PB97-964611
EPA/541/R-97/199
January 1998

EPA Superfund Record of Decision:

East Multnomah County Ground Water Contamination, OU 2
Multnomah County, OR
12/31/1996

DEQ Remedial Action Record of Decision

for the

Cascade Corporation Site

Troutdale Gravel Aquifer

Oregon Department of Environmental Quality

Waste Management & Cleanup Division

December 1996

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1. INTRODUCTION

1.1 Introduction

This document presents the selected remedial action for soil and shallow groundwater contamination within the Troutdale Gravel Aquifer (TGA) at the Cascade Corporation (Cascade) site, in Gresham, Oregon. The selected remedial action was developed in accordance with Oregon Revised Statutes 465.200 through 465.380, Oregon Administrative Rules (OAR) Chapter 340, Division 122, Section 080-110 (340-122-010 to 340-122-110). Also, to the extent practicable, the selected remedial action is consistent with the federal regulations contained in the National Contingency Plan (NCP), 40 CFR Part 300. The Cascade site is within the East Multnomah County Groundwater Contamination site proposed for inclusion on the National Priorities List (NPL or "Superfund" List) in May 1993 by the U.S. Environmental Protection Agency (EPA). A final decision on listing the site on the NPL is pending.

The selected remedial action is based on the administrative record for the site. A copy of the administrative record index is attached as Appendix A. This record of decision summarizes the more-detailed information contained in the administrative record, particularly the Remedial Investigation Reports (RI) and Final Feasibility Study (FS).

Cascade conducted the remedial investigation and feasibility study (RI/FS) and several interim removal action measures (IRAMs) to control contaminant migration in soil and groundwater in accordance with the requirements specified in DEQ Consent Order Number ECSR-NWR-89-11 issued August 28, 1989. The groundwater IRAMs are components of the selected remedial action.

1.2 Scope and Role of Selected Remedial Action

The selected remedial action addresses soil and groundwater contamination in the Troutdale Gravel Aquifer (TGA) at the Cascade site. The remedial action for the groundwater contamination in the Troutdale Sandstone Aquifer (TSA) underlying the TGA originating from historical releases at the Cascade facility and the Boeing of Portland facility, will be addressed under a separate remedial action record of decision. The investigation and development of remedial action alternatives for the TSA are being jointly performed by Cascade and the Boeing Company under the requirements of DEQ Consent Order Number ECSR-NWR-93-07.

2. SUMMARY OF SELECTED REMEDY

The selected remedial action for soil source areas and the Troutdale Gravel Aquifer (TGA) contaminant plume includes the following components:

Unsaturated Zone Soil Remediation

- Soil vapor extraction (SVE) to remove volatile organic chemicals (VOCs) from unsaturated zone soil;
- Destruction of VOCs in soil gas vapors using a catalytic oxidation unit or equivalent treatment system, prior to venting to the atmosphere;
- Additional characterization of several areas of soil contamination, to determine whether SVE is necessary in these areas;
- Maintenance of existing asphalt and concrete paved areas where soil contaminant concentrations exceed protective levels; and.
- Application of institutional controls for soil source areas where residual contaminant concentrations exceed protective levels.

Groundwater Remediation in the Shallow Troutdale Gravel Aquifer (TGA)

- Continued operation of the on- and off-site interim removal measures (IRAMs), consisting of a hydraulic control system for TGA contaminant plume;
- Expansion of the off-site IRAM system, if remedy performance monitoring indicates that hydraulic capture of the off-site component of the contaminant plume is not effective with existing components;
- Removal of light non-aqueous phase liquids (LNAPL) by co-pumping LNAPL and groundwater;
- Additional on-site groundwater extraction from 8 existing extraction wells and one new extraction well;
- Air sparging from approximately 25 air sparging wells in on-site source areas;

- Discharge of treated groundwater to the Columbia Slough or Fairview Lake via Multnomah County storm water drainage ways;
- Long-term groundwater monitoring;
- A contingency to provide long-term hydraulic control of those portions of the TGA contaminant plume that cannot be restored to cleanup levels; and
- Institutional controls for groundwater use restrictions for the TGA, should restoration of the TGA be determined to be infeasible.

Section 9 provides a detailed description of the selected remedy summarized above.

3. SITE DESCRIPTION

3.1 Site Setting

The Cascade facility is located within Section 29, Township 1 North, Range 3 East, Willamette Meridian at 2201 NE 201st Avenue, Gresham, Oregon (Figure 3-1). The facility is owned and operated by Cascade Corporation. Cascade's property is approximately 47 acres in size. The production facility where Cascade manufactures fork lift truck attachments and the product development center located on the northeast corner of the property occupy approximately 8 acres (Figure 3-2). The remaining portions of the property are undeveloped and are covered by natural vegetation (trees, grasses, etc.).

3.1.1 Site Definition

For purposes of the discussion in this document, the terms "site" or "on site" refer to portions of Cascade's property containing contaminated soil and/or groundwater contamination at levels requiring remedial action. "Off site" refers to the properties north of the Cascade property with soil and/or groundwater contamination.

3.1.2 Surrounding Land Use and Populations

The Cascade site is bounded on the north by a Union Pacific Railroad (UPRR) corridor and Interstate 84 (I-84), on the east by NE 201st Avenue, on the south by undeveloped portions of Cascade's property. Cascade's property to the south is bordered by residential properties, and on the west by undeveloped property zoned for industrial use. Between I-84 and Sandy Boulevard is a 26 acre tract of land owned by Sandy Boulevard Development Corporation (a subsidiary of Cascade). This property was used for growing vegetables by a commercial produce company until the summer of 1996. An adjacent tract to the west is owned by Boyd Coffee Company.

3.2 Physical Setting

This section summarizes the physical setting of the Cascade site including topography, climate, surface water, geology, hydrogeology, and surface water and groundwater beneficial uses.

3.2.1 Topography

The site slopes gently toward the north, from an elevation of approximately 170 feet (ft) above mean sea level (MSL) along the southern property line to 140 ft MSL along the northern boundary. The topography of the area north of the site has a more pronounced slope, descending from south to north in a series of terraces to the modern alluvial plain of the Columbia River (Figure 3-2).

3.2.2 Climate

Eastern Multnomah County is characterized by mild, wet winters and moderately warm, dry summers. The mild climate is a result of the surrounding terrain and distance from the Pacific Ocean. Temperatures typically range between 35° F to 52° F in the winter, and 54° F to 78° F in the summer. Average annual rainfall in the Portland area is 37 inches with approximately 80 percent occurring between October and May. Prevailing winds are generally from the east paralleling the Columbia River during the spring and summer, and from the southwest during the summer.

3.2.3 Surface Water

Surface water near the site includes:

- Taggart and Shepard springs, which emerge from the TGA along the erosional truncation of the TGA; see Section 3.2.4 for description of hydrogeologic units.

- Osbourn Spring and Osbourn Creek, which emerge southeast of the site and flow north, approximately one-quarter mile east of the site.

- Fairview Lake, approximately 4,000 feet (ft) to the north-northeast.

- The Columbia Slough, which originates at Fairview Lake.

- A drainage ditch (the east ditch) that flows east from NE 201st Avenue to Osbourn Creek, approximately 1,500 ft northeast of the site.

- A drainage ditch at the north site boundary (the north ditch) that parallels the UPRR corridor and is routed southeast to join the east ditch.

Stormwater runoff from the site discharges into the north and east ditches, which form part of the Multnomah County storm sewer system.

3.2.4 Geologic and Hydrogeologic Setting

Geologic units under the site include Quaternary deposits and the Tertiary Troutdale Formation. The Quaternary deposits are less than 15 ft thick and consist of unconsolidated gravel with silt, sand and clay. The Troutdale Formation consists of interbedded clastic deposits of volcanic and fluvial origin consisting of silt, clay, sand, sandstone, siltstone and conglomerate.

