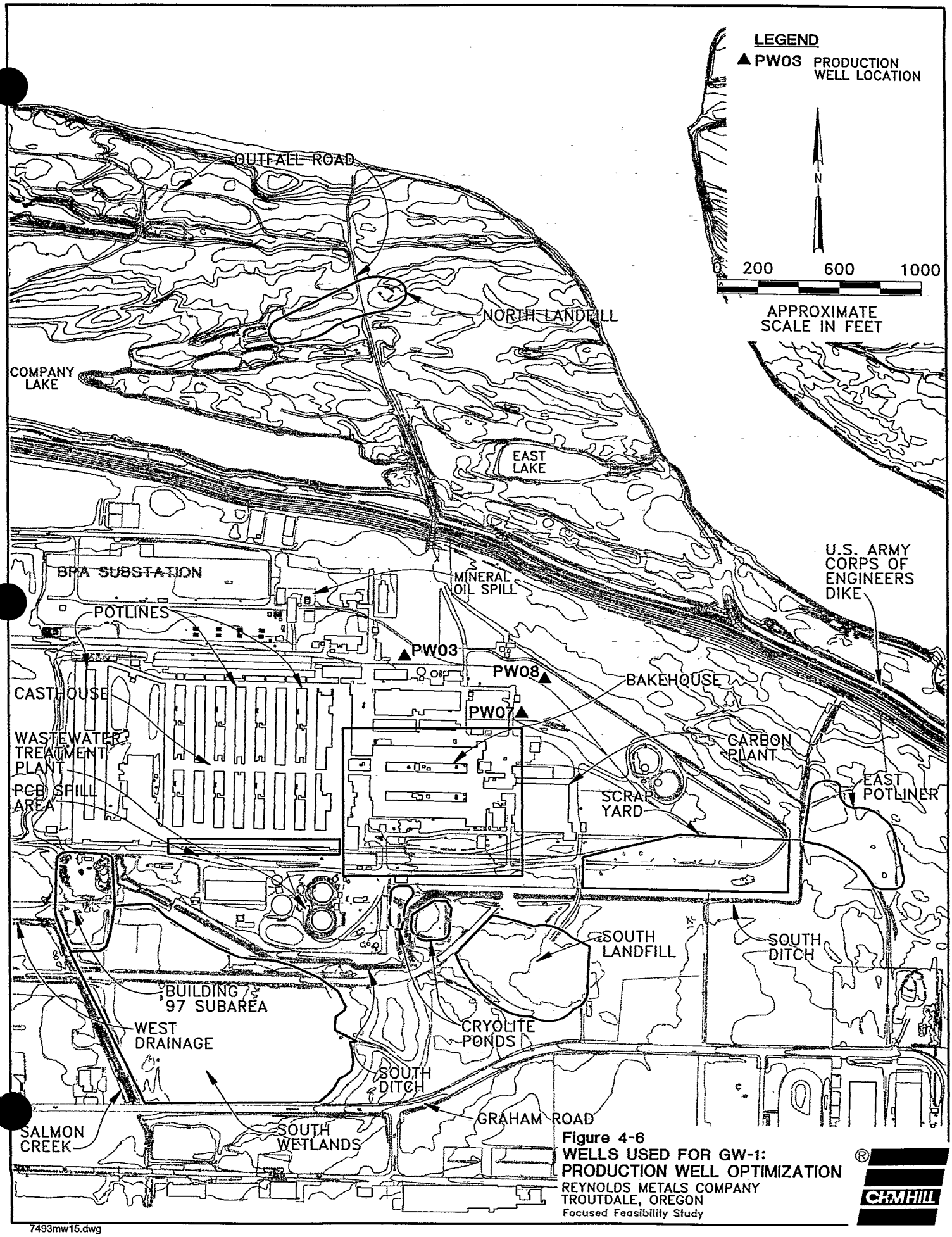

Figure 4-6
WELLS USED FOR GW-1: PRODUCTION WELL OPTIMIZATION
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

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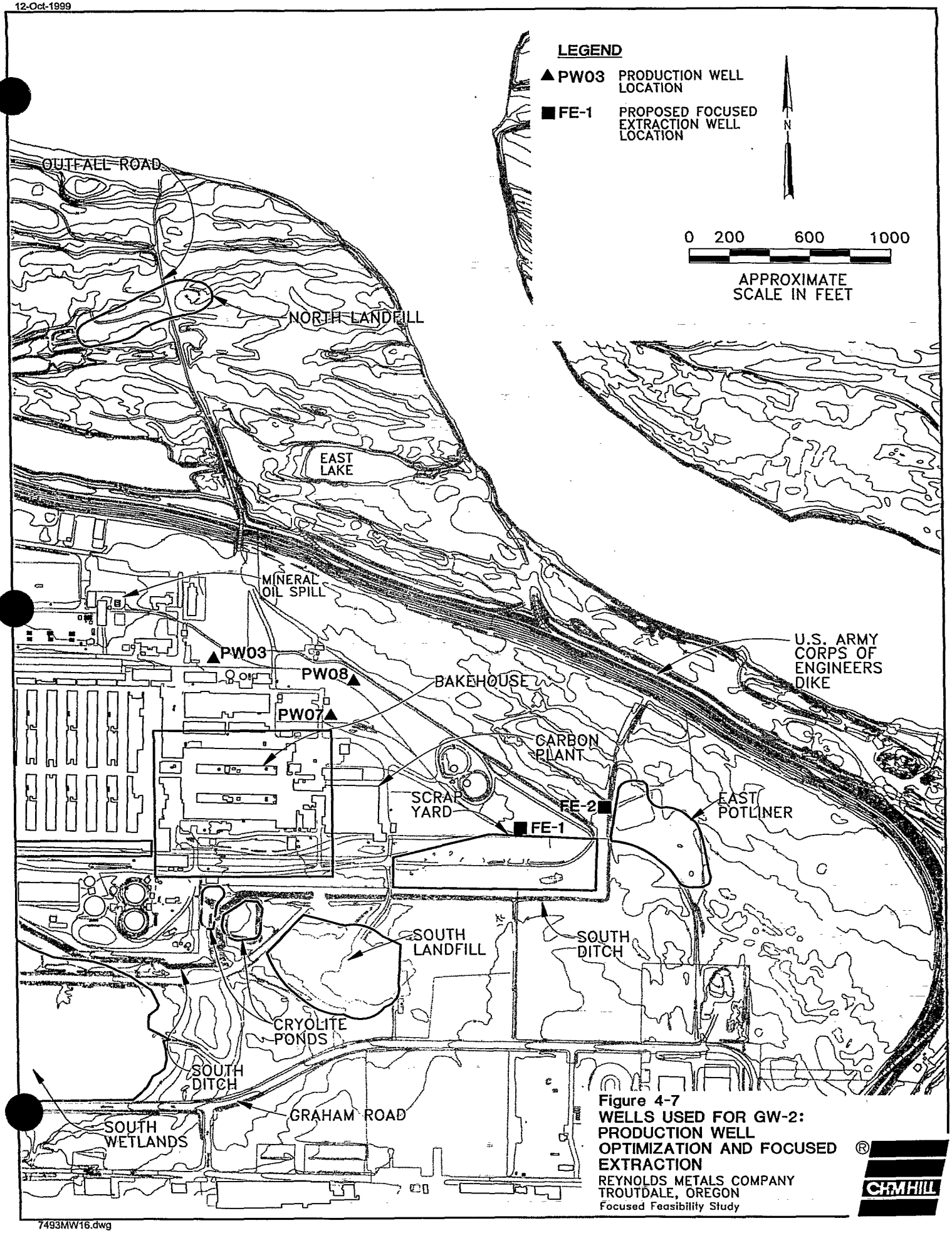

Figure 4-7
WELLS USED FOR GW-2: PRODUCTION WELL OPTIMIZATION AND FOCUSED EXTRACTION
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2M HILL

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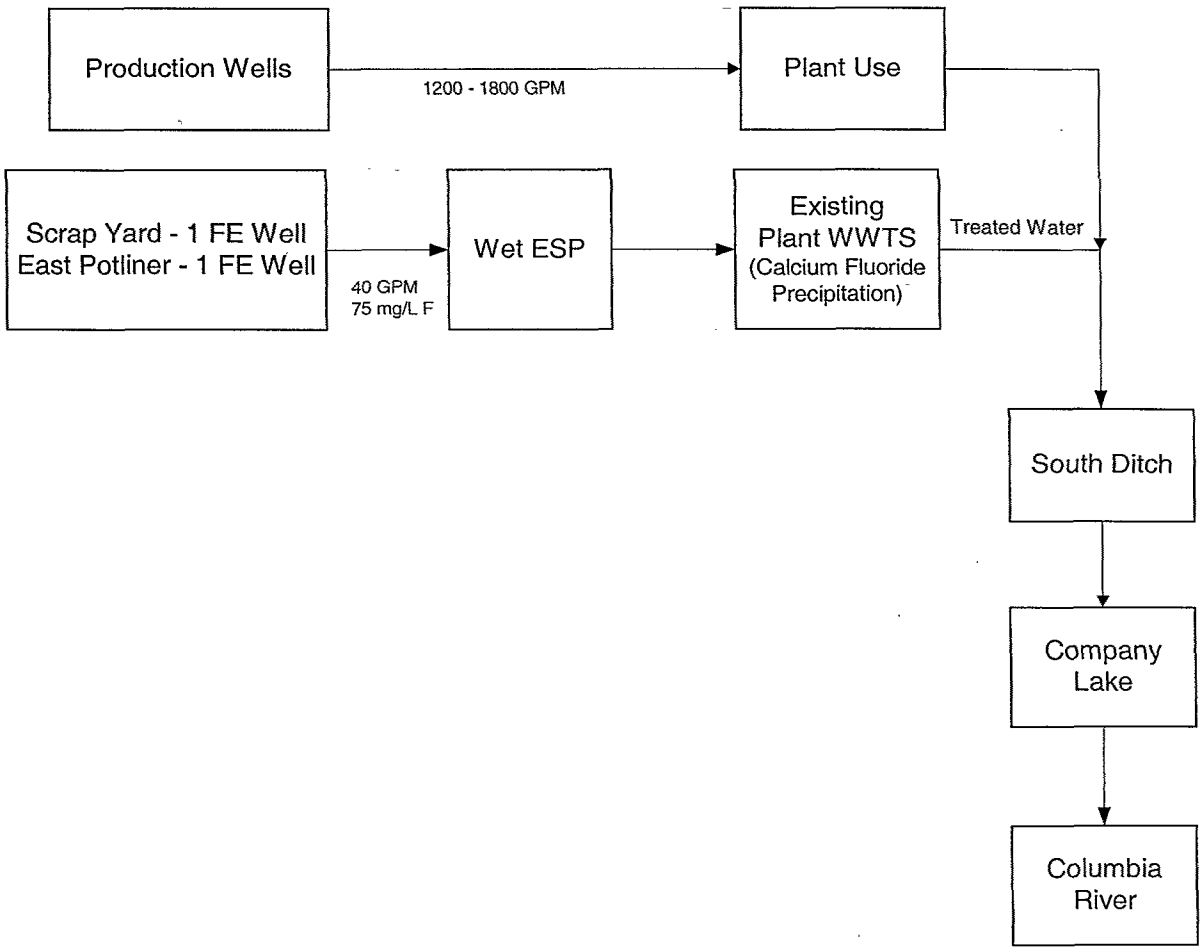
Figure 4-8 - Extracted Groundwater Treatment Flow Diagram for GW-2



Note: 1. Flows are estimated and concentrations are at startup. Not intended as a mass balance.
2. Flows may change after implementation and concentrations will decrease.
3. Calcium fluoride solids removal not shown.

12-Oct-1999

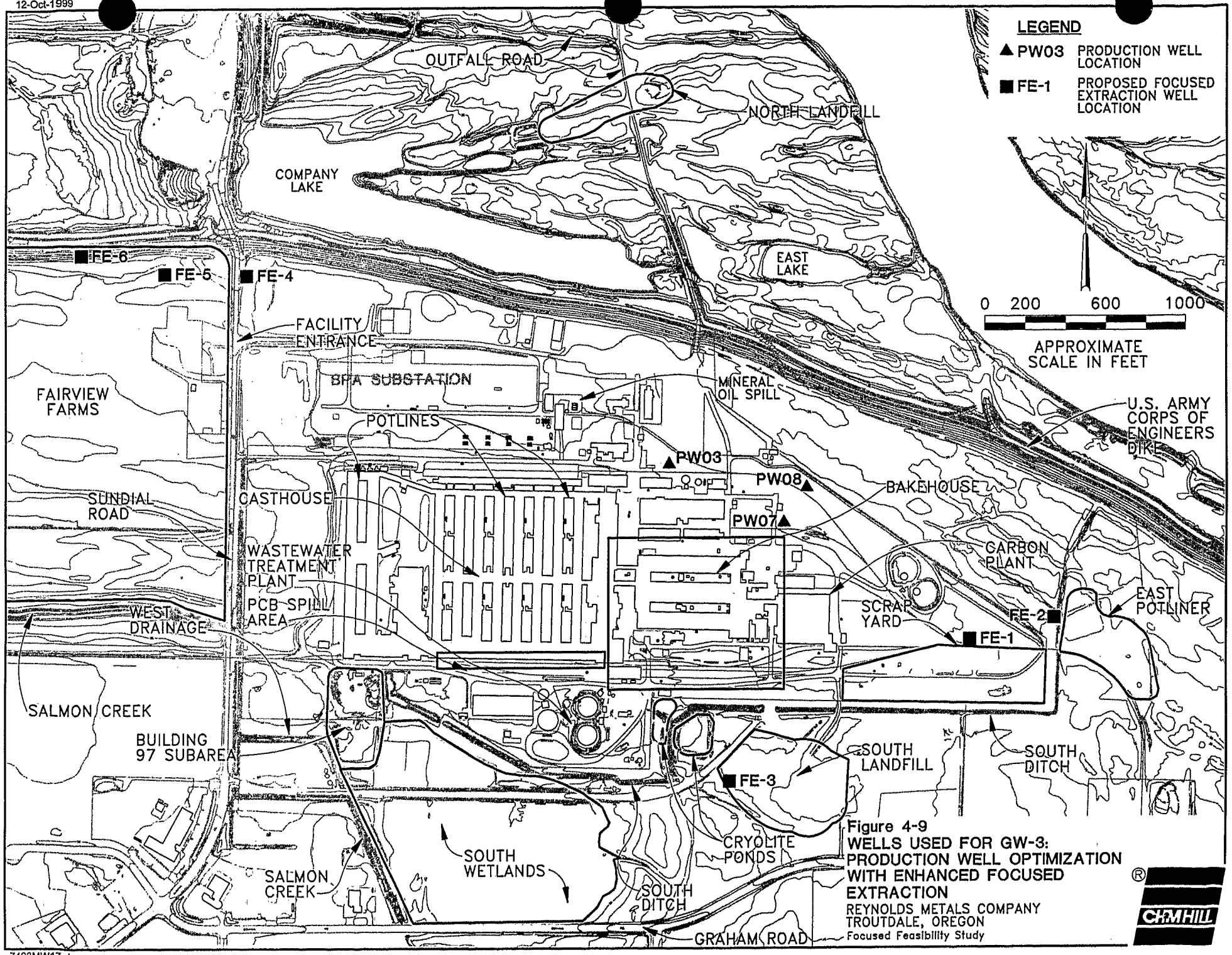


Figure 4-9
WELLS USED FOR GW-3: PRODUCTION WELL OPTIMIZATION WITH ENHANCED FOCUSED EXTRACTION
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2M HILL