Hydrogeologic Units beneath and in the vicinity of the site, listed in order of increasing depth, are the Troutdale Gravel Aquifer (TGA), confining unit one (CU1), the Troutdale Sandstone Aquifer (TSA), confining unit two (CU2), and the Sand and Gravel Aquifer (SGA) (Table 3-1). CU1 and CU2 are aquitards that separate the TGA from the TSA and the TSA from the SGA, respectively.

The TGA consists of gravel with sand, silt, and clay, and is approximately 50 feet thick on-site. The TGA gradually thins and terminates at an erosional interface located on the sloping terrace at the Sandy Boulevard Development and Boyd Coffee properties. The upper TGA consists primarily of unconsolidated silty, sandy gravel with cobbles and boulders. The lower TGA is typically an indurated sandstone.

CU1 is estimated to be more than 60 ft thick beneath the southern portion of the site. It gradually thins to less than 15 ft in thickness north of the site, being thinner near the erosional boundary. CU1 is 40 to 45 ft thick near the north property boundary. It consists of interbedded siltstone and claystone; sandstone interbeds are common within CU1.

The TGA is an unconfined aquifer that is recharged both locally and farther upgradient, primarily by infiltration of precipitation from the ground surface. Groundwater in the TGA flows north (Figure 3-3). Prior to implementing interim hydraulic control of the contaminant plume off-site, groundwater in the TGA exited the aquifer in the immediate vicinity of the site by one of three mechanisms: discharge from Shepard Spring, subsurface flow over the CU1 truncation north of the site where it recharged the TSA, or vertical leakage downward through CU1. Spring flow from Shepard Spring reinfiltrates into the ground and also recharges the TSA.

The upper portion of the TSA consists of sandstone, and the lower portion consists of unconsolidated conglomerate. Regional groundwater flow in the TSA is toward the northeast. Local groundwater flow in the TSA is influenced by TGA recharge north of the TGA truncation which creates a groundwater mound and complex radial groundwater flow patterns.

3.2.5 Groundwater and Surface Water Use

No domestic, industrial, or irrigation wells completed in the TGA were identified within one mile of the Cascade site. No surface water rights were identified for Taggard or Shepard Springs, or Osbourn Creek. Fairview Lake uses include agricultural irrigation water supply, recreation and fishing.

4. SITE HISTORY

This section summarizes the manufacturing activities conducted at the Cascade facility, the types of chemicals used during manufacturing operations, and historical releases related to manufacturing activities.

4.1 Operational History

The Cascade forklift manufacturing facility has operated continuously at the site since 1956. Between 1956 and 1963, the production facility included a paint booth, a parts and hydraulic cylinders assembly area and a maintenance shop. From 1963-1966, the facility was expanded to incorporate nickel and chrome electroplating operations and vapor degreasing of parts. The vapor degreaser was removed in 1975 and replaced by hot water and biodegradable soaps for cleaning of parts.

The production facility was expanded to nearly its present size between 1976 and 1985. Cascade discontinued chrome and nickel plating operations in 1978. Nickel plating was resumed between 1982 and 1986. Since 1985, Cascade manufacturing operations have involved parts machining, welding, maintenance, aqueous degreaser washing, painting, and assembly.

4.1.1 Process Wastes, Management and Disposal Practices

Wastes associated with the historical manufacturing processes at the facility have included cutting oil, hydraulic fluid and coolants from the machine shop, spent nickel and chrome plating processing solutions, cyanide salts and contaminated heat treatment pots from the carburizing process, and paint sludge and paint booth wash water containing minor amounts of paint ingredients such as toluene, methyl isobutyl ketone (MIBK) and alcohols. Since 1980, Cascade has maintained manifests for wastes sent off-site for disposal.

Electroplating Operations. Wastes associated with electroplating operations included plating solutions and wastewater. Wastewaters were discharged to the City of Gresham sanitary sewer system. Electroplating solutions were drummed and manifested for off-site disposal. Incidental releases from electroplating operations have not been reported but are suspected, based on detections of chromium in soil and groundwater in the vicinity of the plating areas.

Parts Painting. Paint dry filters and paint dust were disposed of off-site at St. Johns Landfill.

Parts Machining and Cleaning. Wastes associated with parts machining included cutting oils and cooling liquids. Cutting oils typically contained chlorinated solvents. Parts cleaning included spent solvents (trichloroethene [TCE]), and sludges which accumulated in the vapor degreaser tank.

Cascade installed two underground storage tanks (USTs) in 1971 to store used coolants and oils associated with parts machining. Waste coolants and oils were transferred to the tanks manually or by a pump in a cutting bin collection sump installed near the UST locations in 1978. Waste fluids from the USTs were periodically removed for off-site disposal. The USTs were removed in 1988 and replaced with above-ground storage tanks.

Historical releases of process wastes were not well documented by Cascade during the RI. Prior to completion of the FS, the only known releases reported by Cascade to DEQ involved an overflow and release of approximately 40 gallons of cutting oil from the UST in 1985, a 25 gallon spill of methylene chloride inside the plant in 1986, and hydraulic oil within a hydraulic trench within the production facility in 1990. The first two releases were reportedly cleaned up. The contamination in the trench line is being addressed as part of the final remedial action for the site.

In 1995, Cascade reported information obtained from former and current Cascade employees indicating that wastes from the parts machining and cleaning had been land disposed on-site in several areas. Spent TCE was reportedly discharged to the ground in two locations (defined as Area 2 in Section 5.2). These areas are beneath the production facility, which expanded after these disposal practices occurred. In addition, sludges from the degreaser tank and cutting oils were disposed near the former UST location and the edge of the parking lot located west of the production facility (defined as Area 6 in Section 5.2). Both of these areas are now beneath the current limits of the paved parking lot.

4.2 History of Environmental Investigations

Investigations of the Cascade site began in 1988 following the discovery of soil contamination during decommissioning of the two underground storage tanks used for storage of fluid used for machining of fork lift parts. During 1986 and 1987, and prior to tank decommissioning, Cascade sampled its industrial water supply well for halogenated volatile organic compounds (VOCs) at the request of DEQ. The monitoring was performed in response to the discovery of groundwater contamination at and in the vicinity of the Boeing of Portland facility in 1986. The following sections summarize the historical investigations of the Cascade site. The results of these investigations are summarized in Section 5.

4.2.1 Industrial Well Monitoring

Cascade performed monthly sampling of its industrial well (completed in the TSA) from 1986 to 1988 after dissolved solvents were detected in groundwater at The Boeing Company (Boeing) of

Portland facility. Analytical results from the industrial well samples showed TCE concentrations ranging from 20 to 130 parts per billion (ppb). The source of VOCs in the industrial well was determined to be leakage of contaminated TGA groundwater along the well casing to the TSA. The well was decommissioned in 1991 to eliminate this localized pathway.

4.2.2 Preliminary Remedial Investigation

A preliminary RI and hydrogeological investigation of the Cascade site was performed in 1988 in accordance with DEQ Consent Order No. ECSR-NWR-88-01. The preliminary RI included review of Cascade's waste management records related to manufacturing operations and sampling of soil and groundwater, to determine whether historical manufacturing waste management practices had resulted in contamination to these media requiring additional investigation. The preliminary RI included installation of 8 monitoring wells on-site, sampling of soils during drilling of those wells, and collection of surface soil samples in the north ditch. The investigation documented contamination of soil and groundwater at the site leading to the DEQ issuance of a Consent Order for completion of an RI/FS.

4.2.3 Remedial Investigation Phases 1 and 2

Cascade conducted phases 1 and 2 of the RI between December 1989 and September 1991. Phases 1 and 2 of the RI included:

- Installation and sampling of 17 groundwater monitoring wells on- and off-site and one on-site recovery well;
- Sampling of soils in the north and east ditches, and in the vicinity of the waste coolant USTs;
- Surface water sampling of Shepard and Taggart Springs and the east ditch;
- Completion of a geophysical survey to characterize the TGA and CU1 off-site;
- Completion of a soil gas survey beneath and in the vicinity of the production facility;
- Additional investigations of the industrial supply well;
- Completion of an aquifer test at the recovery well; and
- Preparation of an interim remedial action measures (IRAM) report.

The results of these investigations and the preliminary RI were used to identify potential contaminant sources at the site, design interim removal actions, which are discussed in Section 4.3, and scope additional investigations for completion of the RI/FS.

4.2.4 Phase 3 Remedial Investigation and Feasibility Study

Phase 3 of the RI/FS began in March 1992. The Phase 3 RI/FS included:

- Evaluation of the effectiveness of the on-site IRAM pump-and-treat system for hydraulic control and contaminant removal;
- Completion of an off-site source and receptor survey;
- Characterization of the nature and extent of the Cascade-related contamination in the TSA;
- Development of a site specific groundwater flow model;
- Completion of a treatability study for biological treatment of groundwater;
- Completion of a potassium bromide tracer study in the TGA;
- Pilot tests for soil vapor extraction and for expansion of the IRAM for the off-site component of the plume not controlled by the on-site actions;
- Completion of a human and environmental risk assessment; and
- Development and evaluation of cleanup options for the site.

The Phase 3 RI/FS was completed in January 1996 with submittal of the final FS report. Investigation results related to the TSA were incorporated into the TSA RI/FS, which was conducted jointly by Cascade and Boeing under a separate DEQ consent order.

4.3 Interim Removal Action Measures

This section summarizes the interim removal action measures (IRAMs) performed by Cascade since initiation of investigations in 1988. The IRAMs were implemented to control contaminant migration in groundwater, both on- and off-site, and for removal of soil contamination in selected areas at the facility that acted as sources of groundwater contamination.

4.3.1 TGA Groundwater

The on-site IRAM is a TGA groundwater extraction and treatment system designed to prevent further off-site migration of a dissolved VOC plume. The system consists of five removal wells spaced approximately 50-100 ft apart (one which was a monitoring well converted for extraction), and an air stripping tower located along the northern property boundary. The pump and treat system began operation with one removal well in June 1991 and was expanded to three wells in 1992, four wells in 1994, and to its current configuration of five wells in February 1996.

Through December 1995, the onsite IRAM has removed and treated more than 27 million gallons of TGA groundwater containing approximately 380 pounds of VOCs.

The off-site IRAM, located approximately 600 ft north of the Cascade site, is a 400-ft long trench with the bottom keyed into the CU1. The trench is designed to intercept the off-site dissolved VOC plume in TGA groundwater and reduce the contaminant flux from the TGA to the TSA via groundwater and spring flow over the CU1 outcrop. Groundwater collected from the trench is treated in an air stripper and discharged to the Multnomah County storm sewer system under discharge requirements specified in the Cascade consent order. The TGA control trench has operated since December 1995, except for two brief periods of shutdown due to power outages. Groundwater discharge flow to Shepard Spring ceased soon after operation of the trench began.

4.3.2 Soil Source Area Removals and Other Actions

North Ditch Soil Source Area. Approximately 190 cubic yards (yd^3) of contaminated soil was excavated from the north ditch in 1989 and disposed of at St. John's Landfill. This area received runoff from the parking areas of the facility. Soil was excavated to a depth of 4-7 feet below ground surface. Soil contamination remained at the side wall and base of the excavation. However, additional excavation was discontinued, due to the concerns of impacting the structural integrity of the Union Pacific Railroad spur.

Oil/Water Separator Removal and Replacement. An oil and water separator and surrounding petroleum contaminated soil were removed in March and April 1990, and a new oil and water separator installed. Some of the excavated soil was landfarmed in a lined area south of the research and development building and subsequently used for fill on the site, and the remainder transported off-site for disposal.

Industrial Well Decommissioning. An industrial supply well located just west of the production facility was decommissioned in the summer of 1991, because of leakage of contaminated groundwater from the TGA to the TSA along the well casing.

5. REMEDIAL INVESTIGATION SUMMARY

This section summarizes the findings of the Remedial Investigation and Endangerment Assessment for the Cascade site conducted in accordance with OAR 340-122-080 and EPA's guidance *Guidance for Conducting Remedial Investigations and Feasibility Studies*, EPA/540/G-89/004, October 1988.

5.1 Types of Contamination

Contamination at the Cascade site includes solvents, primarily TCE, from historical parts degreasing and painting activities, petroleum hydrocarbons from oils and lubricants used for parts machining, and chromium and nickel from plating operations.

5.2 Source Areas

Six contaminated areas have been identified at the site (Figure 5-1). The source areas located inside Cascade's production facility were identified from evaluations of past manufacturing processes and associated waste streams, and from the distribution of high concentrations of VOCs in soil vapor. Sources outside the production facility were identified based on knowledge of waste management practices and soil, soil vapor, and groundwater data.

5.2.1 Area 1 - Former Waste Coolant USTs.

Area 1 includes the area around the former USTs, the former cutting bin storage area that was near the USTs and connected to them, and the cutting bin drainage collection system. Area 1 is the primary source area at the site in terms of magnitude of soil and groundwater contamination with petroleum hydrocarbons and VOCs.

5.2.2 Area 2 - Former Vapor Degreaser

A vapor degreaser, formerly located in the northwest part of the production facility, is a source of VOCs in soil and groundwater. This area also includes locations beneath the existing production building where spent solvents were reportedly disposed.

5.2.3 Area 3 - Former Chrome Plating Facility.

The area in the vicinity of the former chrome plating facility inside the western part of the production facility is a source of chromium and VOCs contamination of soil and groundwater. The chrome plating facility was removed in 1978. The area is covered by the production facility building and pavement adjacent to the production building.

5.2.4 Area 4 - North Ditch.

Soil contamination in the drainage ditch at the north site boundary (the north ditch) which receives stormwater runoff from the site, consists primarily of petroleum hydrocarbons. VOCs have also been detected in north ditch soil samples. Contaminated soil was removed to a depth ranging from 4-7 feet below ground surface from part of the ditch in 1989. Additional contamination remains below the depth of the 1989 soil removal.

5.2.5 Area 5 - Hydraulic Line Trench

Soil with elevated concentrations of TPH, presumably from hydraulic fluid leaks, remains in the area of the hydraulic line trench inside the southern part of the production facility. A precast liner was installed in the trench in 1990 during facility upgrades.

5.2.6 Area 6 - Vapor Degreaser Sludge and Coolant Disposal Area

Soil in this disposal area is impacted primarily by petroleum hydrocarbons. Visual evidence of contamination is present in the upper 2-4 feet below ground surface. No VOCs were detected in any of the soil samples collected in this area.

5.3 Nature and Extent of Contamination

The nature and extent of contamination is described below. The nature and extent of contamination was determined from the results of numerous analyses of soil, soil vapor, groundwater and surface water samples collected from the Cascade site since 1988.

5.3.1 Soil and Soil Vapor

The characterization of soil contamination included sampling from over 15 soil borings, 20 test pits, and 40 soil vapor test or extraction points. The analyses performed on various soil samples have included aromatic and halogenated VOCs, polynuclear aromatic hydrocarbons (PAHs) and other semi-volatile compounds, metals, cyanide and total petroleum hydrocarbons (TPH). Table 5-1 summarizes the range of contaminants detected in site soil.

Metals. Chromium, nickel and copper are the metals associated with Cascade's manufacturing processes. Chromium was the only metal detected at levels significantly above background levels. None of the soil metals concentrations exceeded risk-based screening concentrations.

Volatile Organic Compounds. Trichlorethene (TCE), 1,2-dichloroethene (1,2-DCE), tetrachlorethene (PCE), and fuel-related compounds toluene, ethyl benzene and xylene have been detected in site soil. TCE was detected in 5 of 82 soil samples analyzed for VOCs. The maximum TCE concentration of 5.5 parts per million (ppm or mg/kg) was found in a soil sample from Area 1 - former waste coolant USTs, at a depth of 10 feet below ground surface (bgs). The maximum level of 1,2-DCE in soil was found in the same location and depth at a concentration of 10 ppm. The maximum PCE concentration was found at 9 feet bgs in Area 4. The maximum concentrations of toluene, ethyl benzene and xylene were detected at a depth of 5 feet bgs in Area 1.