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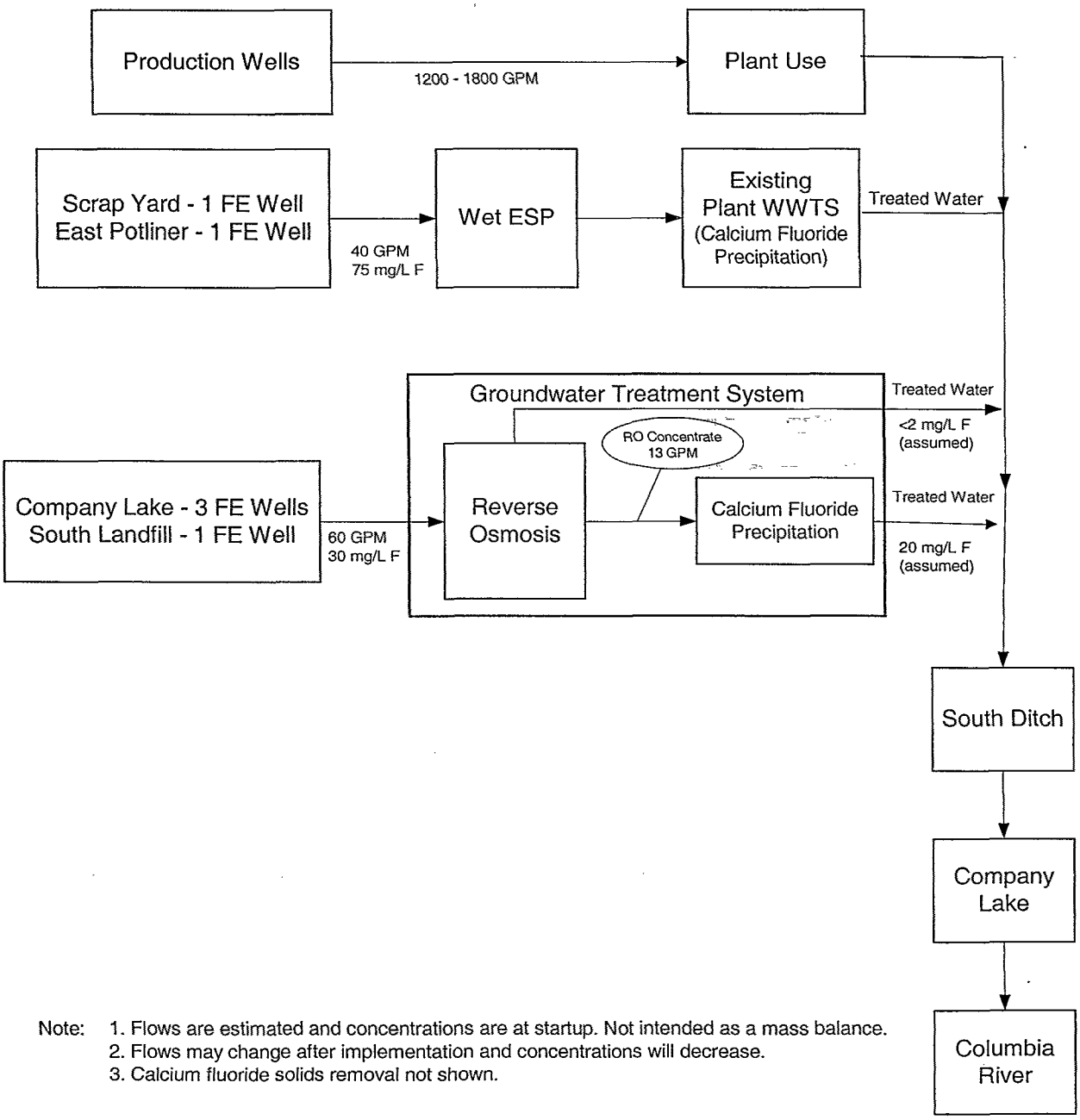
Figure 4-10 - Extracted Groundwater Treatment Flow Diagram for GW-3



Note: 1. Flows are estimated and concentrations are at startup. Not intended as a mass balance.
2. Flows may change after implementation and concentrations will decrease.
3. Calcium fluoride solids removal not shown.

12-Oct-1999

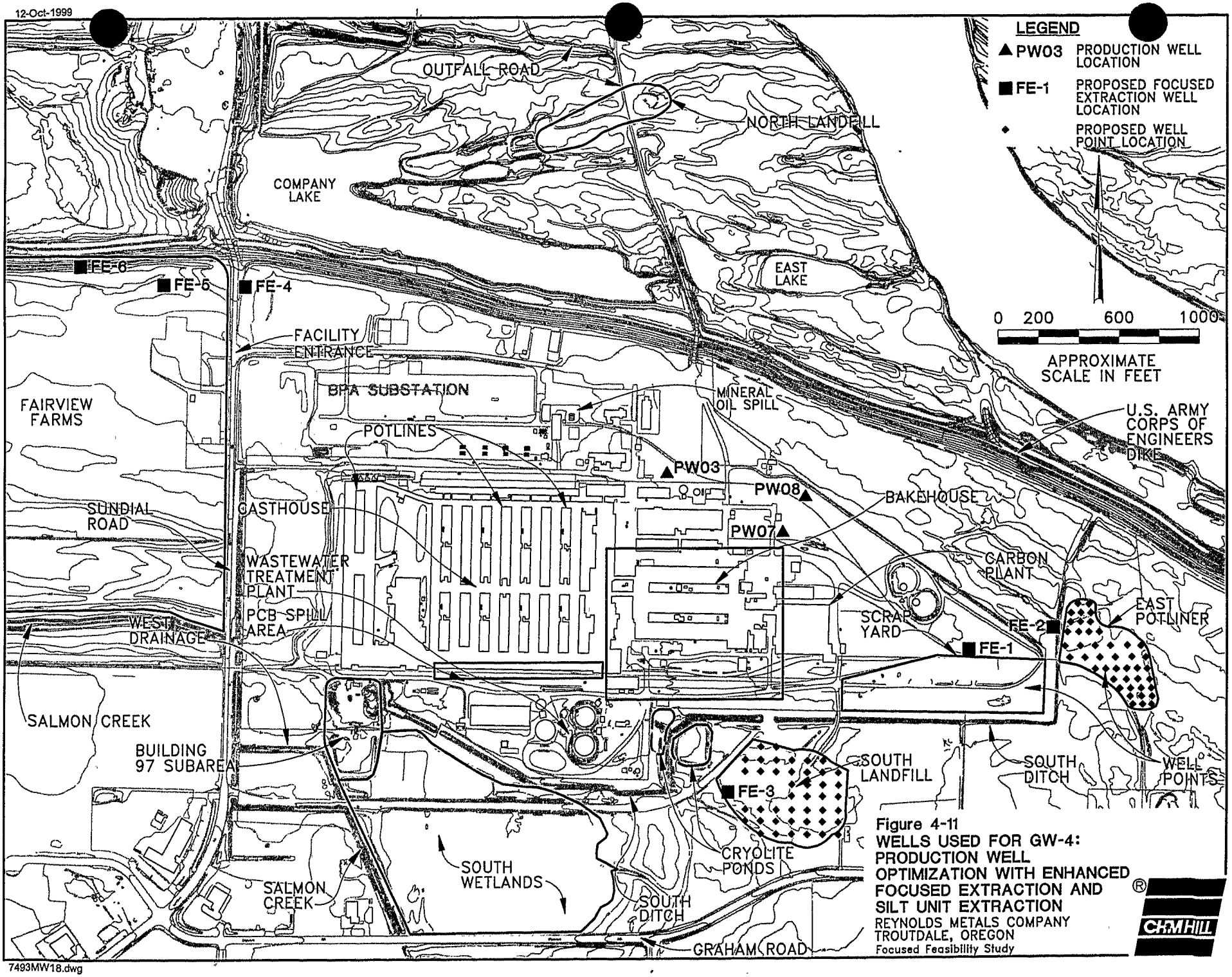


Figure 4-11
WELLS USED FOR GW-4: PRODUCTION WELL OPTIMIZATION WITH ENHANCED FOCUSED EXTRACTION AND SILT UNIT EXTRACTION
REYNOLDS METALS COMPANY
TROUTDALE, OREGON
Focused Feasibility Study

CH2M HILL

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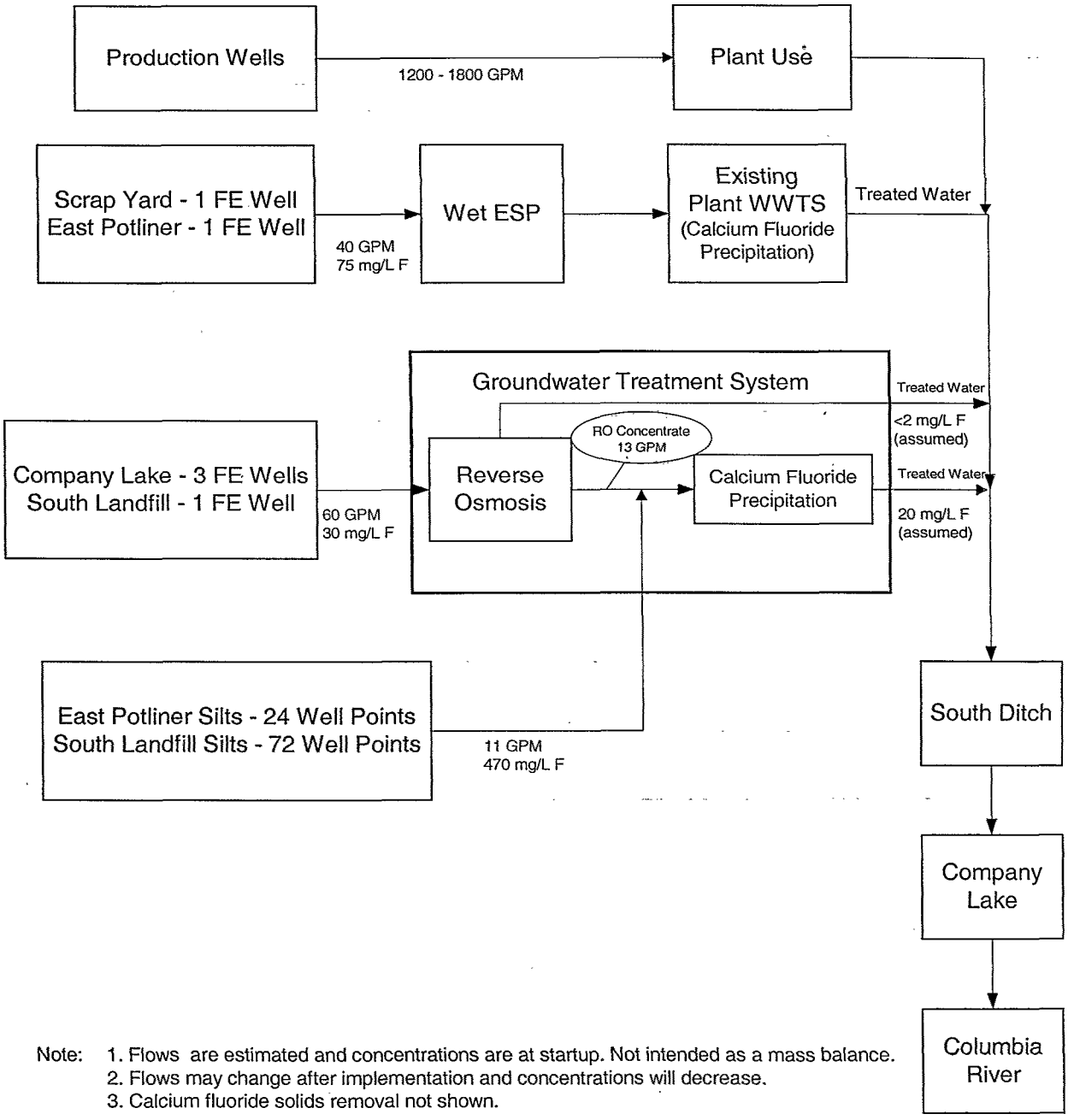
Figure 4-12 - Extracted Groundwater Treatment Flow Diagram for GW-4



Note: 1. Flows are estimated and concentrations are at startup. Not intended as a mass balance.
2. Flows may change after implementation and concentrations will decrease.
3. Calcium fluoride solids removal not shown.

SECTION 5

Remedial Alternative Development

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Remedial Alternative Development

The purpose of this section is to present sitewide remedial alternatives that include a range of remedial actions and meet the RAOs presented in Section 2.4. Table 5-1 outlines the major components of four sitewide alternatives that have been developed to address concerns at the Troutdale facility. Sections 5.2 through 5.5 introduce the strategy and components of each sitewide alternative. (The alternatives are evaluated in detail in Section 6.)

5.1 Cost Assumptions

Table 5-2 summarizes the costs for Alternatives A, B, and C and identifies the remedial options from Section 4 that are incorporated into each alternative. Detailed cost summaries for each alternative are provided in Appendix D. The No Action Alternative does not incur costs and is not included in Table 5-2.

The cost estimates for the area- or media-specific remedial *options* presented in Section 4 cannot be compared directly with the cost estimates for the sitewide remedial *alternatives* presented in this section. A key difference between the cost estimates for excavation and dredging options and the corresponding element in the sitewide alternatives is the assumption made with regard to disposal of excavated and dredged material. Offsite landfill disposal was assumed in Section 4 for all of the excavation and dredging options so that they could be evaluated and compared as independent area-of-concern actions. For sitewide alternatives, which can take advantage of economies of scale, this assumption is no longer required. Based on cost-effectiveness, onsite landfill disposal replaces offsite disposal in Alternatives B and C. (Alternative A does not include excavation.) The cost of an onsite landfill has been estimated separately for each alternative and is presented in separate line items for Alternatives B and C.

Therefore, the costs of some area-of-concern actions appear much lower when they are presented as an element of a sitewide alternative than when presented as an individual option in Section 4. Some of this difference is due to the cost of offsite transport and disposal, which is much higher than that of onsite disposal. However, the main difference is because the area-specific option costs include disposal costs, and the sitewide alternatives present disposal costs as a separate component. [For instance, Option NLF-4 has a total capital cost (including offsite disposal) of $10.8 million; NLF-4 presented as part of sitewide Alternative C (excluding disposal costs) has a total capital cost of $1.5 million.] With this exception, the costs for the options were not changed when included in a sitewide alternative.

5.2 No Action Alternative

The No Action Alternative assumes that the RMC plant will continue to operate in a normal fashion and includes:

- Continued use of the scrap yard for industrial storage

- Production well pumping in accordance with the manufacturing needs of the facility
- Continued use of Company Lake as part of the NPDES system

The No Action Alternative assumes that no further sources of COPCs will be introduced at the site in the future. As required by the NCP, the No Action Alternative has been retained for detailed analysis.