VOCs in Soil Vapor. A total of 41 soil vapor samples were collected from known or suspected source areas at the site. A total of 13 soil vapor samples were collected in the parking lot area and along the perimeter of the production plant and 28 from within the production facility. The predominant VOCs detected were PCE, TCE, 1,2-DCE, and vinyl chloride. VOCs detected in soil vapors are summarized in Table 5-2.

Semi-Volatile Organic Compounds. A total of 35 samples were analyzed for semi-volatile organic compounds. PAHs were detected in 5 samples. The sum of the PAHs detected in soil samples was less than 1 ppm and below risk-based screening concentrations. The low level PAHs are associated with TPH contamination at the site.

Petroleum Hydrocarbons (TPH). TPH was detected in soil samples from Area 1 - USTs, Area 4 - North Ditch, Area 5 - Hydraulic Trench Line and Area 6 - Sludge Disposal Area. The maximum TPH concentration detected in Area 1 was 35,000 mg/kg at 10 feet bgs. Between Area 1 and Area 4, TPH contamination has been detected at levels up to 15,000 mg/kg and in Area 4 at levels up to 7,000 mg/kg. The maximum TPH concentrations in Area 6 was 800 mg/kg. TPH was detected in Area 5 at a level of 73,000 mg/kg. The source of the TPH in Area 5 is presumed to be leaks from hydraulic fluid lines.

Summary. VOCs in unsaturated zone soil at the source areas are the primary contaminants of concern to groundwater contamination. VOCs are known to be present in Areas 1 through 4, although Area 1 appears to be the area of highest VOC contamination. Area 1 is also the location of the highest TPH contamination. The TPH contamination extends through the entire unsaturated zone. TPH contamination in the north ditch extends laterally beneath the Union Pacific Railroad Spur and vertically beyond the maximum depth of soil removed from this area in 1989. TPH contamination in Area 5 is believed to be associated with incidental leaks from hydraulic lines. In Area 6, TPH contamination is shallow and confined to an approximate 2-4 foot interval immediately beneath the parking lot subgrade. An evaluation of PAH contamination associated with TPH indicates that the PAH concentrations do not pose a significant human health risk from direct contact. Chromium contamination is present in the chrome plating area at levels below risk-based screening levels and does not pose a threat to human health from direct contact.

5.3.2 Groundwater

The groundwater investigation included the installation of 36 monitoring wells, piezometers and extraction wells in the TGA (Figure 5-2). Groundwater has been monitored since the fall of 1988. Routine monitoring on at least a quarterly basis began in February 1992, and on a monthly schedule from selected TGA wells during initial groundwater IRAM baseline performance monitoring. Water levels have been measured monthly in each of Cascade's on- and off-site TGA and TSA monitoring wells, since February 1991. Currently, 25 TGA monitoring wells, 2 piezometers, 5 vapor extraction wells, 5 recovery wells, and 2 surface water points are sampled quarterly and analyzed for VOCs.

Groundwater in the TGA has been contaminated both on- and off-site by a number of VOCs, and to a limited extent by chromium, iron, manganese and lead. A summary of on-site groundwater metals and VOC data by source area and representative data from select off-site monitoring wells is presented in Table 5-3.

Metals. Groundwater data from upgradient monitoring wells MW-4a and MW-4b indicate no detectable concentrations of chromium, lead, manganese, and iron. Dissolved chromium has been detected in 5 on-site wells and one off-site well. The maximum chromium levels were detected in the vicinity of Area 3 - Chrome Plating Area, at a concentration of 172 ug/L. Chromium concentrations in this well have subsequently declined to levels below the federal maximum contaminant level (MCL) drinking water standard for chromium of 100 ug/L. No off-site wells have shown chromium at levels exceeding the MCL. Lead and iron have been detected in several wells at concentrations less than health-based screening levels. Manganese has been detected in approximately half of the groundwater samples collected for metals analyses. The maximum manganese detection was recorded in monitoring well MW-5a located downgradient of Area 1.

VOCs. A total of 13 VOCs have been detected in groundwater (see Table 5-3). The VOCs of concern include TCE, cis-1,2-DCE, PCE, and vinyl chloride. Other VOCs which were detected at low concentrations and are of limited extent include 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethene (1,1-DCE), and benzene.

The extent of TCE and total VOC contamination in the TGA is shown in Figures 5-3 and 5-4, respectively. TCE and cis-1,2-DCE make up the bulk of the total VOC plume shown in this figure. The highest levels of TCE are in and immediately downgradient of Area 1, the former UST location. High TCE concentrations have also been found in groundwater at or downgradient of Areas 2 and 3. Vinyl chloride, a breakdown product of DCE, is localized to Area 1 (the former USTs location), with concentrations approximately 2-3 orders in magnitude less than TCE concentrations. The highest levels of PCE were found in the vicinity of Area 3, the chrome plating area (MW-7) at concentrations generally an order of magnitude less than maximum TCE concentrations. PCE concentrations off-site are generally 1 to 2 orders in magnitude less than TCE concentrations.

LNAPL. Light non-aqueous phase liquids (LNAPL) or floating product was discovered in Area 1 near the former USTs location in 1995. LNAPL has been detected in two monitoring wells in Area 1 at thicknesses of up to 1 foot. LNAPL has not been observed in any other areas or downgradient of Area 1. The LNAPL is believed to be used cutting oils and to contain chlorinated solvents. TCE and 1,1-DCE were detected in a sample of the LNAPL at concentrations of 26,000 ppm (2.6 percent) and 2,630 ppm, respectively. The LNAPL serves as a long-term source of dissolved phase VOCs contamination to groundwater.

Summary. The primary contaminants in the TGA are TCE, cis-1,2-DCE, PCE and vinyl chloride. Maximum TCE, 1,2-DCE, PCE and vinyl chloride concentrations are located on-site in the immediate vicinity of groundwater contamination source areas. Groundwater contamination extends off-site to the TGA outcrop north of the site and has impacted Shepard Spring. Maximum off-site VOC concentrations are generally one to two orders of magnitude less than maximum on-site concentrations. Chromium and manganese contamination are present in on-site TGA groundwater above risk-based screening concentrations, but do not extend off-site above these levels. Lead concentrations are below risk-based screening levels. Iron is considered non-toxic.

5.3.3 Surface Water

The surface water investigation focused on Shepard and Taggart Springs and the east drainage ditch which historically received stormwater runoff from the Cascade site and the north ditch. Table 5-4 summarizes the range of contaminants detected in Shepard and Taggart Springs surface water.

Shepard Spring. Shepard Spring has been sampled over 20 times for site related contaminants (chlorinated VOCs and chromium). TCE and cis-1,2-DCE have been consistently detected at significant levels (see Table 5-5). TCE concentrations ranged from 105 ppb to 950 ppb, and cis-1,2-DCE from 93 ppb to 1,200 ppb. Chromium has been detected once at a concentration of 6 ppb.

Taggart Spring. TCE, cis-1,2-DCE and PCE in the concentration range of 1-2 ppb were consistently detected in Taggart Spring up until 1992. Most samples collected since that time have been "non-detect" for VOCs. Chromium was detected twice at a concentration of 6 ppb.

East Drainage Ditch. Seven sediment samples and four surface water samples were collected from the east drainage ditch, to assess whether historical storm water drainage from the site had impacted the ditch. No contamination was detected in sediments. Chloroform was the only VOC detected in surface water at a maximum concentration of 18 ppb. Chloroform is not a significant site-related contaminant and the detections are not directly attributable to the Cascade site.

5.4 Contaminant Fate and Transport

The contamination in one or more of the six source areas includes VOCs, petroleum hydrocarbons, and chromium. Each of these contaminants has impacted soil and groundwater in at least one of the source areas. Figure 5-5 illustrates the transport pathways discussed below.

VOCs disposed at the site volatilized to a limited extent and percolated into the subsurface soil and TGA groundwater. VOCs trapped in soil void spaces will volatilize to a limited extent and gradually vent to the soil surface and/or dissolve into infiltrating rainfall. Soil vapor data indicate that transport of volatile gases in the subsurface occurs at the Cascade site. The highest soil vapor concentrations are found near source Areas 1 and 2; concentrations generally decrease rapidly with distance from these sources. It is unlikely that soil vapors emitted from source areas or concentrated portions of the VOC plume will vent to the surface at significant levels (e.g. detectable), because most of the site is paved or covered by buildings.

Advective flow with groundwater is the primary contaminant transport pathway in the saturated portion of the TGA. This is demonstrated by the VOC contaminant distributions near and hydraulically downgradient of the identified source areas. Advection has caused the VOC plume in the TGA to move beyond the northern site boundary. The TGA plume consists of commingled contamination originating primarily from source Areas 1 and 2, with lesser contribution from source Area 3. Advective transport of chromium and TPH contamination, however, is limited to the vicinity of the source areas and has not resulted in off-site groundwater contamination at levels of concern.

The range of groundwater flow velocities in the TGA beneath the Cascade site is estimated to be from 0.2 to 1.0 ft per day (assuming a range of hydraulic conductivity from 1.7 to 7.2 ft per day). Without retardation, chemical transport rates would range from 0.2 to 1.0 ft per day. With retardation, a result of the aquifer's organic content, transport rates of 0.2 to 0.8 ft per day for *cis*-1,2-DCE, 0.1 to 0.5 ft per day for TCE, and 0.06 to 0.3 ft per day for PCE are expected for the range of groundwater flow velocities estimated for the site.

Vertical gradients in the TGA show a downward component of flow at the site. The vertical distribution of contaminants, however, suggests that flow from the upper TGA to the more indurated lower TGA is limited. An exception is found near the removal wells, where pumping stresses have increased the hydraulic connection between the TGA subunits. North of the site, the contamination has migrated into the lower portion of the TGA, due to thinning of most of the saturated thickness of the aquifer to the lower portion of the TGA.

Water quality data from the TGA, including Shepard Spring, and the TSA indicate that dissolved VOCs have been transported from the TGA to the TSA. Transport to the TSA occurs (a) by infiltration of surface water discharge from Shepard Spring and lesser seeps, (b) by subsurface flow through the surficial alluvium that covers the truncated surface of CU1, and (c) by leakage downward through CU1 via fractures and other pathways north of the site. Transport to the TSA by infiltration of spring discharge (surface water) and subsurface flow through the alluvium at the CU1 truncation has decreased since construction of the cutoff trench.

Contaminants will not migrate through CU1 beneath the site (and source areas) without first spreading to the lower TGA. As the TGA thins north of the site, the saturated thickness of the upper TGA decreases; only the lower TGA is saturated immediately south of the TGA-CU1 truncation. Thus, TGA contamination extends to the top of CU1 north of I-84, which is the area where downward leakage through CU1 is considered most likely.

5.5 Endangerment Assessment

An endangerment assessment (EA) was performed as part of the RI, in accordance with OAR 340-122-080 and USEPA guidance, to evaluate the potential risks to human health and the environment and the need for remedial action, or no action, at the site. The EA included a human health evaluation and an ecological evaluation. Each evaluation includes an evaluation of the chemicals of concern, a toxicity assessment, an exposure assessment, risk characterization, and uncertainty assessment.

5.5.1 Human Health Evaluation

Chemicals of Potential Concern. Chemicals detected in soil and groundwater were screened to determine those that posed the greatest potential risk to human health and the environment. The screening process included the following:

- Calculating the relative risk factor for each detected chemical, on the basis of maximum concentrations detected and chemical toxicity.
- Evaluating the frequency of detection for the chemicals posing the highest relative risk.

Health-based screening levels were derived consistent with EPA Region 10 guidelines. The screening levels were based on standard default exposure factors and on a hazard quotient of 0.1 for non-carcinogens or 1×10^{-7} excess cancer risk for carcinogens. The chemicals of concern (COCs) are TCE, PCE, *cis*-1,2-DCE, vinyl chloride, chromium, and manganese. TPH was identified as a COC for the FS due to the magnitude of contamination in certain areas, but was not carried through the quantitative risk characterization because of the lack of toxicity information for petroleum products. The hazardous constituents which may be associated with TPH (e.g. TCE), however, were quantitatively evaluated.

Exposure Assessment. The exposure assessment evaluates current or potential future exposure scenarios whereby humans might be exposed to contaminants in affected media (e.g., soil, groundwater, or air). The EA evaluation of soil found no compounds at concentrations sufficient to identify them as COCs in soil. Exposure to soil was, therefore, not quantitatively evaluated. Significant exposure to contaminants through inhalation of particulates (metals and semi-volatile compounds) or vapors (VOCs) was also not considered likely because the source areas are either paved or contaminants are present at depths greater than 4 feet (north ditch).

An assessment of the beneficial uses of groundwater within 1 mile of the site identified no water supply wells completed in the TGA. Although there are no current uses of TGA water in the study area, the exposure assessment presumed future residential use of contaminated TGA groundwater for domestic use in the absence of remedial action. Future use of TGA groundwater for normal household use could result in exposure through ingestion or inhalation of chemicals volatilizing from water. The exposure assessment estimated daily intake for each COC on the basis of an average exposure scenario and a reasonable maximum exposure (RME) scenario. Data collected from the lower TGA, the upper TGA, Taggart Spring, and Shepard Spring were used.

Toxicity Assessment. For the EA, human health effects were divided into two groups, non-carcinogenic and carcinogenic. The division is based on the mechanism of action associated with the COCs. Toxicity factors for the assessment were obtained from EPA's Integrated Risk Information System (IRIS) and/or EPA's Health Effects Summary Tables (HEAST).

A reference dose, or RfD, is the toxicity value used in evaluating non-carcinogenic effects resulting from exposure to contaminants. The RfD is the estimate of a daily exposure for humans that is unlikely to produce an appreciable risk or deleterious effect during an exposure period. The calculated intake of a chemical divided by its reference dose is called the hazard quotient (HQ). The sum of the HQs for each pathway for each COC at the site is a hazard index (HI). An HI greater than one (1.0) suggests that deleterious effects may occur to exposed individuals.

For carcinogens, a slope factor (SF) is used to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a potential carcinogen. Total excess cancer risk (TECR) is determined by dividing the intake of a chemical by its SF for each COC and summing the individual risk contributions. The risk is expressed as a probability (e.g., 1×10^{-6} means one additional chance in one million).

Risk Characterization. As previously noted, the EA did not quantify the potential cancer and non-cancer risks related to soil contamination, based on the screening evaluation and consideration of background concentrations for metals, and the occurrence and depth of contamination.

Table 5-5 summarizes the calculated hazard index and excess cancer risk for the potential future household TGA groundwater and Shepard spring use scenarios. The combined ingestion and inhalation HIs were found to exceed 1.0 (and thus represent a risk) for cis-1,2-DCE, and manganese in the TGA. These results suggest potential concern for adverse non-carcinogenic effects from future exposure to water from the aquifer via ingestion or inhalation, in the absence of remediation. There was also found to be potential concern for such effects at Shepard Spring, but not at Taggart Spring. The potential TECRs associated with future use of contaminated TGA groundwater ranged from approximately 4×10^{-5} for an average exposure to approximately 3×10^{-4} for an RME. These estimates exceed applicable MCLs and the State of Oregon protective level of 1×10^{-6}.

Uncertainty Evaluation. The evaluation of site risks involves the use of assumptions on potential exposure scenarios and toxicity of chemicals based on animal studies. Conservative parameters were used for exposure duration, frequency and water ingestion rates. Also, the exposure assessment assumed that no degradation of site contaminants would occur with time, which might overestimate or underestimate risks, because vinyl chloride, a degradation product of PCE and TCE, has a higher toxicity than these chemicals.