5.3 Alternative A

Sitewide Alternative A was developed to provide capping and containment of primary source materials and to minimize direct contact with COPCs at the site. Its major components are:

- Riprap cover at the north landfill
- Soil and vegetation cap at south landfill
- Gravel cap in the north area of the scrap yard
- Permeable cap for Company Lake sediments
- Production well optimization
- Institutional controls on groundwater and land use

The riprap cover at the north landfill provides erosion protection and reduces potential exposure pathways to COPCs. The permeable caps at the other areas reduce or eliminate potential exposure pathways.

Alternative A reduces or eliminates exposure of human and ecological receptors to COPCs at the site. While the risk assessment indicates that the north landfill, the south landfill, and the scrap yard do not exceed EPA human or ecological risk thresholds, they do exceed DEQ risk threshold criteria. The permeable caps address all but the trench worker scenario, which will be addressed by institutional controls. The permeable cap at Company Lake addresses human exposure to COPCs that exceed DEQ threshold criteria and ecological exposure to COPCs that exceeds EPA threshold criteria.

The groundwater approach for Alternative A offers an effective package to contain groundwater onsite at minimal cost. Production well optimization also protects against human exposure to COPCs in groundwater in the onsite industrial scenario. Deed restrictions to prevent us of groundwater exceeding MCLs are also included. This alternative will meet most but not all of the RAOs.

The total NPV cost for Alternative A is estimated at $8.1 million. Of this NPV amount, approximately 58 percent is for the permeable cap at Company Lake; 13 percent is for the production well optimization system; and the remaining 29 percent is for capping the land units.

5.4 Alternative B

Alternative B was developed using a strategy that focused on containment and restoration of groundwater, including targeted source removal and groundwater extraction at areas believed to have the most direct impact on groundwater quality. Removal actions will target

source materials within these areas that present the highest potential for continued migration of COPCs to intermediate and deep groundwater zones.

The main elements of Alternative B are:

- Dredging of process residue at Company Lake
- Excavation of the waste layer in the north portion of the scrap yard
- Riprap cover at the north landfill
- Institutional controls at the south landfill and the scrap yard, and on future land and groundwater use
- Production well optimization plus two focused extraction wells (at the east potliner area and at the scrap yard)
- Use of extracted groundwater from east potliner and the scrap yard as makeup water in the wet ESP system
- Consolidation of excavated and dredged material in a new onsite landfill

Alternative B provides many benefits by using a balance of cost-effective actions that focus on the overall protection of human health and the environment. The synergistic combination of area-of-concern actions and groundwater actions enhances the effectiveness of remediation. The basic approach of Alternative B is to remove the highest concentrations of COPCs in the scrap yard by excavation, and to remove process residue from Company Lake by dredging. COPCs at the scrap yard and Company Lake are the primary contributors of fluoride to groundwater in the UGS, intermediate, and deep zones.

The groundwater package will provide adequate containment of groundwater in the plant area through production well optimization (PWO). It will also protect the quality of RMC's water supply and restore portions of the groundwater plume through focused extraction (FE) and Company Lake dredging. The FE wells will be located in areas that are the primary contributors of fluoride to the intermediate- and deep-zone groundwater. Restoration of the intermediate and deep groundwater in the south plant area, along with the UGS below the scrap yard and the east potliner area, will be accomplished by the combination of the focused extraction and PWO. All of this will be accomplished cost effectively through the use of existing production wells and reuse of groundwater from the FE wells as makeup water for the wet ESP system. Deed restrictions to prevent use of groundwater exceeding MCLs will also be implemented.

Alternative B will provide erosion protection and reduce human exposure to COPCs at the north landfill. The implementation of access and use restrictions at the south landfill and the scrap yard will reduce human exposures that are above DEQ target risk criteria.

Alternative B incorporates an onsite landfill to consolidate excavated and dredged materials.

The total NPV cost for Alternative B is estimated to be $12.6 million. Of this NPV amount, approximately 56 percent is for dredging Company Lake; 19 percent is for construction of

the onsite landfill; 14 percent is for the groundwater response; and the remaining 11 percent is for the responses at the soil and debris areas.

5.5 Alternative C

Alternative C was developed using a source removal strategy. Its objective is to provide mass removal of COPCs through excavation of waste materials from the landfills and the scrap yard, and dredging of Company Lake. Groundwater restoration in the UGS would be accelerated by enhanced focused extraction. The main elements of Alternative C are:

- Excavation of the waste layer at the north landfill
- Excavation of the waste layer at the south landfill
- Excavation of the waste layer in the north portion of the scrap yard
- Dredging of process residue at Company Lake and mechanical dewatering of dredged materials
- Production well optimization plus six focused extraction wells (one well each at the scrap yard, the east potliner area, and the south landfill, and three wells at Company Lake)
- Use of extracted groundwater from the scrap yard and the east potliner area wells as makeup water in the wet ESP system
- Treatment of groundwater extracted from the Company Lake area and south landfill wells by reverse osmosis with brine treatment by calcium chloride precipitation
- Consolidation of excavated and dredged material in a new onsite landfill
- Institutional controls on land use and groundwater

Alternative C provides further mass removal (relative to Alternative B) by excavating waste materials from the north landfill, the south landfill, and the scrap yard and by dredging process residue from Company Lake. Alternative C incorporates an onsite landfill to consolidate excavated and dredged materials. The inclusion of excavation, dredging, focused extraction wells and advanced wastewater treatment in Alternative C preserves a broad range of remedial options for detailed evaluation.

The groundwater package for this alternative includes the components of Alternative B, plus four additional focused extraction wells (three southwest of Company Lake and one at south landfill) to provide a total of six focused extraction wells. The additional focused extraction well at the south landfill addresses groundwater restoration of a small area of the UGS where fluoride concentrations are above the MCL. This well is expected to reduce fluoride concentrations in the UGS, although there is no evidence of the intermediate zone in this area being affected by leaching of constituents from the south landfill. The focused extraction wells at Company Lake address an area outside the capture zone of the PWO in which fluoride concentrations exceed MCLs in the intermediate zone. A new treatment system for extracted groundwater will be required. Deed restrictions preventing use of groundwater exceeding MCLs will be implemented.

This alternative is considerably more costly than Alternative B. The total NPV cost for Alternative C is estimated to be $24.0 million. Of this NPV amount, the groundwater response accounts for approximately 28 percent; 24 percent is for construction of the onsite landfill; 30 percent is for Company Lake dredging; and the remaining 18 percent is for excavation at the three soil and debris areas.

Section 5 Tables

Table 5-1
Sitewide Remedial Alternatives

Alternative	North Landfill	South Landfill	Scrap Yard	Company Lake	Groundwater	Treatment/Disposal
No Action	No further action	No further action	No further action	No further action	Continued operation of production wells as needed to satisfy industrial process requirements only	None
A	Riprap cover (Option NLF-2)	Soil + vegetation cap (Option SLF-2)	Gravel cap in north area; institutional controls in south area (Option SY-2)	Permeable cap (Option CL-2)	Production well optimization (Option GW-1)	None required
B	Riprap cover (Option NLF-2)	Institutional controls (Option SLF-1)	Excavate waste layer in north area; institutional controls in south area (Option SY-3)[a]	Dredge process residue and mechanically dewater (Option CL-3)[a]	Production well optimization + focused extraction (2 wells at east potliner and scrap yard) (Option GW-2)	Onsite landfill; extracted groundwater used as makeup in wet ESP system
C	Excavate waste layer (Option NLF-4)[a]	Excavate waste layer (Option SLF-4)[a]	Excavate waste layer in north area; institutional controls in south area (Option SY-3)[a]	Dredge process residue and mechanically dewater (Option CL-3)[a]	Production well optimization + enhanced focused extraction (6 wells : 3 southwest of Company Lake, 1 at east potliner, 1 at south landfill, and 1 at scrap yard) (Option GW-3)	Onsite landfill; up to 40 gpm extracted groundwater used as makeup in wet ESP system; remaining groundwater treated by reverse osmosis/ precipitation

[a] In the development of sitewide alternatives, options that include excavation or dredging have been altered to remove offsite disposal. Waste disposal for the sitewide alternative includes a new onsite landfill.

Table 5-2
Cost Summaries for Sitewide Alternatives

Option	Total Capital	Annual O&M	NPV (7% for 30 years)	As-spent Dollars[d]
Remedial Alternative A				
NLF-2	$449,000	$20,000	$697,000	$1,787,000
SLF-2	$724,000	$24,000	$1,026,000	$3,755,000
SY-2	$376,000	$18,000	$597,000	$1,566,000
CL-2	$4,529,000	$17,000	$4,734,000	$6,151,000
GW-1[a]	--	$128,000	$1,057,000	$4,482,000
OSLF[b]	--	NA	NA	--
Total	$6,078,000	$207,000	$8,111,000	$17,741,000
Remedial Alternative B				
NLF-2	$449,000	$20,000	$697,000	$1,787,000
SLF-1	$81,000	$2,000	$106,000	$332,000
SY-3[c]	$500,000	$7,000	$584,000	$992,000
CL-3[c]	$7,070,000	$18,000	$7,117,000	$7,983,920
GW-2[a]	$375,000	$151,000	$1,763,000	$6,375,000
OSLF-B	$1,987,000	$31,000	$2,370,000	$4,212,000
Total	$10,462,000	$229,000	$12,637,000	$21,682,000
Remedial Alternative C				
NLF-4[c]	$1,508,000	$5,000	$1,571,000	$2,019,000
SLF-4[c]	$2,028,000	$4,000	$2,082,000	$2,800,000
SY-3[c]	$500,000	$7,000	$584,000	$992,000
CL-3[c]	$7,070,000	$18,000	$7,117,000	$7,983,000
GW-3[a]	$3,316,000	$297,000	$6,818,000	$10,809,000
OSLF-C	$4,773,000	$85,000	$5,826,000	$19,061,000
Total	$19,195,000	$416,000	$23,998,000	$43,666,000

NA = not applicable.
[a] Costs are in 1998 dollars. Annual performance monitoring costs for groundwater options are $128,000 annually for the first 5 years of operation and are assumed to drop by 50 percent for the remainder of the 30-year life.
[b] An onsite landfill does not apply to this option because no material will be excavated.
[c] In the development of the sitewide alternatives, options that include excavation and dredging have been altered to eliminate offsite hauling and disposal costs. Alternatives B and C include construction and operation costs for a new, onsite landfill.
[d] As-spent dollars estimate the actual outlay of inflated dollars over the duration of a project.

SECTION 6

Detailed Analysis of Remedial Alternatives

SECTION 6

Detailed Analysis of Remedial Alternatives

This section provides a detailed analysis of the sitewide remedial alternatives presented in Section 5. Section 6.1 discusses the criteria used to evaluate the alternatives, and Sections 6.2 through 6.5 contain detailed analyses of each remedial alternative, including the No Action Alternative.

6.1 Evaluation Criteria

According to the *USEPA Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (OSWER Directive 9355.3-01), nine evaluation criteria must be considered in order to address CERCLA requirements:

- Overall protection of human health and the environment
- ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

The first seven criteria are discussed in this section for each of the sitewide alternatives. They are also the basis for the comparative discussion of alternatives and identification of the preferred alternative (Section 7). The last two criteria, state and community acceptance, are not discussed in this section; EPA will address them following public comment on the RI/FS and the Proposed Plan. The following text briefly describes the scope of the evaluation criteria. Note that the evaluation of effectiveness, cost, and implementability for each of the remedial options covered most of the criteria discussed in this section. The purpose of this section is to pull together the area- and media-specific options, and evaluate their combined attributes.

6.1.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment is one of two threshold criteria that the selected alternative must satisfy. The evaluation of this criterion is based on the results of the baseline risk assessment and was included in the discussion of effectiveness for the remedial options. Consideration of the combined effects of the individual components of each alternative is a critical portion of the evaluation. For each alternative, the following evaluations are presented:

- Comparison of baseline human health risk estimates with residual risk estimates
- Comparison of ecological risk estimates with regulatory risk criteria

- Evaluation of exposure pathways for human and ecological receptors following implementation of the remedial alternative

6.1.2 ARARs

Compliance with applicable or relevant and appropriate requirements (ARARs) is the second of the threshold criteria. ARARs have been evaluated for each sitewide alternative and are discussed briefly in this section. Appendix B contains the complete discussion of ARARs. For each alternative, the following evaluations are presented:

- Compliance with location-specific ARARs
- Compliance with chemical-specific ARARs
- Compliance with action-specific ARARs

6.1.3 Long-Term Effectiveness and Permanence

The evaluation of long-term effectiveness and permanence is focused on the technical effectiveness and reliability of the remedies. While this measure of effectiveness was included in the evaluation of remedial options, it is discussed in more detail for the remedial alternatives. For each alternative, the following evaluations are presented:

- Magnitude of residual risk
- Adequacy and reliability of controls

6.1.4 Reduction of Toxicity, Mobility, and Volume Through Treatment

This evaluation criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of waste materials, and thereby reduce the principal threats at a site. For each alternative, the following evaluations are presented:

- Treatment processes used and materials treated
- Amount of waste material destroyed or treated
- Degree of expected reduction in toxicity, mobility, or volume
- Degree to which treatment is irreversible
- Type and quantity of residuals remaining after treatment

6.1.5 Short-Term Effectiveness

The potential effects on human health and the environment during construction and implementation of each alternative are evaluated as short-term effectiveness. The period of evaluation includes the construction and startup period, and the duration of operation until the remedial action objectives are achieved. For each alternative, the following evaluations are presented:

- Protection of community during remedial actions
- Protection of workers during remedial actions
- Environmental impacts
- Time to compliance

For the soil and debris areas and Company Lake, consideration of the time to compliance as a "short-term" issue is consistent with the length of time that will be required to complete

the options, in most cases one or two construction seasons. For the groundwater options, time to compliance will require a much longer time, depending on the area and the groundwater zone, but it is evaluated with short-term considerations here to be consistent with EPA practice.

6.1.6 Implementability

The evaluation of implementability includes the technical and administrative feasibility of implementing each alternative, as well as the availability of services and materials required for implementation. Because the options evaluated in this FS were originally identified as potential early actions, implementability was an important criterion in their selection. For each alternative, the following evaluations are presented:

- Ability to construct, operate, and monitor the technology
- Reliability of the technology
- Ease of undertaking additional remedial action, if necessary
- Ability to coordinate with and obtain approvals from other agencies
- Availability of equipment, specialists, technologies, offsite treatment, storage or disposal services, and capacity

6.1.7 Cost

The cost of each remedial option is presented using two costing methods: net present value (NPV) and as-spent dollars. The NPV measure includes initial capital expenditures for implementation of the remedial action, as well as the annual operation and maintenance (O&M) costs incurred during the lifetime of the remedial action. NPV costs present the present worth of the costs assuming a discount rate of 7 percent over a 30-year operation period.

As-spent dollars provide a measure of the costs incurred as a result of initial capital expenditures and annual O&M costs on the basis of actual cash flows. In effect, this measure provides a rollup of cash expenditures inflated on an annual basis over a 30-year period. RMC uses this tool to evaluate future cash flows. For each alternative, the following evaluations are presented:

- Capital costs
- Annual operation and maintenance costs
- Net present value (30-year basis)
- As-spent cost (30-year basis)

6.2 No Action Alternative

The No Action Alternative serves as a baseline for comparison with other potential remedial alternatives. No Action assumes continued use of both the scrap yard for storage and of Company Lake as part of the NPDES system. Groundwater extraction from the production wells would continue as needed to meet the needs of the manufacturing operation. No monitoring or site access or use restrictions would be implemented.

Tables NA-1 through NA-7 summarize the No Action Alternative with regard to the first seven CERCLA criteria listed on page 6-1.

In summary, the No Action Alternative does not reduce risk and is therefore not protective. The No Action alternative does not meet ARARs groundwater quality requirements. Considerations of implementability and effectiveness are moot, and the alternative does not incur costs.

6.3 Alternative A

Alternative A reduces exposure of human and ecological receptors to COPCs at the site by providing capping and containment of primary source materials.

Tables Alt. A-1 through Alt. A-7 summarize Alternative A with regard to the first seven CERCLA criteria listed on page 6-1.

In summary, Alternative A is expected to reduce risk to acceptable levels for all scenarios except for trench workers at the three soil and debris areas, and future offsite residential use of groundwater. Trenching at the north landfill is extremely unlikely because of its location. Trenching at the other two locations is also unlikely, but if it occurred, workers would be required to wear protective clothing. The future offsite residential groundwater use, at Fairview Farms, is highly unlikely because of current and anticipated zoning restrictions, the presence of high-voltage power lines, and the proximity to heavy manufacturing property. Groundwater use, like trench worker exposure, will be addressed by a combination of production well optimization and institutional controls, including deed restrictions. Alternative A is therefore considered protective overall.

ARARs are met by the actions in Alternative A except for exceedance of MCLs in groundwater at several locations throughout the site. Although the actions taken at the soil and debris areas and Company Lake in Alternative A are not permanent, they are effective and reliable in both the long term and short term, and, with the exception of the cap at Company Lake, are easily implemented. The groundwater action in Alternative A is protective under all but the future potential offsite residential use scenario. It is effective in preventing deterioration of current conditions and is easily implemented. The cost of Alternative A is approximately 64 percent of the next most costly alternative.

6.4 Alternative B

Alternative B is focused on containment and restoration of groundwater, with targeted source removal actions at areas believed to have the primary impact on groundwater quality.

Tables Alt. B-1 through Alt. B-7 summarize Alternative B with regard to the first seven CERCLA criteria listed on page 6-1.

In summary, Alternative B reduces risk to protective levels by capping at north landfill, by excavation of waste at the scrap yard and dredging of Company Lake sediments, and by institutional controls on groundwater use, and at the south landfill and the scrap yard. The removal actions in this alternative at the scrap yard and Company Lake are permanent. All

the actions in Alternative B are effective, reliable, and easily implemented. The groundwater actions in this alternative are effective in preventing offsite migration of groundwater containing COPCs above MCLs, and will improve groundwater quality onsite by providing focused extraction in the scrap yard and east potliner areas. The combination of dredging of Company Lake sediments with production well optimization will result in accelerated restoration of groundwater quality south and east of Company Lake. The cost of Alternative B is approximately 156 percent of Alternative A and approximately 53 percent of Alternative C.

6.5 Alternative C

Alternative C incorporates a source removal strategy with the goal of accelerating restoration of the groundwater.

Tables Alt. C-1 through Alt. C-7 summarize the evaluation of Alternative C with regard to the first seven CERCLA criteria listed on page 6-1.

In summary, Alternative C reduces risk by removing waste at the north landfill, the south landfill, the scrap yard, and Company Lake. All these actions are permanent, effective, reliable, and implementable. Excavation of the landfills does not provide additional risk reduction or other benefits (compared to Alternative B) proportional to the increased cost. The additional groundwater actions in Alternative C, focused extraction at the south landfill and at Company Lake, do not result in significant risk reduction, but only shorten the time that groundwater use restrictions would be required at Company Lake. Fluoride in groundwater at the south landfill is not migrating from the UGS to the intermediate and deep zones, and therefore is not a significant problem. Treatment of this extracted groundwater would require installation of a new treatment system, probably incorporating reverse osmosis, which is costly and may not be effective for this groundwater. Alternative C costs are approximately three times higher than those for Alternative A and twice the cost of Alternative B.

Section 6 Tables

No Action Alternative Tables
Tables NA-1 Through NA-7

Table NA-1 Overall Protection of Human Health and the Environment – No Action Alternative	
Comparison of Baseline Human Health Risk Estimates with Residual Risk Estimates	
North Landfill South Landfill	EPA target risk criteria not exceeded. DEQ risk criteria exceeded for trespasser, intermittent maintenance worker, and trench worker scenarios.
Scrap Yard	EPA target risk criteria not exceeded. DEQ risk criteria exceeded for intermittent maintenance worker and trench worker scenarios.
Company Lake	EPA target risk criteria not exceeded. DEQ risk criteria exceeded for trespasser scenario.
Groundwater	Future offsite residential risk estimate exceeds EPA and DEQ criteria. All other exposure scenarios below risk criteria.
Comparison of Ecological Risk Estimates with Regulatory Risk Criteria	
North Landfill South Landfill	The north and south landfills do not exceed ecological risk criteria.
Scrap Yard	Not applicable.
Company Lake	Tier 2 ecological risk criteria exceeded for fluoride.
Groundwater	Not applicable. Groundwater has no measurable effect on surface water quality and therefore does not affect ecological receptors.
Evaluation of Exposure Pathways for Human and Ecological Receptors Following Implementation of the Remedial Alternative	
North Landfill South Landfill	EPA human health target risk criteria not exceeded. DEQ human health risk criteria exceeded for trespasser, intermittent maintenance worker, and trench worker scenarios.
Scrap Yard	EPA human health target risk criteria not exceeded. DEQ human health risk criteria exceeded for intermittent maintenance worker and trench worker scenarios.
Company Lake	EPA human health target risk criteria not exceeded. DEQ human health risk criteria exceeded for trespasser scenario. Ecological exposure to COPCs in sediments exceeds EPA criteria.
Groundwater	Future offsite residential risk estimate exceeds EPA and DEQ criteria. All other exposure scenarios below risk criteria.

Table NA-2 ARARs – No Action Alternative	
Compliance with Location-Specific ARARs	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	Not applicable.
Compliance with Chemical-Specific ARARs	
North Landfill South Landfill Scrap Yard Company Lake	No Action would not trigger chemical-specific requirements.
Groundwater	Groundwater exceeds MCLs for fluoride in multiple locations throughout the site. MCL exceedances were detected for a small number of COPCs. With few exceptions, these were co-located with the fluoride plume. See Appendix B for further detail.
Compliance with Action-Specific ARARs	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	Not applicable.

Table NA-3 Long-Term Effectiveness and Permanence – No Action Alternative	
Magnitude of Residual Risk	
North Landfill South Landfill Scrap Yard Company Lake	No reduction in risk achieved by No Action.
Groundwater	COPC concentrations in groundwater do not exceed EPA or DEQ threshold risk criteria for any scenario other than the future offsite residential receptor.
Adequacy and Reliability of Controls	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	Not applicable.

Table NA-4 Reduction of Toxicity, Mobility, and Volume Through Treatment – No Action Alternative	
Treatment Processes Used and Materials Treated	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	None.
Amount of Waste Material Destroyed or Treated	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	None.
Degree of Expected Reduction in Toxicity, Mobility, or Volume	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	None.
Degree to Which Treatment Is Irreversible	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	Not applicable.
Type and Quantity of Residuals Remaining After Treatment	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	Not applicable.

Table NA-5 Short-Term Effectiveness – No Action Alternative	
Protection of Community During Remedial Actions	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	Not applicable.
Protection of Workers During Remedial Actions	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	Not applicable.
Environmental Impacts	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	No change in current conditions.
Time to Compliance	
North Landfill South Landfill Scrap Yard Company Lake	Not applicable.
Groundwater	Not expected to achieve compliance with MCLs within several hundred years.

Table NA-6 Implementability – No Action Alternative	
Ability to Construct, Operate, and Monitor the Technology	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	Not applicable.
Reliability of the Technology	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	Not applicable.
Ease of Undertaking Additional Remedial Action, If Necessary	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	No obstacles to future action.
Ability to Coordinate with and Obtain Approvals from Other Agencies	
North Landfill	No Action for the north landfill may not be acceptable to stakeholders (and may require coordination with or approval from other agencies) because the landfill is located in a 10-year floodplain, the potential for erosion is not addressed, and risk threshold criteria are exceeded.
South Landfill	No Action would not require approval from or coordination with other agencies.
Scrap Yard	No Action would not require approval from or coordination with other agencies.
Company Lake	No Action for Company Lake may not be acceptable to stakeholders (and may require coordination with or approval from other agencies) because of its location in the 10-year floodplain and the exceedance of human and ecological risk criteria.
Groundwater	No Action would not require approval from or coordination with other agencies.
Availability of Equipment, Specialists, Technologies, Offsite Treatment, Storage or Disposal Services, and Capacity	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	Not applicable.

Table NA-7 Cost – No Action Alternative	
Capital Costs	
North Landfill South Landfill Scrap Yard Company Lake Groundwater Onsite Landfill Total	Not applicable.
Annual Operation and Maintenance Costs	
North Landfill South Landfill Scrap Yard Company Lake Groundwater Onsite Landfill Total	Not applicable.
Net Present Value (30-Year Basis)	
North Landfill South Landfill Scrap Yard Company Lake Groundwater Onsite Landfill Total	Not applicable.
As-Spent Cost (30-Year Basis)	
North Landfill South Landfill Scrap Yard Company Lake Groundwater Onsite Landfill Total	Not applicable.

Alternative A Tables
Tables Alt. A-1 Through Alt. A-7

Table Alt. A-1 Overall Protection of Human Health and the Environment – Alternative A	
Comparison of Baseline Human Health Risk Estimates with Residual Risk Estimates	
North Landfill	Reduces risk to acceptable levels for all but the trench worker scenario, which is addressed by institutional controls. Trenching or subsurface construction at north landfill is extremely unlikely because of zoning restrictions and its location north of the COE dike in the floodplain.
South Landfill	Reduces risk to acceptable levels for all but the trench worker scenario, which is addressed by institutional controls.
Scrap Yard	Reduces risk in the north area to acceptable levels for all but the trench worker scenario, which is addressed by institutional controls. Protection of the intermittent maintenance worker and the trench worker is addressed by institutional controls for the south area.
Company Lake	Reduces risk to acceptable levels.
Groundwater	The offsite future residential exposure scenario exceeds threshold risk criteria, and this is not expected to improve in the foreseeable future.
Comparison of Ecological Risk Estimates with Regulatory Risk Criteria	
North Landfill	North landfill does not exceed ecological risk criteria.
South Landfill	South landfill does not exceed ecological risk criteria.
Scrap Yard	Not applicable.
Company Lake	Installation of a permeable cap on the sediments at Company Lake is expected to reduce ecological risk below threshold criteria.
Groundwater	Not applicable. Groundwater has no measurable effect on surface water quality and, therefore, does not affect ecological receptors.
Evaluation of Exposure Pathways for Human and Ecological Receptors Following Implementation of the Remedial Alternative	
North Landfill	Human and ecological exposure to COPCs will be prevented by installation of a riprap cap for all scenarios except the trench worker, which will be addressed by institutional controls.
South Landfill	Human and ecological exposure to COPCs will be prevented by installation of a soil and vegetation cover for all scenarios except the trench worker, which will be addressed by institutional controls.
Scrap Yard	Capping of the waste layer in the north area will prevent human exposure to COPCs for all scenarios except the trench worker, which may need to be addressed by institutional controls. The intermittent maintenance worker and trench worker scenarios will be addresses by institutional controls, such as site use restrictions, for the south area.
Company Lake	Installation of a permeable cap on the sediments at Company Lake is expected to reduce the exposure to COPCs for trespassers and ecological receptors below threshold criteria.
Groundwater	Deed restrictions will be implemented to address the future offsite residential exposure pathway for groundwater.

Table Alt. A-2 ARARS – Alternative A	
Compliance with Location-Specific ARARs	
North Landfill	Installation of a riprap cap at the north landfill is expected to comply with restrictions on construction in floodplains.
South Landfill Scrap Yard	No location-specific ARARs were identified for these areas.
Company Lake	Installation of a permeable cap on the sediments at Company Lake is expected to comply with restrictions on construction in floodplains.
Groundwater	No location-specific ARARs for this action.
Compliance with Chemical-Specific ARARs	
North Landfill South Landfill Scrap Yard Company Lake	No chemical-specific ARARs were identified for this action.
Groundwater	Because the plant water system provides both process and potable water, the MCLs under the Safe Drinking Water Act are applicable (at the tap) to the groundwater extracted using production well optimization. Groundwater will continue to exceed MCLs at various locations throughout the site. Production well optimization will prevent MCLs from being exceeded in the plant water supply.
Compliance with Action-Specific ARARs	
North Landfill	A riprap cover should meet action-specific ARARs.
South Landfill	A soil and vegetation cover should meet action-specific ARARs.
Scrap Yard	No action-specific ARARs were identified for this action, other than proper management of any debris removed prior to placement of the gravel cap.
Company Lake	Placement of the permeable cap on the sediments at Company Lake will need to be controlled to prevent violation of the RMC-Troutdale NPDES permit.
Groundwater	It is assumed that production well optimization can be implemented within the existing RMC water rights.

Table Alt. A-3 Long-Term Effectiveness and Permanence – Alternative A	
Magnitude of Residual Risk	
North Landfill	Reduces risk to acceptable levels for all but the trench worker scenario, which is addressed by institutional controls. Trenching or subsurface construction at north landfill is extremely unlikely because of its location north of the COE dike in the floodplain.
South Landfill	Reduces risk to acceptable levels for all but the trench worker scenario, which is addressed by institutional controls.
Scrap Yard	Reduces risk in the north area to acceptable levels for all but the trench worker scenario, which is addressed by institutional controls. The intermittent maintenance worker and trench worker scenarios in the south area are addressed by institutional controls.
Company Lake	Expected to reduce human and ecological risk to below threshold criteria.
Groundwater	Groundwater does not exceed threshold risk criteria except for the future offsite residential scenario, which is addressed by institutional controls.
Adequacy and Reliability of Controls	
North Landfill	A riprap cap is expected to be effective indefinitely in preventing erosion of the north landfill. Minimal maintenance to address settlement is expected after the first few years.
South Landfill	A soil and vegetation cover is expected to be effective in preventing contact with the waste layer at south landfill. Maintenance of the cover to address settling or erosion will be required during the first few years until the vegetation cover is well established. After establishment of the vegetation, minimal maintenance is expected to keep the cover functional indefinitely.
Scrap Yard	A gravel cover over the north area of the scrap yard is expected to be effective in preventing contact with waste layer indefinitely. Due to continued industrial use of the scrap yard, regular maintenance of the gravel cover will be required. Institutional controls on intermittent maintenance worker exposure in the south area, and on potential trench worker exposure, are expected to be effective.
Company Lake	The permeable geotextile cap over the sediments in Company Lake is expected to be effective in preventing contact with COPCs in the sediments indefinitely. Periodic inspection of the cap will be required to ensure its continued performance.
Groundwater	Production well optimization is expected to reliably provide hydraulic control of the groundwater fluoride plume in the intermediate and deep zones.