Toxicity data used in the EA were derived by the EPA in a conservative fashion and incorporate uncertainty factors in the reference dose and carcinogenic slope factors to account for extrapolation of toxicity data from animals to humans or the level of confidence in the toxicity studies. Thus, potential risks may be overestimated.

The EA did not quantify potential risk from exposure to PCE and TCE through ingestion, because EPA has withdrawn the toxicity parameters from their database and is re-evaluating the toxicity of these chemicals. Since TCE and PCE are two of the major contaminants in TGA groundwater, the potential risks could be greater than the estimates presented in Table 5-7.

5.5.2 Ecological Evaluation

Ecological receptors were qualitatively evaluated, with the focus on fauna. The potential for adverse population-level effects on wildlife was evaluated by estimating the size of the population expected to be exposed to impacted water at Shepard Spring and Taggart Spring. Estimates of the size of the potentially exposed population were then compared with the natural population size to determine the overall system impact. The following were concluded:

- Site-related chemicals were not expected to adversely impact the environment;
- Stressed vegetation has not been observed around Shepard Spring or Taggart Spring;
- No federal or state threatened, endangered, or sensitive species inhabit the area of Shepard Spring or Taggart Spring or are expected to depend on either spring; and
- The number of animals expected to be exposed to impacted water at either Shepard Spring or Taggart Spring is too small to significantly affect local wildlife populations.

As noted in Section 4 above, contaminated groundwater flow to Shepard spring has been eliminated as a result of operation of the TGA cutoff trench. This will result in a relocation of wildlife which may have inhabited this area to nearby areas such as Taggart Spring.

6. REMEDIAL ACTION OBJECTIVES AND CLEANUP LEVELS

The overall goal of the remedial action for the Cascade site is to protect human health and the environment from exposure to contaminated soil and groundwater while allowing existing and future use of the site consistent with land use zoning. This section summarizes the site specific remedial action objectives (RAOs) and cleanup levels for soil, surface water and groundwater that will achieve the overall goal and eliminate the potential risks to human health and the environment which were described in Section 5.5. Additionally, this section presents a description of the major applicable or relevant and appropriate requirements (ARARs) and other standards for components of the remedial alternatives is provided.

Section 7 provides a description of the remedial alternatives and Section 8 provides an evaluation of the ability of each of the remedial alternatives to satisfy the RAOs and ARARs.

6.1 Remedial Action Objectives

The following site specific remedial action objectives (RAOs) were developed to describe how protection of human health and the environment would be achieved through the cleanup. The contaminants of concern (COC) and the media affected, for which the RAOs apply are included in Tables 6-1 and 6-2.

The RAOs for groundwater, surface water and soil are as follows.

(a) Restore the TGA to background or the lowest protective concentrations, if feasible, in a reasonable time. If this is not feasible, minimize the areal extent of the TGA that contains contaminants above maximum contaminant levels (MCLs), 1×10^{-6} excess cancer risk, or a hazard quotient of 1.0 (whichever is more protective), and provide long-term containment for areas where concentrations are above MCLs or risk-based levels.

(b) Prevent ingestion of TGA groundwater or surface water that contains contaminants at concentrations above MCLs or acceptable risk-based cleanup levels.

(c) Protect environmental receptors by preventing discharge of TGA groundwater to surface water at VOC concentrations that may exceed ambient water quality criteria.

(d) Prevent the further spread of contamination in the TGA to the extent practicable.

(e) Protect groundwater quality in the TSA.

(f) Allow existing uses of groundwater resources in east Multnomah County.

(g) Prevent direct contact with unsaturated soil that has contaminant concentrations exceeding risk-based protective cleanup levels.

(h) Reduce contaminant concentrations in, and prevent contaminant migration from, unsaturated soil, to the extent necessary to achieve the groundwater RAOs defined above.

6.2 Cleanup Levels

This section summarizes the numerical risk-based cleanup levels for soil and groundwater to satisfy the remedial action objectives described above. Cleanup levels for surface water in Shepard Spring are the same as the groundwater cleanup levels because groundwater is the source of the surface water in the spring.

6.2.1 Groundwater Cleanup Levels

The cleanup goals for the chemicals of potential concern in groundwater (TCE, PCE, cis-1,2-DCE, vinyl chloride and chromium) are the drinking water standards, which are referred to as the Maximum Contaminant Levels (MCLs). MCLs are federally promulgated standards for the protection of human health from use of contaminated drinking water. They are promulgated under the Safe Drinking Water Act (SDWA) and are the maximum concentrations of contaminants allowed in water used for drinking (40 CFR 141.11-141.16). Oregon has adopted the federal regulations as state water regulations (OAR Chapter 333 Division 61). The current MCLs for the VOCs and chromium, and corresponding risk levels are listed on Table 6-1. The risk levels were estimated using EPA residential exposure assumptions for ingestion of, dermal contact with, and inhalation of chemicals volatilizing from groundwater during normal household use.

The excess cancer risk corresponding to the MCLs for vinyl chloride and PCE exceed $1x10^{-6}$. However, the expected residual concentrations of these chemicals after cleanup will be much less than their respective MCLs, if the MCL for TCE is obtained. The vinyl chloride and PCE plumes are encompassed by the TCE plume, with the vinyl chloride hot spot in Area 1 and the PCE hot spot in Area 3. To illustrate, a remediation of groundwater in Area 1 where TCE concentrations are reduced from their current maximum level (5,000 to 10,000 ppb) to the MCL (5 ppb) represents a 1,000- to 2,000-fold reduction in concentrations. If this 1000-2000 fold factor is similarly applied to the maximum vinyl chloride concentrations (less than 10 ppb), it is anticipated that the concentrations will be proportionally reduced to 0.01 ppb. This concentration corresponds to an estimated cancer risk levels less than $1x10^{-6}$ for vinyl chloride (based on residential exposure via ingestion, dermal contact, and inhalation). Similarly, analysis for PCE indicates that PCE concentrations would be expected to be below the 1×10^{-6} risk based concentration in most, if not all, of the TGA.

6.2.2 Soil Cleanup Levels

The primary cleanup goals for soil are to prevent exposure to contamination exceeding acceptable risk-based concentrations under existing and future industrial site uses, and to prevent continued release of contaminants from the unsaturated soil zone resulting in groundwater contaminant concentrations exceeding groundwater cleanup levels. Table 6-2 presents the soil cleanup levels for direct contact and groundwater protection. Background concentrations for VOCs, carcinogenic PAHs and TPH are assumed to be zero. Background concentrations for chromium are generally less than 70 mg/kg.

6.3 Applicable or Relevant and Appropriate Requirements

While not a remedy selection criterion or State law requirement, remedy implementation will comply with "applicable or relevant and appropriate requirements" (ARARs) to help meet RAOs and provide consistency with the federal NCP. The ARARs identified for Cascade are described below.

6.3.1 Resource Conservation and Recovery Act (RCRA)

Regulations implementing the Oregon Hazardous Waste Management Act (OAR 340-100-001*et.sec.*) generally adopt the federal RCRA regulations. These regulations are applicable to cleanups involving "hazardous wastes" as defined in these rules. 40 CFR Part 261 contains definitions and criteria for identifying RCRA hazardous wastes. As noted in Section 4, several of the source areas to be addressed in this cleanup involved disposal of spent solvents and sludges from the former vapor degreaser, which are F001 listed hazardous wastes. Wastes consisting of soil cuttings from drilling activities, soil removal, or extracted groundwater that contain the F001 hazardous waste constituents would have to be managed, treated, and disposed of as hazardous waste, unless the agency determines through a "contained in" determination that the constituents are below health-based levels. Listed wastes which are found to be below health-based levels may still be hazardous waste, based on the toxicity characteristic leaching procedure (TCLP). Potential characteristic waste codes for wastes at the Cascade site include D007, D039, D040, and D043.

Wastes that are determined to be hazardous waste must meet the applicable regulations under OAR 340-122-100, 101, 102, 104, 105, and 106, as well as Sections 260, 261, 262, 265 and 268 of RCRA, unless specific requirements are exempted by the Director of DEQ under ORS 465.315, or determined to be procedural requirements. Oregon regulations in OAR Chapter 340 establish state requirements that are in addition to federal requirements, including annual reporting and fees for hazardous waste generation.