Table Alt. A-4 Reduction of Toxicity, Mobility, and Volume Through Treatment – Alternative A	
Treatment Processes Used and Materials Treated	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	No treatment included in this action.
Amount of Waste Material Destroyed or Treated	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	Not applicable.
Degree of Expected Reduction in Toxicity, Mobility, or Volume	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	Not applicable.
Degree to Which Treatment Is Irreversible	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	Not applicable.
Type and Quantity of Residuals Remaining After Treatment	
North Landfill South Landfill Scrap Yard Company Lake Groundwater	Not applicable.

Table Alt. A-5 Short-Term Effectiveness – Alternative A	
Protection of Community During Remedial Actions	
North Landfill South Landfill Scrap Yard Company Lake	Minimal impact on community, other than truck traffic delivering cap material.
Groundwater	No impact on community.
Protection of Workers During Remedial Actions	
North Landfill South Landfill Scrap Yard	Minimal exposure of workers to COPCs during grading and placement of cap materials.
Company Lake	Minimal exposure of workers to COPCs during placement of cap materials.
Groundwater	Production well optimization will not result in any additional exposure of workers to COPCs.
Environmental Impacts	
North Landfill	No adverse short-term environmental impacts are expected to result from placement of a riprap cap at the north landfill.
South Landfill	No adverse short-term environmental impacts are expected to result from placement of a soil and vegetation cap at the south landfill.
Scrap Yard	No adverse short-term environmental impacts are expected to result from placement of a gravel cap at the scrap yard.
Company Lake	Short-term environmental impacts could be expected from placement of a permeable cap over Company Lake sediments. The primary impact would be entrainment of sediment in the water column, which could pose a threat of discharge to the Columbia River. Installation of the cap would have to be done with the aid of silt curtains or other technology to prevent discharge of sediments through the Company Lake outfall.
Groundwater	No adverse environmental impacts are expected from implementation of production well optimization.
Time to Compliance	
North Landfill	One construction season.
South Landfill	One construction season.
Scrap Yard	One construction season.
Company Lake	One construction season.
Groundwater	Achieves containment of most groundwater in the UGS, intermediate, and deep zones that does not currently meet MCLs. Does not achieve MCLs in the UGS, intermediate zone, deep zone, or silt unit for several hundred years.

Table Alt. A-6 Implementability – Alternative A	
Ability to Construct, Operate, and Monitor the Technology	
North Landfill South Landfill Scrap Yard	Standard, proven technology. Straightforward implementation and operation.
Company Lake	Sediment caps are a proven technology. Implementation is achievable, but will require care to prevent entrainment of sediments.
Groundwater	Production wells are already in operation. No construction needed.
Reliability of the Technology	
North Landfill South Landfill Scrap Yard	Capping is a proven, reliable technology.
Company Lake	A properly installed sediment cap would be expected to have high reliability and a long life.
Groundwater	Production wells have been in service for a number of years and have operated well. With maintenance, they are expected to operate reliably indefinitely.
Ease of Undertaking Additional Remedial Action, If Necessary	
North Landfill	Removal of a riprap cap would present some difficulties, but it would be relatively inexpensive and would facilitate future action at north landfill, if necessary.
South Landfill	Removal of a soil and vegetation cap would be simple and relatively inexpensive, and it would facilitate future action at south landfill, if necessary.
Scrap Yard	Removal of a gravel cap would be simple and relatively inexpensive, and it would facilitate future action at the scrap yard, if necessary.
Company Lake	Removal of the permeable cap on the sediment would be difficult and expensive. Entrainment of sediments above and below the cap would be very likely. Controlling the discharge of sediment to the Columbia River would require significant effort.
Groundwater	Changing pumping rates or incorporating additional production wells would be straightforward and involve little cost.

Table Alt. A-6 (continued) Implementability – Alternative A	
Ability to Coordinate with and Obtain Approvals from Other Agencies	
North Landfill South Landfill	Capping north or south landfill would not require coordination with or approval by other agencies.
Scrap Yard	Capping the scrap yard would not require coordination with or approval by other agencies.
Company Lake	Capping of the sediments in the lake should not require coordination with or approval from other agencies.
Groundwater	It is assumed that production well optimization will operate within the RMC-Troutdale water rights and will not require coordination with other agencies.
Availability of Equipment, Specialists, Technologies, Offsite Treatment, Storage or Disposal Services, and Capacity	
North Landfill	Riprap is readily available and can be installed using standard labor and equipment.
South Landfill	Soil for a cap is readily available and can be installed and seeded using standard labor and equipment.
Scrap Yard	Gravel is readily available and can be installed using standard labor and equipment.
Company Lake	Geotextile for the sediment cap is readily available. Installation is a specialized service but is expected to be available.
Groundwater	No additional equipment or services are required for implementation of production well optimization.

Table Alt. A-7 Cost – Alternative A	
Capital Costs	
North Landfill	$450,000
South Landfill	$724,000
Scrap Yard	$376,000
Company Lake	$4,529,000
Groundwater	$0
Onsite Landfill	Not applicable
Total	$6,078,000
Annual Operation and Maintenance Costs	
North Landfill	$20,000
South Landfill	$24,000
Scrap Yard	$18,000
Company Lake	$17,000
Groundwater	$128,000
Onsite Landfill	Not Applicable
Total	$207,000
Net Present Value (30-Year Basis)	
North Landfill	$697,000
South Landfill	$1,026,000
Scrap Yard	$597,000
Company Lake	$4,734,000
Groundwater	$1,057,000
Onsite Landfill	Not applicable
Total	$8,111,000
As-Spent Cost (30-Year Basis)	
North Landfill	$1,787,000
South Landfill	$3,755,000
Scrap Yard	$1,566,000
Company Lake	$6,151,000
Groundwater	$4,482,000
Onsite Landfill	Not applicable
Total	$17,741,000

Alternative B Tables
Tables Alt. B-1 Through Alt. B-7

Table Alt. B-1 Overall Protection of Human Health and the Environment – Alternative B	
Comparison of Baseline Human Health Risk Estimates with Residual Risk Estimates	
North Landfill	EPA target risk criteria not exceeded. Capping reduces risk to acceptable levels for all but the trench worker scenario under DEQ risk criteria, which is addressed by institutional controls. Trenching or subsurface construction at the north landfill is extremely unlikely because of its location north of the COE dike in the floodplain.
South Landfill	EPA target risk criteria not exceeded. DEQ risk criteria exceeded for trespasser, intermittent maintenance worker, and trench worker scenarios, which are addressed by institutional controls. Institutional controls expected to reduce human health risk below threshold criteria.
Scrap Yard	EPA target risk criteria not exceeded. Excavation is expected to reduce risk to acceptable levels in the north area for for the maintenance worker and trench worker scenarios under DEQ risk criteria. Depending on residual soil concentrations, the trench worker scenario, may need to be addressed by institutional controls. Maintenance and trench worker exposures in the south area are addressed by institutional controls.
Company Lake	EPA target risk criteria not exceeded. Dredging is expected to reduce risk below threshold criteria for the trespasser scenario under DEQ risk criteria.
Groundwater	EPA and DEQ target risk criteria not exceeded, except for future offsite residential scenario, which is addressed by groundwater use restrictions.
Comparison of Ecological Risk Estimates with Regulatory Risk Criteria	
North Landfill	North landfill does not exceed ecological risk criteria.
South Landfill	South landfill does not exceed ecological risk criteria.
Scrap Yard	Not applicable.
Company Lake	Dredging sediments from Company Lake is expected to reduce ecological risk to acceptable levels.
Groundwater	Not applicable. Groundwater has no measurable effect on surface water quality and therefore does not affect ecological receptors.
Evaluation of Exposure Pathways for Human and Ecological Receptors Following Implementation of the Remedial Alternative	
North Landfill	Placement of a riprap cover should eliminate the pathway for human and ecological exposure to COPCs at north landfill.
South Landfill	Site access and use restrictions are expected to reduce or eliminate the trespasser and maintenance worker exposure pathways. The trench worker exposure is addressed by institutional controls.
Scrap Yard	Excavation of the north portion of the waste layer is expected to eliminate the exposure pathway in the north area for all trench worker scenarios. Institutional controls will be used to address intermittent maintenance worker and potential trench worker exposures in the south area.
Company Lake	Dredging is expected to significantly reduce or eliminate the sediment exposure pathway for human and ecological receptors.
Groundwater	Production well optimization with focused extraction prevents offsite exposure to the existing groundwater fluoride plume in the south plant area in the intermediate and deep zones, and provides an additional measure of protection for onsite users. The future offsite residential exposure is addressed by deed restrictions.

Table Alt. B-2 ARARS – Alternative B	
Compliance with Location-Specific ARARs	
North Landfill	Installation of a riprap cover at the north landfill is expected to comply with restrictions on construction in floodplains.
South Landfill	No location-specific ARARs identified for the south landfill.
Scrap Yard	No location-specific ARARs identified for the scrap yard.
Company Lake	Dredging of Company Lake is expected to comply with restrictions on construction in a floodplain. Because Company Lake is permitted as part of the NPDES system, COE dredging requirements are not applicable.
Groundwater	No location-specific ARARs for this action.
Compliance with Chemical-Specific ARARs	
North Landfill South Landfill Scrap Yard	No chemical-specific ARARs identified for actions in these areas.
Company Lake	The NPDES permit limits for discharges from Company Lake to the Columbia River will be ARARs for the dredging action, unless waivers or temporary standards are incorporated in the new NPDES permit prior to the dredging activity.
Groundwater	Because the plant water system provides both process and potable water, the MCLs under the Safe Drinking Water Act are applicable (at the tap) to the groundwater extracted using production well optimization. Groundwater will continue to exceed MCLs at various locations throughout the site. Production well optimization and focused extraction will prevent MCLs from being exceeded in the plant water supply. Discharge of treated groundwater will need to comply with the effluent standards in the RMC-Troutdale NPDES discharge permit.
Compliance with Action-Specific ARARs	
North Landfill	A riprap cover should meet action-specific ARARs.
South Landfill	DEQ solid waste landfill closure requirements are not applicable to the south landfill, since it ceased operation before January 1, 1980.
Scrap Yard	Excavation of the north portion of the waste layer at the scrap yard will be subject to storm-water protection standards if the area of excavation exceeds 5 acres. Disposal of the excavated material must comply with RCRA substantive requirements for both solid and hazardous waste management.
Company Lake	Dredging Company Lake sediments and disposal of the dewatered sediments must comply with RCRA solid waste management requirements, as well as with the terms of RMC's NPDES permit.
Groundwater	No action-specific ARARs were identified for the groundwater action.

Table Alt. B-3 Long-Term Effectiveness and Permanence – Alternative B	
Magnitude of Residual Risk	
North Landfill	EPA target risk criteria not exceeded. Capping reduces risk to acceptable levels for all but the trench worker scenario under DEQ risk criteria, which is addressed by institutional controls. Trenching or subsurface construction at the north landfill is extremely unlikely because of its location north of the COE dike in the floodplain.
South Landfill	EPA target risk criteria not exceeded. DEQ risk criteria exceeded for trespasser, intermittent maintenance worker, and trench worker scenarios. Institutional controls expected to reduce human health risk to acceptable levels.
Scrap Yard	EPA target risk criteria not exceeded. Excavation of the north portion of the waste layer is expected to reduce risk in the north area below DEQ risk criteria for all scenarios. Institutional controls may need to be implemented to address the trench worker scenario, depending on COPC concentrations remaining following excavation. In the south area, institutional controls, such as use restrictions, will be implemented to reduce exposure to intermittent maintenance workers and potential trench workers.
Company Lake	EPA human health target risk criteria not exceeded. Dredging is expected to reduce risk below DEQ criteria for the trespasser scenario. Ecological risk should also be reduced below EPA and DEQ criteria.
Groundwater	Future offsite residential risk estimate will exceed EPA and DEQ criteria for a period of 50 to 100 years. This exposure is addressed by groundwater use restrictions. Other scenarios do not exceed risk criteria.
Adequacy and Reliability of Controls	
North Landfill	Capping is a reliable method for reducing or preventing human and ecological exposure.
South Landfill	Institutional controls, especially industrial use restrictions, are expected to be effective and reliable in preventing worker exposure to COPCs at the south landfill. Trespasser exposure will be addressed through fencing and signage.
Scrap Yard	Excavation is an adequate and reliable method of preventing human and ecological exposure to COPCs. Institutional controls, especially industrial use restrictions, are expected to be effective and reliable in preventing worker exposure to COPCs in the south area.
Company Lake	Dredging is an adequate and reliable method of preventing human and ecological exposure to COPCs.
Groundwater	Production well optimization provides hydraulic containment over most of the RMC-Troutdale site and, combined with focused extraction, captures the existing fluoride plume in the intermediate and deep zones. The production wells to be included in this program have a history of reliable service.

Table Alt. B-4 Reduction of Toxicity, Mobility, and Volume Through Treatment – Alternative B	
Treatment Processes Used and Materials Treated	
North Landfill South Landfill Scrap Yard	None.
Company Lake	Mechanical dewatering of sediment dredged from Company Lake.
Groundwater	Groundwater from the focused extraction wells will be used as makeup water for the wet ESP system. The bleed stream from the ESP system is treated using calcium fluoride precipitation prior to discharge to Company Lake.
Amount of Waste Material Destroyed or Treated	
North Landfill South Landfill Scrap Yard	Not applicable.
Company Lake	Approximately 38,000 cubic yards of sediment will be dredged from Company Lake and dewatered, resulting in approximately 22,000 cubic yards of solids.
Groundwater	The two focused extraction wells at the scrap yard and east potliner will each produce approximately 20 gpm. The estimated groundwater fluoride concentration from these wells is 75 mg/L.
Degree of Expected Reduction in Toxicity, Mobility, or Volume	
North Landfill South Landfill Scrap Yard	Not applicable.
Company Lake	Dewatering is expected to reduce sediment volume by 42 percent.
Groundwater	Because extracted groundwater will be used in the wet ESP system prior to treatment, the percent removal of fluoride from the groundwater itself is not known.
Degree to Which Treatment Is Irreversible	
North Landfill South Landfill Scrap Yard	Not applicable.
Company Lake	Irreversible.
Groundwater	Precipitation of fluoride is not reversible.
Type and Quantity of Residuals Remaining after Treatment	
North Landfill South Landfill Scrap Yard	Not applicable.
Company Lake	22,000 cubic yards of dewatered sediment containing fluoride and PAHs will be produced.
Groundwater	Treatment of extracted groundwater using calcium fluoride precipitation (following use in the wet ESP system) results in production of residual solids.

Table Alt. B-5 Short-Term Effectiveness – Alternative B	
Protection of Community During Remedial Actions	
North Landfill	Minimal impact on community, other than truck traffic delivering cap material.
South Landfill	Not applicable.
Scrap Yard	Minimal impact because excavated material will be consolidated onsite in a new solid waste landfill. Its construction will increase truck traffic as materials are hauled onsite.
Company Lake	Minimal impact because dredging, dewatering, and disposal of sediments will occur onsite. Construction of new onsite landfill will increase truck traffic as materials are hauled onsite.
Groundwater	No impact on community.
Protection of Workers During Remedial Actions	
North Landfill	Minimal exposure of workers to COPCs during grading and placement of cap materials.
South Landfill	Not applicable.
Scrap Yard	Excavation of north portion of the waste layer will require adequate PPE and monitoring procedures. Existing data on the area will be used to plan for safe working conditions.
Company Lake	Dredging operations will require adequate PPE, monitoring procedures, and physical safety precautions. Existing sediment data will be used to plan for safe working conditions.
Groundwater	Installation of two focused extraction wells and associated piping is not expected to pose a hazard to workers. Appropriate safety procedures will be implemented.
Environmental Impacts	
North Landfill	Capping the north landfill will not create short-term adverse environmental impacts.
South Landfill	Not applicable.
Scrap Yard	Because the scrap yard is within the main industrial area of the plant, excavation of the north portion of the waste layer is not expected to pose adverse environmental impacts. Care will be taken to ensure that stormwater runoff is contained during construction.
Company Lake	Dredging of Company Lake sediments will require implementation of protective measures to prevent discharge of sediment to the Columbia River. A suspended solids management plan will be prepared as part of construction planning.
Groundwater	No adverse impacts expected from construction of the new FE wells and associated piping.
Time to Compliance	
North Landfill	One construction season.
South Landfill	Not applicable.
Scrap Yard	One construction season.
Company Lake	One construction season.
Groundwater	Achieves containment of most groundwater in the UGS and deeper that currently does not meet MCLs. Achieves MCLs in the intermediate and deep zones in the south plant area in 10 years, north and southeast of Company Lake in 15 years, and southwest of Company Lake in 50-100 years. Achieves compliance with MCLs in the UGS at scrap yard and east potliner in 10 years, at Company Lake in 15-20 years, and at south landfill in several hundred years. Complete restoration of the aquifer (including the silt unit) is expected to take several hundred years.

Table Alt. B-6 Implementability – Alternative B	
Ability to Construct, Operate, and Monitor the Technology	
North Landfill	Standard, proven technology. Straightforward implementation and operation. Maintenance and monitoring requirements would be minimal.
South Landfill	Not applicable.
Scrap Yard	Excavation is a standard construction activity. No operation or monitoring required.
Company Lake	Dredging is a proven technology. However, implementation of dredging requires skilled and experienced operators to effectively remove sediments without entraining excessive amounts of sediment in the water column. Suspended solids would be monitored closely at the Company Lake discharge to prevent violation of the RMC NPDES permit.
Groundwater	Installation of focused extraction wells and associated piping is a proven, standard technology.
Reliability of the Technology	
North Landfill	Riprap covers are extremely reliable and require little maintenance.
South Landfill	Not applicable.
Scrap Yard	Excavation is permanent and, therefore, reliable.
Company Lake	Dredging is a permanent and, therefore, reliable technology.
Groundwater	Production well optimization and focused extraction are proven, reliable technologies. The production wells have been in operation for several years and can be expected to continue to operate reliably.
Ease of Undertaking Additional Remedial Action, If Necessary	
North Landfill	Removal of a riprap cap would present some difficulties, but it would be relatively inexpensive and would facilitate future action at north landfill, if necessary.
South Landfill	Not applicable.
Scrap Yard	Removal of the clean backfill material would be relatively inexpensive.
Company Lake	Dredging of the sediments at Company Lake would not prevent additional action, if necessary.
Groundwater	Production well optimization and focused extraction would not prevent additional groundwater actions, if necessary.

Table Alt. B-6 (continued) Implementability – Alternative B	
Ability to Coordinate with and Obtain Approvals from Other Agencies	
North Landfill	Capping north landfill would not require coordination with or approval by other agencies.
South Landfill	Not applicable.
Scrap Yard	No other agency approvals should be required for excavation of the north portion of the waste layer from the scrap yard.
Company Lake	NPDES approval is required for actions at Company Lake. Consultation with resource trustees is required for discharges to the Columbia River.
Groundwater	Coordination of water rights with the Oregon Water Resources Department may be required. NPDES approval will be required for groundwater treatment and discharge.
Availability of Equipment, Specialists, Technologies, Offsite Treatment, Storage or Disposal Services, and Capacity	
North Landfill	No special material or services required.
South Landfill	Not applicable.
Scrap Yard	No special material or services required.
Company Lake	Specialized services will be required for dredging the Company Lake sediments. These services are available in the Pacific Northwest.
Groundwater	No special material or services required.

Table Alt. B-7 Cost – Alternative B	
Capital Costs	
North Landfill	$450,000
South Landfill	$81,000
Scrap Yard	$500,000
Company Lake	$7,070,000
Groundwater	$375,000
Onsite Landfill	$1,987,000
Total	$10,463,000
Annual Operation and Maintenance Costs	
North Landfill	$20,000
South Landfill	$2,000
Scrap Yard	$7,000
Company Lake	$18,000
Groundwater	$151,000
Onsite Landfill	$31,000
Total	$229,000
Net Present Value (30-Year Basis)	
North Landfill	$697,000
South Landfill	$106,000
Scrap Yard	$584,000
Company Lake	$7,118,000
Groundwater	$1,763,000
Onsite Landfill	$2,370,000
Total	$12,637,000
As-Spent Cost (30-Year Basis)	
North Landfill	$1,787,000
South Landfill	$332,000
Scrap Yard	$992,000
Company Lake	$7,984,000
Groundwater	$6,375,000
Onsite Landfill	$4,212,000
Total	$21,682,000

Alternative C Tables
Tables Alt. C-1 Through Alt. C-7

Table Alt. C-1 Overall Protection of Human Health and the Environment – Alternative C	
Comparison of Baseline Human Health Risk Estimates with Residual Risk Estimates	
North Landfill	EPA target risk criteria not exceeded. Excavation of waste layer is expected to reduce risk to acceptable levels for all scenarios under DEQ criteria. Trench worker scenario may still exceed risk criteria, depending on residual concentrations of COPCs remaining in soil after the waste is removed. However, trenching or subsurface construction is extremely unlikely because of the north landfill's location north of the COE dike in the floodplain. Trench worker scenario will be addressed by institutional controls, if needed.
South Landfill	EPA target risk criteria not exceeded. Excavation of waste layer is expected to reduce risk to acceptable levels for all scenarios under DEQ criteria. Trench worker scenario may still exceed risk criteria, depending on residual concentrations of COPCs remaining in soil after the waste is removed. Trench worker scenario will be addressed by institutional controls, if needed.
Scrap Yard	EPA target risk criteria not exceeded. Excavation of waste layer is expected to reduce risk in the north area to acceptable levels for all but the trench worker scenario under DEQ criteria. Trench worker scenario is addressed by institutional controls. Intermittent maintenance worker scenario in the south area is addressed by institutional controls.
Company Lake	EPA target risk criteria not exceeded. Dredging is expected to reduce risk to acceptable levels for the trespasser scenario under DEQ criteria.
Groundwater	Future offsite residential risk estimate will exceed EPA and DEQ criteria for a period of approximately 10 to 15 years. This exposure is addressed by groundwater use restrictions. Other scenarios do not exceed risk criteria.
Comparison of Ecological Risk Estimates with Regulatory Risk Criteria	
North Landfill South Landfill	North landfill and south landfill do not exceed ecological risk criteria.
Scrap Yard	Not applicable.
Company Lake	Dredging sediments from Company Lake is expected to reduce ecological risk to acceptable levels.
Groundwater	Not applicable. Groundwater has no measurable effect on surface water quality and therefore does not affect ecological receptors.
Evaluation of Exposure Pathways for Human and Ecological Receptors Following Implementation of the Remedial Alternative	
North Landfill South Landfill	Excavation should eliminate the pathway for human or ecological exposure to COPCs.
Scrap Yard	Excavation should eliminate the pathway for human or ecological exposure to COPCs in the north area, with the exception of the trench worker scenario. Institutional controls are expected to reduce or eliminate exposure in the south area.
Company Lake	Dredging should reduce or eliminate the pathway for human or ecological exposure to COPCs.
Groundwater	Production well optimization with focused extraction will prevent offsite exposure to the existing groundwater fluoride plume in the south plant area in the intermediate and deep zones. The future offsite residential exposure is addressed by deed restrictions until COPC concentrations are reduced below MCLs.

Table Alt. C-2 ARARS – Alternative C	
Compliance with Location-Specific ARARs	
North Landfill	Excavation of the waste layer at north landfill will comply with construction restrictions in floodplains.
South Landfill Scrap Yard	No location-specific ARARs were identified.
Company Lake	Dredging of Company Lake is expected to comply with restrictions on construction within a floodplain. Because Company Lake is permitted as part of the NPDES system, COE dredging requirements are not applicable.
Groundwater	No location-specific ARARs were identified.
Compliance with Chemical-Specific ARARs	
North Landfill South Landfill Scrap Yard	No chemical-specific ARARs were identified.
Company Lake	The NPDES permit limits for discharges from Company Lake to the Columbia River will be ARARs for the dredging action, unless waivers or temporary standards are incorporated in the new NPDES permit prior to the dredging activity.
Groundwater	Because the plant water system provides both process and potable water, the MCLs under the Safe Drinking Water Act are applicable (at the tap) to groundwater extracted using production well optimization. Groundwater will continue to exceed MCLs at various locations throughout the site. Production well optimization, combined with focused extraction, will prevent MCLs from being exceeded in the plant water supply. Discharge of treated groundwater will need to comply with the effluent standards in the RMC-Troutdale NPDES discharge permit.
Compliance with Action-Specific ARARs	
North Landfill South Landfill Scrap Yard	Excavation of the waste layer at the landfills or of the north portion of the scrap yard will be subject to stormwater protection standards if any area of excavation exceeds 5 acres. Disposal of the excavated material must comply with substantive requirements of RCRA for waste management.
Company Lake	Dredging Company Lake sediments and disposal of the dewatered sediments must comply with RCRA solid waste management requirements, as well as with the terms of the RMC Troutdale NPDES permit.
Groundwater	No action-specific ARARs were identified for this action.

Table Alt. C-3 Long-Term Effectiveness and Permanence – Alternative C	
Magnitude of Residual Risk	
North Landfill	EPA target risk criteria not exceeded. Excavation of the waste layer is expected to reduce risk to acceptable levels for all scenarios under DEQ criteria. Trench worker scenario may still exceed risk criteria, depending on residual concentrations of COPCs remaining in soil after the waste is removed. However, trenching or subsurface construction is extremely unlikely because of the north landfill's location north of the COE dike in the floodplain. The trench worker scenario is addressed by institutional controls.
South Landfill	EPA target risk criteria not exceeded. Excavation of the waste layer is expected to reduce risk to acceptable levels for all scenarios under DEQ criteria. Trench worker scenario may still exceed risk criteria, depending on residual concentrations of COPCs remaining in soil after the waste is removed. The trench worker scenario is addressed by institutional controls.
Scrap Yard	EPA target risk criteria not exceeded. Excavation of the north portion of the waste layer is expected to reduce risk in the north area below DEQ risk criteria for all trench worker scenarios. Institutional controls may need to be implemented to address the trench worker scenario, depending on COPC concentrations remaining after excavation. Institutional controls will be implemented to address intermittent maintenance worker exposure in the south area.
Company Lake	EPA target risk criteria not exceeded. Dredging is expected to reduce risk to acceptable levels for the trespasser scenario under DEQ criteria. Ecological risk should also be reduced below EPA and DEQ criteria.
Groundwater	Future offsite residential risk estimate will exceed EPA and DEQ criteria for approximately 10 to 15 years. This exposure is addressed by groundwater use restrictions. Other scenarios do not exceed risk criteria.
Adequacy and Reliability of Controls	
North Landfill South Landfill Company Lake	Excavation and dredging are permanent actions, and are reliable methods of preventing human and ecological exposure to COPCs.
Scrap Yard	Excavation is a permanent action, and is a reliable method of preventing human exposure to COPCs. Institutional controls are also expected to be effective in reducing or eliminating human exposure to levels below DEQ threshold criteria.
Groundwater	Production well optimization and enhanced focused extraction will provide hydraulic containment over most of the RMC-Troutdale site, and will capture the existing fluoride plumes in the south plant and Company Lake areas. The production wells included in this program have a history of reliable service. Focused extraction in the south landfill and Company Lake areas will require treatment by reverse osmosis. Reverse osmosis may or may not be effective in treating fluoride in groundwater at this site.

Table Alt. C-4 Reduction of Toxicity, Mobility, and Volume Through Treatment – Alternative C	
Treatment Processes Used and Materials Treated	
North Landfill South Landfill Scrap Yard	Not applicable.
Company Lake	Mechanical dewatering of sediment dredged from Company Lake.
Groundwater	Some groundwater from the focused extraction wells will be used as makeup water for the wet ESP system. The bleed stream from the ESP system is treated by calcium fluoride precipitation prior to discharge to Company Lake. Remaining groundwater from the focused extraction system will be treated by reverse osmosis (RO). The brine from the RO system will be treated by calcium fluoride precipitation.
Amount of Waste Material Destroyed or Treated	
North Landfill South Landfill Scrap Yard	Not applicable.
Company Lake	Approximately 38,000 cubic yards of sediment will be dredged from Company Lake and dewatered, resulting in approximately 22,000 cubic yards of solids.
Groundwater	The two focused extraction wells at the scrap yard and east potliner will each produce approximately 20 gpm. The estimated groundwater fluoride concentration from these wells is 75 mg/L. The focused extraction wells at the south landfill and Company Lake will have a combined production of 60 gpm and an estimated fluoride concentration of 30 mg/L.
Degree of Expected Reduction in Toxicity, Mobility, or Volume	
North Landfill South Landfill Scrap Yard	Not applicable.
Company Lake	Dewatering is expected to reduce sediment volume by 42 percent.
Groundwater	For the portion of the extracted groundwater that will be used in the wet ESP and treated by the plant's existing calcium chloride precipitation system, the percent removal of fluoride from the groundwater itself is not known. The RO system is expected to achieve an effluent fluoride concentration of less than 2 mg/L. Brine treatment by calcium fluoride precipitation is expected to achieve an effluent concentration of 20-30 mg/L.
Degree to Which Treatment Is Irreversible	
North Landfill South Landfill Scrap Yard	Not applicable.
Company Lake Groundwater	Not reversible in this context.

Table Alt. C-4 (continued) Reduction of Toxicity, Mobility, and Volume Through Treatment – Alternative C	
Type and Quantity of Residuals Remaining After Treatment	
North Landfill South Landfill Scrap Yard	Not applicable.
Company Lake	22,000 cubic yards of dewatered sediment will be produced.
Groundwater	Treatment of extracted groundwater through the plant's calcium fluoride precipitation system, as well as precipitation of the RO brine, results in production of residual solids.