Table 6-2 includes the universal treatment standards specified in Section 268 of RCRA, which must be met prior to land disposal of waste determined to be hazardous waste under Section 261 of RCRA. Wastes determined to be non-hazardous pursuant to Section 261, must be managed in accordance with the substantive requirements for solid waste described in Section 6.3.2 below.

Wastewater (e.g. groundwater treated through air stripper) discharges that are point source discharges subject to regulation under Section 402 of the Clean Water Act are excluded as hazardous waste at the point of discharge under Section 261.4(a)(2) of the RCRA rules. However, these wastewaters must be managed in accordance with applicable hazardous waste regulations until the point of discharge. Wastewaters generated during drilling activities which are temporarily stored in tanks or drums, however, must be managed in accordance with applicable hazardous waste requirements.

6.3.2 Solid Waste Management Regulations

The Oregon Solid Waste Management Regulations (OAR 340-93 through 97) regulate the management of nonhazardous solid wastes. Soil exceeding the site specific risk based concentrations in Table 6-2 would be disposed off-site in accordance with these regulations. Soil which is treated to soil cleanup levels for protection of groundwater in Table 6-2 may be used as fill at the site.

6.3.3 Clean Air Act

Oregon Air Pollution Control Laws (OAR 340-20 and 28) regulate operations of air pollution stationary sources. These regulations are applicable to air stripping or soil vapor extraction units.

6.3.4 Drinking Water Quality Act

The Oregon rules for public water systems (OAR 333-61) implement the Oregon Drinking Water Act (ORS 448.115 through 990). These regulations are applicable to any cleanup which involves beneficial reuse of treated groundwater as a source of public water supply. The maximum contaminant levels (MCLs) presented in Table 6-1 are applicable standards for beneficial reuse of treated groundwater. The MCLs are also relevant and appropriate standards for cleanup of the TGA, because they are assumed to be protective.

6.3.5 Clean Water Act

The federal Clean Water Act administered under Oregon Water Pollution Laws regulate the discharge of pollutants to surface waters of the State and are applicable to the discharge of treated groundwater.

7. DESCRIPTION OF REMEDIAL ACTION ALTERNATIVES

This section describes the remedial action alternatives developed by Cascade in the FS Report. The alternatives were developed to satisfy the RAOs described in the previous section. The range of remedial alternatives addressed the requirements of OAR 340-122-080(3)(a).

7.1 Areas and Volumes

This section summarizes the areas and volumes of contaminated soil and groundwater that are subject to the remedial action alternatives.

7.1.1 Groundwater

Figure 5-3 illustrates the areal extent of TGA groundwater contamination exceeding at least one of the risk-based cleanup levels presented in Table 6-1. The extent of the plume covers approximately 10 acres. The estimated volume of contaminated groundwater is 20 million gallons.

7.1.2 Soil

The volume of impacted soil (exceeding background) in all 6 source areas is estimated to be 6000 cubic yards.

7.2 Common Remedial Components

This section describes the remedial actions common to the five alternatives evaluated in Cascade's FS for the TGA.

7.2.1 Existing Hydraulic Control Systems

As summarized in Section 4, there are two systems (on- and off-site) currently operating to provide hydraulic control of contaminated groundwater at the site. Each alternative developed in the FS includes continued operation of these systems.

On-site Hydraulic Control. The existing on-site hydraulic control system is a groundwater pump-and-treat system that collects groundwater from five extraction wells located along the north boundary of the site, downgradient of the soil source areas and the production facility (Figure 7-1). The on-site system is effectively controlling further off-site migration of TGA contaminated groundwater. Extracted groundwater is treated with a packed-tower air stripper, discharged to the north ditch, and then conveyed to the east ditch under a National Pollution

Discharge Elimination System (NPDES) permit previously issued by DEQ. Treated groundwater is commingled with noncontact cooling water from Cascade's manufacturing plant before flowing into the east ditch.. The treatment system capacity is approximately 20 gallons per minute (gpm) and has a VOC removal efficiency of approximately 99 percent.

Off-site Hydraulic Control. The current off-site hydraulic control system is a 420-ft interceptor trench located north of the site and just upgradient of Shepard Springs (Figure 7-1). The trench extends to the base of the TGA (average depth of 26 ft below the ground surface), and is keyed into CU1. Water is extracted from nine sumps with variable-speed submersible pumps. Trench operations appear to be effectively controlling horizontal TGA groundwater flow, based on elimination of groundwater discharge to Shepard Spring and water level monitoring.

Extracted water is piped to an air stripper capable of treating 100 gpm at a 99.5 percent VOC removal efficiency. Treated groundwater from the TGA trench is discharged by gravity flow through a 6-inch diameter pipeline to the storm sewer. NPDES conditions for this discharge are specified in the Cascade consent order.

VOC emissions from the on- and off-site groundwater treatment systems are below DEQ significant emission rates and treatment of off-gasses containing VOCs is not required.

7.2.2 Additional Source Area Characterization

Each of the alternatives, except for Alternative 1, includes additional characterization of the north ditch (Area 4), the hydraulic line trench (Area 5), and the vapor degreaser sludge and coolant disposal areas (Area 6) source areas. The characterization would include soil gas monitoring for VOCs in all areas, and near-surface soil characterization for chromium and TPH in Area 4.

An option for the north ditch is to cap soil in the ditch to reduce the potential for direct contact with contaminated soil. A culvert would also be installed to direct surface water drainage to the storm sewer. If additional characterization shows concentrations of VOCs in unsaturated zone soil that might result in a long-term contaminant source to groundwater, then soil vapor extraction (SVE), included as a remedial component in Alternatives 2 through 5, will be expanded to include the north ditch area.

Remedial action for Area 5 and Area 6 will be evaluated after additional VOC soil gas monitoring.

7.2.3 Cap Maintenance

All the source areas, except the north ditch, are now covered by buildings, asphalt, or concrete. Each remedial alternative includes resurfacing and maintaining the asphalt pavement covering Areas 1 and 6, to prevent future exposure to residual soil contamination by site workers. The other source areas are covered by concrete and should not require resurfacing, but would also be maintained.

7.2.4 Groundwater Monitoring

All alternatives include groundwater monitoring to evaluate performance of remedial systems. Details on the monitoring program will be developed during remedial design. The groundwater samples would be analyzed for VOCs on all wells, and chromium on selected wells.

7.2.5 Institutional Controls

In each alternative, a notice of the potential that contaminants will remain on site above the cleanup levels would be filed in the deed records of Multnomah County. This notice would identify areas where subsurface activities (e.g., excavation) might require special precautions to prevent exposure to the residual contaminants.

7.3 Description of Alternatives

This section discusses the five remedial alternatives that were evaluated in Cascade's FS for the TGA, including technological components, estimated cleanup times, and permitting requirements. The estimated implementation timeframes and total capital and operation and maintenance costs for each of the five remedial alternatives is summarized in Table 7-1.

7.3.1 Alternative 1

Description. Alternative 1 would continue implementation of existing on- and off-site hydraulic control systems and groundwater monitoring to assess remediation performance. A deed notice would be filed with Multnomah County, and regular maintenance of existing paved areas would also be implemented.

Estimated Implementation and Cleanup Timeframes. The estimated time to achieve the groundwater cleanup levels is 33 years for the on-site portion of the contaminant plume and 14 to 30 years for the off-site component of the plume. The estimates are based on predicted contaminant mass removal rates of 8 pounds per month and the contaminant mass estimates summarized in Table 8-1.

Factors such as contaminant adsorption to soil, heterogeneities in contaminant distribution and site conditions, presence of nonaqueous phase liquid (NAPL), and contaminant transport to groundwater from persistent contaminant sources within the unsaturated zone would probably prolong cleanup beyond 33 years for the on-site portion of the plume. Cleanup times for the off-site portion of the plume could increase, if the on-site hydraulic control system is not completely effective in preventing transport of contaminated groundwater off-site.