Table C-5
Short-Term Effectiveness – Alternative C

Protection of Community During Remedial Actions	
North Landfill South Landfill Scrap Yard	Minimal impact because excavated material will be consolidated onsite in a new, solid waste landfill. Construction of the onsite landfill will increase truck traffic as materials are hauled onsite.
Company Lake	Minimal impact because dredging, dewatering, and disposal of sediments will occur onsite. Construction of the new landfill will increase truck traffic as materials are hauled onsite.
Groundwater	No impact on community.
Protection of Workers During Remedial Actions	
North Landfill South Landfill Scrap Yard	Excavation will require adequate personal protective equipment (PPE) and monitoring procedures, as well as physical safety precautions. Existing data will be used to plan for safe working conditions.
Company Lake	Dredging will require adequate PPE and monitoring procedures, as well as physical safety precautions. Existing data on the sediments will be used to plan for safe working conditions.
Groundwater	Installation of the focused extraction wells and associated piping is not expected to pose a hazard to workers. Appropriate safety procedures will be implemented.
Environmental Impacts	
North Landfill	Excavation of north landfill will be planned and implemented to minimize short-term environmental impacts. Special precautions will be taken into account for floodplain and stormwater issues.
South Landfill	Excavation of south landfill is not expected to result in significant short-term environmental impacts. Care will be taken to control stormwater runoff during the excavation to prevent discharge to south wetlands.
Scrap Yard	Because the scrap yard is within the main industrial area of the plant, excavation of the north portion of the waste layer is not expected to pose adverse environmental impacts. Care will be taken to ensure that stormwater runoff is contained during construction.
Company Lake	Dredging of Company Lake sediments will require implementation of protective measures to prevent discharge of sediment or solids to the Columbia River. A suspended solids management plan will be prepared as part of construction planning.
Groundwater	No adverse impacts expected from construction of new extraction wells/associated piping.
Time to Compliance	
North Landfill	One construction season.
South Landfill	One construction season.
Scrap Yard	One construction season.
Company Lake	One construction season.
Groundwater	Achieves containment of most groundwater in the UGS and deeper that does not currently meet MCLs. Achieves MCLs in the intermediate and deep zones in the south plant area in 10 years, and at Company Lake in 10-15 years. Achieves compliance with MCLs in the UGS at scrap yard and east potliner in 10 years, at Company Lake in 15-20 years, and at south landfill in 5-10 years. Complete restoration of the aquifer (including the silt unit) is expected to take several hundred years.

Table Alt. C-6 Implementability – Alternative C	
Ability to Construct, Operate, and Monitor the Technology	
North Landfill South Landfill Scrap Yard	Excavation is a standard construction activity. No operation or monitoring is required.
Company Lake	Dredging is a proven technology. However, successful implementation of dredging requires skilled and experienced operators to effectively remove sediments without entraining excessive solids in the water column. Suspended solids will be monitored closely at the Company Lake discharge to prevent violation of the RMC Troutdale NPDES permit.
Groundwater	Installation of focused extraction wells and associated piping is a proven, standard technology.
Reliability of the Technology	
North Landfill South Landfill Scrap Yard	Excavation is permanent and, therefore, reliable.
Company Lake	Dredging is permanent and, therefore, reliable.
Groundwater	Production well optimization and focused extraction are proven, reliable technologies. The production wells have been in operation for several years and can be expected to continue to operate reliably.
Ease of Undertaking Additional Remedial Action, If Necessary	
North Landfill South Landfill Scrap Yard	Removal of clean backfill material would be straightforward and relatively inexpensive.
Company Lake	Dredging would not prevent additional action, if necessary.
Groundwater	Production well optimization and focused extraction would not prevent additional action, if necessary.
Ability to Coordinate with and Obtain Approvals from Other Agencies	
North Landfill South Landfill Scrap Yard	No other agency approvals should be required for excavation.
Company Lake	NPDES approval is required for actions at Company Lake. Consultation with resource trustees is required for discharges to the Columbia River.
Groundwater	Coordination of water rights with the Oregon Water Resources Department may be required. NPDES approval will be required for groundwater treatment and discharge.
Availability of Equipment, Specialists, Technologies, Offsite Treatment, Storage or Disposal Services, and Capacity	
North Landfill South Landfill Scrap Yard	No special materials or services are required.
Company Lake	Specialized services are required for dredging the Company Lake sediments. These services are available in the Pacific Northwest.
Groundwater	No special material or services are required.

Table Alt. C-7 Cost – Alternative C	
Capital Costs	
North Landfill	$1,508,000
South Landfill	$2,028,000
Scrap Yard	$500,000
Company Lake	$7,070,000
Groundwater	$3,316,000
Onsite Landfill	$4,773,000
Total	$19,196,000
Annual Operation and Maintenance Costs	
North Landfill	$5,000
South Landfill	$4,000
Scrap Yard	$7,000
Company Lake	$18,000
Groundwater	$297,000
Onsite Landfill	$85,000
Total	$416,000
Net Present Value (30-Year Basis)	
North Landfill	$1,571,000
South Landfill	$2,082,000
Scrap Yard	$584,000
Company Lake	$7,118,000
Groundwater	$6,818,000
Onsite Landfill	$5,826,000
Total	$23,998,000
As-Spent Cost (30-Year Basis)	
North Landfill	$2,019,000
South Landfill	$2,800,000
Scrap Yard	$992,000
Company Lake	$7,984,000
Groundwater	$19,061,000
Onsite Landfill	$10,809,000
Total	$43,666,000

SECTION 7

Comparative Analysis of Alternatives

SECTION 7

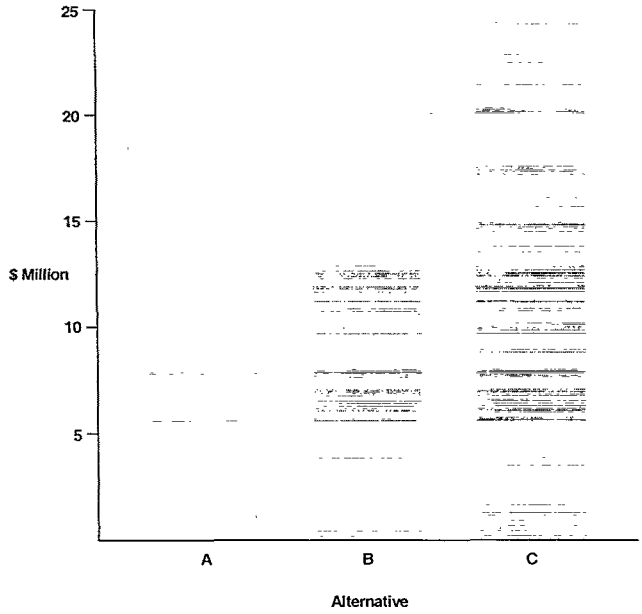
Comparative Analysis of Alternatives

RMC developed three sitewide remedial alternatives (in addition to the No Action Alternative), each of which uses a consistent approach to achieve the RAOs:

- Alternative A—Permeable caps for the landfills, the scrap yard, and Company Lake and hydraulic containment of groundwater—$8.1 million NPV
- Alternative B—Source removal at the areas most directly affecting groundwater quality in the intermediate zone: the scrap yard and Company Lake, hydraulic containment, and focused extraction for groundwater—$12.6 million NPV
- Alternative C—Excavation of the landfills and the scrap yard, dredging at Company Lake, hydraulic containment, and additional focused extraction of groundwater—$24.0 million NPV

7.1 Comparison of Alternatives

Alternative B represents an estimated increase of $4.5 million (56 percent) over Alternative A. Alternative C represents an estimated increase of $15.9 million (196 percent) over Alternative A and an estimated increase of $11.4 million (90 percent) over Alternative B.



Alternative A satisfies the threshold risk criteria, and meets some regulatory requirements, but it does not include active remediation of either the source materials or the groundwater. The permeable caps reduce risk from direct contact and protect the north landfill from erosion, but they do not reduce mass loading of COPCs to groundwater. Except for a limited

area north and west of Company Lake, where groundwater use is highly unlikely, production well optimization prevents offsite migration of groundwater that exceeds MCLs. Within the site boundaries, COPCs continue to migrate from the UGS to the intermediate and deep zones under the influence of natural and pumping-induced gradients.

Alternative B meets the threshold requirement of risk reduction, meets almost all of the regulatory requirements, and addresses migration of COPCs to groundwater. Dredging of Company Lake (for an additional $2.4 million over Alternative A) and excavation at the scrap yard (a slight increase in capital costs over Alternative A) provide reduction of surface exposure risks, as well as constituent mass reduction. These source removal actions directly address the major sources of COPC migration from the UGS to the intermediate groundwater zone. Dredging of Company Lake also removes the risk of constituent release due to scour during an extreme flood event. Construction of an onsite landfill to receive the waste from Company Lake and the scrap yard results in a cost of approximately $2.4 million over Alternative A.

As in Alternative A, capping at the north landfill reduces surface exposure risk and prevents potential erosion during an extreme flood event. Institutional controls at the south landfill reduce surface exposure risk. Constituents present at the landfills are not the sources of the intermediate- and deep- zone plumes at the site.

Production well optimization provides the benefits described in Alternative A. The combination of dredging and production well optimization results in acceleration of the restoration of groundwater quality around Company Lake. Focused extraction of groundwater at the scrap yard and east potliner areas intercepts the main sources of constituents migrating from the UGS to the intermediate and deep zones for an additional cost of $0.7 million. Focused extraction also results in containment of constituents in the UGS in the south plant area that exceed MCLs. In addition, the combination of source removal, production well optimization, and focused extraction reduces time to compliance in the intermediate and deep groundwater zones.

Alternative C includes the components of Alternative B and adds excavation at the landfills, as well as focused extraction at the south landfill and Company Lake, for an increased cost of $11.1 million.

Additional excavation adds approximately $1 million over Alternative B to the remedy for the north landfill. Excavation at the north landfill eliminates the potential for erosion of waste material during extreme flood events, and it reduces migration of constituents from the landfilled materials to the groundwater. However, excavation of the north landfill does not appreciably decrease the real risk, because (a) the groundwater in this area is unlikely to be used for drinking water purposes and does not pose an unacceptable risk at the river, and (b) the chances of erosion during a severe flood would be greatly reduced by the riprap cover provided in Alternative B. Excavation of the south landfill adds approximately $2.0 million to the remedy cost yet provides little risk reduction, since groundwater at the south landfill does not appear to migrate to the intermediate or deep zone, and is not a significant problem. The cost of constructing a new onsite landfill for this alternative is increased by approximately $3.4 million over Alternative B.

The cost of additional groundwater extraction and treatment adds approximately $5.1 million to Alternative C. The focused extraction well at the south landfill in this remedy is not expected to provide a benefit to groundwater commensurate with the cost of extraction and treatment, because groundwater at the south landfill is not contributing to the sitewide groundwater plume in the intermediate and deep zones. Because there is no current or anticipated use of groundwater near Company Lake, the additional focused extraction wells southwest of Company Lake would serve only to decrease the time period during which the groundwater use restrictions (included in Alternatives A , B, and C) would be required, and would not directly result in greater risk reduction than the other two alternatives.

Treatability studies indicated that treatment of actual site groundwater for removal of fluoride is cost effective only when the influent fluoride concentration exceeds approximately 100 mg/L. (See Appendix F.) Treatment of groundwater with fluoride concentrations of less than 70 mg/L by calcium chloride precipitation was almost totally ineffective. Treatment of groundwater with fluoride concentrations between 70 and 100 mg/L had mixed results. Therefore, as described in Section 4, groundwater from the Company Lake and the south landfill areas would require treatment by an advanced and expensive process, such as reverse osmosis (RO). On the basis of the concentration and flow rate estimates presented in Section 4, an RO system would remove approximately 15 lb/day of fluoride from the extracted groundwater. The effectiveness of RO treatment for the extracted groundwater is uncertain.

7.2 Alternative B Is Protective and Cost-Effective

In summary, Alternative B satisfies the remedial action objectives for the site and provides a cost-effective approach to risk reduction by:

- Removing waste materials from the scrap yard and Company Lake, which are the primary sources of fluoride migration to sitewide groundwater.
- Containing the existing fluoride plume onsite by production well optimization
- Containing groundwater in the UGS that exceeds MCLs by operation of focused extraction wells at the scrap yard and at the east potliner area
- Reducing time to compliance in the intermediate and deep zones, as well as in the UGS in the south plant area and near Company Lake
- Protecting the north landfill against erosion and Company Lake sediments from washout in an extreme flood event
- Providing institutional controls to prevent human exposure to COPCs at the south landfill, the south portion of the scrap yard, and to groundwater during implementation of the groundwater remedial actions.

7.3 Summary of Comparison Against EPA Criteria

Tables 7-1 through 7-7 present the detailed comparative analysis for the No Action Alternative and RMC's three remedial alternatives against EPA's seven criteria.

Section 7 Tables

Table 7-1
Comparative Analysis of Alternatives
Criterion: Overall Protection of Human Health and the Environment

Evaluation	No Action Alternative	Alternative A	Alternative B	Alternative C
Comparison of baseline human health risk estimates with residual risk estimates	Risk criteria for at least one exposure scenario exceeded at NLF, SLF, SY, and Co.L., as well as groundwater.	Addresses surface exposure risk by capping (NLF, SLF, SY, Co.L). Groundwater will require deed and use restrictions for several hundred years for the future offsite residential scenario.	Addresses surface exposure risk by capping (NLF), excavation (SY), dredging (Co.L.), and institutional controls (SLF and SY). Groundwater will require deed and use restrictions for the future offsite residential scenario for 50 to 100 years.	Addresses surface exposure risk by excavation (NLF, SLF, SY), institutional controls (SY) and dredging (Co.L.). Groundwater will require deed and use restrictions for the future offsite residential scenario for 10 to 15 years.
Comparison of ecological risk estimates with regulatory risk criteria	No Action will not reduce ecological risk to acceptable levels.	Capping Co.L. sediments expected to reduce ecological risk below threshold criteria.	Dredging Co.L. expected to reduce ecological risk below threshold criteria.	Dredging Co.L. expected to reduce ecological risk below threshold criteria.
Evaluation of exposure pathways for human and ecological receptors following implementation of the remedial alternative	Not applicable.	Capping reduces or eliminates surface exposure pathways. Groundwater exposure addressed by use restrictions.	Surface exposure pathways reduced or eliminated by: capping (NLF), excavation (SY), dredging (Co.L.), and institutional controls (SLF, SY). Groundwater exposure addressed by use restrictions.	Surface exposure pathways reduced or eliminated by: excavation (NLF, SLF, and SY), institutional controls (SY), dredging (Co.L). Groundwater exposure addressed by use restrictions.
Summary	Inadequate protection of human health and the environment.	Provides adequate protection of human health and the environment.	Provides adequate protection of human health and the environment.	Provides adequate protection of human health and the environment.

Table 7-2
Comparative Analysis of Alternatives
Criterion: ARARs

Evaluation	No Action Alternative	Alternative A	Alternative B	Alternative C
Compliance with location-specific ARARs	Not applicable.	Complies with floodplain restrictions for NLF and Co.L. Complies with requirements for solid waste disposal facilities located in floodplains.	Complies with floodplain restrictions for NLF and Co.L. Complies with requirements for solid waste disposal facilities located in floodplains.	Complies with floodplain restrictions for NLF and Co.L. Complies with requirements for solid waste disposal facilities located in floodplains.
Compliance with chemical-specific ARARs	Does not achieve MCLs in groundwater in a reasonable timeframe.	Because the plant water system provides both process and potable water, the MCLs under the Safe Drinking Water Act are applicable to the groundwater extracted using PWO. Groundwater will continue to exceed MCLs at various locations throughout the site. PWO will prevent MCLs from being exceeded in the plant water supply.	Because the plant water system provides both process and potable water, the MCLs under the Safe Drinking Water Act are applicable to the groundwater extracted using PWO. Groundwater will continue to exceed MCLs at various locations throughout the site. PWO will prevent MCLs from being exceeded in the plant water supply. The NPDES permit limits for discharges from Company Lake to the Columbia River will be ARARs for the dredging action, unless waivers or temporary standards are incorporated in the new NPDES permit.	Because the plant water system provides both process and potable water, the MCLs under the Safe Drinking Water Act are applicable to the groundwater extracted using PWO. Groundwater will continue to exceed MCLs at various locations throughout the site. PWO will prevent MCLs from being exceeded in the plant water supply. The NPDES permit limits for discharges from Company Lake to the Columbia River will be ARARs for the dredging action, unless waivers or temporary standards are incorporated in the new NPDES permit.

Table 7-2, continued
Comparative Analysis of Alternatives
Criterion: ARARs

Evaluation	No Action Alternative	Alternative A	Alternative B	Alternative C
Compliance with action-specific ARARs	Not applicable.	A riprap cover will meet action-specific ARARs. A vegetated soil cover will meet action-specific ARARs. Placement of the permeable cap on the sediments at Company Lake will need to be controlled to prevent violation of the NPDES permit. PWO can be implemented within the existing RMC water rights.	A riprap cover will meet action-specific ARARs. Excavation of the north portion of the waste layer at the scrap yard will be subject to the stormwater protection standards if the area of excavation exceeds 5 acres. Disposal of excavated materials must comply with the substantive requirements of RCRA for both solid and hazardous waste management. Dredging and disposal of Company Lake sediments must comply with RCRA solid waste management requirements and the terms of the RMC NPDES permit. The new onsite landfill must comply with the substantive requirements of RCRA for solid waste management.	Excavation of the north landfill, the south landfill, and the north portion of the waste layer at the scrap yard will be subject to the stormwater protection standards if any area of excavation exceeds 5 acres. Disposal of excavated materials must comply with the substantive requirements of RCRA for both solid and hazardous waste management. Dredging and disposal of Company Lake sediments must comply with RCRA solid waste management requirements and the terms of the RMC NPDES permit. The new onsite landfill must comply with the substantive requirements of RCRA for solid waste management.
Summary	Does not satisfy ARARs for the site.	Meets most ARARs.	Meets most ARARs.	Meets most ARARs.

Table 7-3
Comparative Analysis of Alternatives
Criterion: Long-Term Effectiveness and Permanence

Evaluation	No Action Alternative	Alternative A	Alternative B	Alternative C
Magnitude of residual risk	No reduction in risk.	Residual risk acceptable for all but trench worker and future offsite residential scenario for groundwater, which will be addressed by institutional controls.	Residual risk acceptable for all but surface exposures at SLF and SY, trench worker, and future offsite residential scenario for groundwater, which will be addressed by institutional controls.	Residual risk acceptable for all but surface exposures at SY, trench worker, and future offsite residential scenario for groundwater, which will be addressed by institutional controls.
Adequacy and reliability of controls	Not applicable.	Capping provides adequate exposure reduction when properly maintained. Groundwater program expected to be reliable.	Capping (NLF) provides adequate exposure reduction with low maintenance requirements. Excavation (SY) and dredging (Co.L.) are permanent actions; more reliable controls than capping. Institutional controls at the south landfill and scrap yard expected to be adequate. Groundwater program expected to be reliable.	Excavation (NLF, SLF, SY) and dredging (Co. L.) are permanent actions; more reliable controls on exposure than capping or institutional controls. Institutional controls at the scrap yard expected to be adequate. Groundwater program expected to be reliable.
Summary	Inadequate.	Adequate reduction of risk; reliable with maintenance.	Adequate reduction of risk; requires less long-term maintenance.	Adequate reduction of risk; minimal long-term maintenance.

Table 7-4
Comparative Analysis of Alternatives
Criterion: Reduction of Toxicity, Mobility, and Volume Through Treatment

Evaluation	No Action Alternative	Alternative A	Alternative B	Alternative C
Treatment processes used and materials treated	Not applicable.	Not applicable.	Mechanical dewatering of sediment from Company Lake. Groundwater extraction; some groundwater treated by industrial waste treatment plant.	Mechanical dewatering of sediment from Company Lake. Groundwater extraction; some groundwater treated by industrial waste treatment plant; some groundwater treated by RO; RO brine treated by calcium fluoride precipitation.
Amount of waste material destroyed or treated	Not applicable.	Not applicable.	Volume reduction by dewatering of sediments (16,000 cubic yards). 40 gpm groundwater extracted and used as makeup in the wet ESP system prior to treatment.	Volume reduction by dewatering of sediments (16,000 cubic yards). 40 gpm groundwater extracted and used as makeup in the wet ESP system prior to treatment. 45 gpm groundwater treated by RO; brine treated by calcium fluoride precipitation.
Degree of expected reduction in toxicity, mobility, or volume	Not applicable.	Not applicable.	Reduced volume of sediment by 42 percent.	Reduced volume of sediment by 42 percent. Fluoride reduction by RO in groundwater from extraction wells.
Degree to which treatment is irreversible	Not applicable.	Not applicable.	Irreversible.	Irreversible.
Type and quantity of residuals remaining after treatment	Not applicable.	Not applicable.	Dewatered sediment (22,000 cubic yards).	Dewatered sediment (22,000 cubic yards). Calcium fluoride (CaF_2) sludge from treatment of RO brine.
Summary	No reduction of toxicity, mobility, or volume achieved.	No reduction of toxicity, mobility, or volume achieved.	Reduction in volume of sediments.	Reduction in volume of sediments.

Table 7-5
Comparative Analysis of Alternatives
Criterion: Short-Term Effectiveness

Evaluation	No Action Alternative	Alternative A	Alternative B	Alternative C
Protection of community during remedial actions	Not applicable.	Minimal impact on community.	Minimal impact on community, other than increased traffic for construction.	Minimal impact on community, other than increased traffic for construction.
Protection of workers during remedial actions	Not applicable.	Primarily standard construction activities. Low potential for exposure to COPCs.	Some potential for exposure to COPCs during excavation of SY or dredging of Co.L. Adequate planning, monitoring, and use of personal protective equipment (PPE) required.	Significant potential for exposure to COPCs during excavation of the landfills. Some potential for exposure to COPCs during excavation of SY or dredging of Co.L. Adequate planning, monitoring, and use of PPE required.
Environmental impacts	Not applicable.	Minimal impacts.	Potential for impact during dredging of Co.L. Precautions required to prevent discharge to the river. Excavation of SY not expected to present significant environmental impacts.	Potential for impact during dredging of Co.L., and excavation of landfills. Precautions required to prevent discharge to the river. Excavation of SY not expected to present significant environmental impacts.
Time to compliance	Not expected to achieve compliance with MCLs within several hundred years.	Achieves containment of most groundwater in the UGS and deeper that currently does not meet MCLs. Does not achieve MCLs in the UGS, intermediate, or deep zone; south plant; or Company Lake for several hundred years.	Achieves containment of most groundwater in the UGS and deeper that currently does not meet MCLs. Achieves MCLs in the intermediate and deep zones in the south plant area in 10 years, north and southeast of Company Lake in 15 years, and southwest of Company Lake in 50 to 100 years.	Achieves containment of most groundwater in the UGS and deeper that currently does not meet MCLs. Achieves MCLs in the intermediate and deep zones in the south plant area in 10 years, and southwest of Company Lake in 10 to 15 years.

Table 7-5, continued
Comparative Analysis of Alternatives
Criterion: Short-Term Effectiveness

Evaluation	No Action Alternative	Alternative A	Alternative B	Alternative C
Time to Compliance, continued		Complete restoration of the aquifer (including the silt unit) expected to take several hundred years.	Achieves compliance with MCLs in the UGS at scrap yard and east potliner in 10 years, at Company Lake in 15 to 20 years, and at south landfill in several hundred years. Complete restoration of the aquifer (including the silt unit) expected to take several hundred years.	Achieves compliance with MCLs in the UGS at scrap yard and east potliner in 10 years, at Company Lake in 15 to 20 years, and at south landfill in 5 to 10 years. Complete restoration of the aquifer (including the silt unit) expected to take several hundred years.
Summary	Not applicable.	Low level of impact to community, workers, environment. Compliance with MCLs in groundwater not reached for several hundred years.	Low level of impact to community. Potential for impact to workers and environment during dredging of Company Lake. Groundwater restoration achieved for portions of the site in 10 to 15 years. Complete restoration of the aquifer (including the silt unit) expected to take several hundred years.	Moderate level of impact to community. Potential for impact to workers and environment during excavation of landfills and dredging of Company Lake. Groundwater restoration achieved for portions of the site in 10 to 15 years. Complete restoration of the aquifer (including the silt unit) expected to take several hundred years.

Table 7-6
Comparative Analysis of Alternatives
Criterion: Implementability

Evaluation	No Action Alternative	Alternative A	Alternative B	Alternative C
Ability to construct, operate, and monitor the technology	Not applicable.	Capping is a standard, proven technology. Production wells already in operation.	Excavation proven; dredging requires skilled implementation. Production wells already in operation.	Excavation proven; dredging requires skilled implementation. Production wells already in operation.
Reliability of the technology	Not applicable.	Capping is reliable, with maintenance. Production wells demonstrated, reliable.	Capping is reliable, with maintenance. Excavation is permanent and, therefore, reliable. Production wells demonstrated, reliable.	Excavation is permanent and, therefore, reliable. Production wells demonstrated, reliable.
Ease of undertaking additional remedial action, if necessary	Not applicable.	Removal of cap on Company Lake sediments in order to perform additional remedial action would be difficult and costly. Removal of the riprap cover at the north landfill would present some difficulties. Removal of gravel or soil caps at the scrap yard and the south landfill would be relatively inexpensive.	Removal of the riprap cover at the north landfill would present some difficulties. Removal of the clean backfill material at the scrap yard would be relatively inexpensive.	Removal of the clean backfill material at the landfills and scrap yard would be relatively inexpensive.
Ability to coordinate with and obtain approvals from other agencies	Not applicable.	Approvals should not be needed from other agencies.	NPDES approval required for actions at Company Lake and groundwater extraction/ treatment/discharge. Consultation with resource trustees required for discharges to Columbia River.	NPDES approval required for actions at Company Lake and groundwater extraction/ treatment/discharge. Consultation with resource trustees required for discharges to Columbia River.

Table 7-6, continued
Comparative Analysis of Alternatives
Criterion: Implementability

Evaluation	No Action Alternative	Alternative A	Alternative B	Alternative C
Availability of equipment, specialists, technologies, offsite treatment, storage or disposal services, and capacity	Not applicable.	Installation of the permeable cover on the Company Lake sediments would require specialized services.	Dredging Company Lake sediments would require specialized services, which are available.	Dredging Company Lake sediments would require specialized services, which are available.
Summary	Not applicable.	Implementable.	Implementable. Dredging Company Lake sediments would require good planning and oversight.	Implementable. Dredging Company Lake sediments would require good planning and oversight.

Table 7-7
Comparative Analysis of Alternatives
Criterion: Cost

Evaluation	No Action Alternative	Alternative A	Alternative B	Alternative C
Capital costs	$ 0	$ 6,078,000	$10,463,000	$19,196,000
Annual operation and maintenance costs	$ 0	$ 207,000	$229,000	$416,000
Net present value (30-year basis)	$ 0	$8,111,000	$12,637,000	$23,998,000
As-spent cost (30-year basis)	$ 0	$17,741,000	$21,682,000	$43,666,000

SECTION 8

References

SECTION 8

References

CH2M HILL. January 1995. *Removal Site Assessment Report*. Prepared for Reynolds Metals Company, Troutdale Facility.

_____. April 5, 1996. *Draft Current Situation Summary*. Prepared for Reynolds Metals Company, Troutdale Facility.

_____. April 11, 1996. *Final Report: Cryolite Pond Area Removal Action*. Prepared for Reynolds Metals Company, Troutdale Facility.

_____. May 8, 1996. *Draft South Wetlands Addendum to the RI/FS Work Plan*. Prepared for Reynolds Metals Company, Troutdale Facility.

_____. May 8, 1996. *Draft Remedial Investigation/Feasibility Study Work Plan*. Prepared for Reynolds Metals Company, Troutdale Facility.

_____. April 3, 1997. *Final Report: East Potliner Area Removal Action*. Prepared for Reynolds Metals Company, Troutdale Facility.

_____. April 3, 1998. *Draft Surface Water and Sediment Areas Addendum to the RI/FS Work Plan*. Prepared for Reynolds Metals Company, Troutdale Facility.

_____. April 9, 1998. *Final Report: Casthouse Remediation Area Removal Action*. Prepared for Reynolds Metals Company, Troutdale Facility.

_____. April 27, 1998. *Final Report: Bakehouse Sumps Area Removal Action*. Prepared for Reynolds Metals Company, Troutdale Facility.

_____. May 29, 1998. *Draft Memorandum GW No. 12: Screening of Groundwater Treatment Technology Options*. Prepared for Reynolds Metals Company, Troutdale Facility.

_____. May 1999. *Draft Baseline Risk Assessment, Part 1—Nongroundwater Media*. Prepared for Reynolds Metals Company, Troutdale Facility.

_____. June 1999. *Draft Groundwater Remedial Investigation Report*. Prepared for Reynolds Metals Company, Troutdale Facility.

_____. July 20, 1999. *Memorandum WP No. 43: Construction Tasks Work Plan—South Wetlands Soil Excavation, Stormwater Discharge Rerouting, South Ditch Dredging, and Upland Piles Relocation*. Prepared for Reynolds Metals Company, Troutdale Facility.

_____. July 1999. *Draft Baseline Risk Assessment, Part 2—Groundwater*. Prepared for Reynolds Metals Company, Troutdale Facility.

_____. August 1999. *Draft Nongroundwater Remedial Investigation Report*. Prepared for Reynolds Metals Company, Troutdale Facility.

Ecology and Environment, Inc. 1991. *Site Inspection Report for Swift Adhesives.*

PRC Environmental Management, Inc. October 19, 1993. *Final Site Inspection Prioritization Report.*

U.S. Environmental Protection Agency. March 8, 1990. *National Oil and Hazardous Substances Pollution Contingency Plan; Final Rule.* 40 CFR Part 300. *Federal Register.*

_____. *USEPA Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA.* Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3-01.