Permitting Requirements. Discharge of treated groundwater from the on-site treatment system would continue under the existing NPDES permit for the Cascade facility. For the off-site system, the existing NPDES discharge limits and requirements specified in the consent order would either be continued under the consent order for remedy implementation or under a NPDES permit. Contaminant discharge limits for the NPDES are presented in Section 9.

7.3.2 Alternative 2

Description. This alternative includes all the components of Alternative 1 and adds additional source area characterization, soil vapor extraction (SVE) and passive product recovery for increased mass removal. These remedial components are described below.

Two wells equipped with bailers would be installed for passive recovery of light nonaqueous phase liquid (LNAPL) in Area 1. Recovered LNAPL would be temporarily stored on-site in an above-ground storage tank, characterized and transported off-site for treatment and disposal, in accordance with applicable RCRA regulations.

Unsaturated soil in Areas 1, 2, and 3 would be treated by SVE. The conceptual design for the SVE system includes 20 wells in Area 1, nine within and downgradient of Area 2, and four wells in Area 3. The SVE systems would operate until the VOCs in the extracted vapor from each source area attain a performance-based concentration below 5 parts per million by volume (ppmv) total VOCs. The 5 ppmv cleanup level for soil vapor VOCs is based on calculated equilibrium concentrations for VOCs adsorbed to soil and partitioning to soil gas or groundwater. The 5 ppmv soil vapor should result in residual VOC concentrations in soil below the soil cleanup levels for protection of groundwater presented in Table 6-2.

SVE pilot test data from the site indicate that emissions from the full scale SVE system would exceed significant emission rates for one or more contaminants in Table 6-2 (e.g., vinyl chloride), and that treatment of VOC air emissions from the system will be required. SVE off-gas will be treated with a catalytic oxidation unit or equivalent system to meet applicable discharge requirements.

Estimated Implementation and Cleanup Timeframes. The estimated time to achieve cleanup is the same as for Alternative 1. The inclusion of passive product recovery and SVE in this alternative is not expected to reduce the overall cleanup time for groundwater to less than 30 years, although it is more likely that cleanup would actually be attained as compared to Alternative 1.

Passive LNAPL Recovery. The volume of LNAPL was not estimated because it has been detected only in two adjacent wells. The time required for passive product recovery is, therefore, difficult to estimate. The passive LNAPL recovery system was assumed to operate for up to five years.

SVE. The predicted time frame to reach the performance-based goal of 5 ppmv total VOCs in unsaturated soil is 10 years. The timeframe is based on the estimated mass of VOCs in the unsaturated zone soil, an initial mass removal rate of 240 pounds per month and an assumed 30 percent reduction in this initial rate each year.

Permitting Requirements. The NPDES requirements for groundwater discharge would be as described for Alternative 1. A Notice of Intent to Construct would be submitted to DEQ's Air Quality Division for discharge of VOCs from the SVE treatment system, as prescribed by OAR 340-28-1720 and 1750. Permitting requirements for RCRA are discussed in Section 9.

7.3.3 Alternative 3

Description. This alternative includes the technologies described for Alternative 2, with the addition of active LNAPL recovery, and both air sparging and groundwater extraction in Source Areas 1, 2, and 3. These additional mass removal technologies within targeted source areas would accelerate cleanup and reduce the overall operation and maintenance time frame for the groundwater extraction and treatment systems. The additional remedial components for Alternative 3 are described below.

Nine groundwater extraction wells would be used in Source Areas 1, 2, and 3 for combined groundwater extraction and SVE. Extracted water would be treated by air stripping. The existing on-site air stripper would be replaced with a 50-gpm system to accommodate the increased volume of extracted groundwater. Groundwater extraction in the source areas would lower the groundwater table and increase the volume of soil that could be treated by SVE.

Two wells in Area 1 would also be used for active LNAPL recovery. The LNAPL recovery system will likely include pneumatic skimmers. Management and disposal of recovered LNAPL would be the same as for Alternative 2.

Air sparging involves injection of air into the saturated portion of the aquifer to facilitate biodegradation and volatilization of VOCs from groundwater. The conceptual design of the air sparging system consists of 25 sparging wells installed in Areas 1, 2, and 3. Contaminants volatilized from groundwater to the unsaturated zone soil would be recovered by the SVE treatment system. Increased air flow to the unsaturated zone soil may also have an added benefit of promoting biodegradation of TPH contamination.

Estimated Implementation and Cleanup Timeframes. The estimated time to achieve cleanup levels with Alternative 3 is expected to be less than for Alternative 2. Based on the anticipated increased mass removal rates, operation of the air sparging and SVE system would continue for approximately seven years, and additional groundwater extraction from source area extraction wells for approximately 15 years. Active product recovery was assumed to be accomplished in two years. Because of the uncertainty in the effectiveness of air sparging and SVE, it was assumed that the on-site hydraulic control system would operate for at least 30 years (the maximum time used for costing purposes).

Permitting Requirements. The permitting requirements are the same as described for Alternative 2, except the existing permit for the on-site system would be modified by DEQ to account for the increased flow rate and addition of contaminant discharge limits and monitoring for chromium.

7.3.4 Alternative 4

Description. Alternative 4 is the same as Alternative 3, with the addition of in-situ groundwater bioremediation. This technology involves the injection of nutrients and oxygen to enhance aerobic degradation of VOCs in saturated soil and groundwater. The application of this technology at the site is described below.

The bioremediation system would consist of aboveground components for delivering nitrogen, phosphorus, a cometabolite (phenol or toluene), and oxygen to the saturated zone via injection wells. Five SVE wells in Areas 2 and 3 would be periodically used as injection wells. During each injection, the air-sparging system, parts of the SVE system, and portions of the source area groundwater extraction system would be inactive. Treated effluent from the on-site hydraulic control system would be used as a source of water for reinjection. A pilot test would be required to determine cometabolite amendment levels, injection flow rates, and system configuration.

Estimated Implementation and Cleanup Timeframes. In-situ bioremediation could increase initial mass removal rates, but, without a field-scale pilot study, it was difficult to determine how effective bioremediation would be in reducing VOC concentrations in groundwater. A five-year duration for biotreatment system operation was assumed for cost-estimating purposes. The estimated time for operation of other remedial components are as described for Alternative 3. Because of uncertainties in estimating remedy performance, the FS assumed that the on- and off-site hydraulic control system would operate for 30 years.

Permitting Requirements. The NPDES requirements would be addressed as described for Alternative 3. DEQ Water Quality Division approval would be obtained for nutrient and chemical injection for in-situ bioremediation.

7.3.5 Alternative 5

Description. This alternative is similar to Alternative 4, with the addition of soil excavation in Area 1. This technology is described below.

Contaminated unsaturated soil would be removed from the area of the former waste coolant USTs (Area 1), and the oil-water separator north of Cascade's production facility would be removed and replaced. Approximately 6,200 cu yd of soil would be removed.

The excavated soil will be characterized to determine whether it is a RCRA hazardous waste. Based on the characterization, the excavated soil would be disposed off-site in accordance with applicable hazardous or solid waste regulations.

During excavation, LNAPL/groundwater would be pumped out and managed as described in Alternative 2. Before the excavation was backfilled, SVE piping and air sparging wells would be installed.

The bioremediation system would be the same as that described for Alternative 4, with additional injection capabilities due to the vapor extraction lines installed in the excavation. These lines would be used periodically for injecting nutrient- and substrate-amended water to enhance in-situ bioremediation of the underlying soil.

Estimated Implementation and Cleanup Timeframes. The estimated remedy implementation timeframes and time to achieve cleanup levels with Alternative 5 were assumed to be the same as for Alternative 4.

Permitting Requirements. The permitting requirements are as described for Alternative 4.

8. EVALUATION OF REMEDIAL ACTION ALTERNATIVES

This section discusses the comparison of the remedial action alternatives, with respect to the remedy selection criteria presented in OAR 340-122-090(5) through (9). The purpose of this evaluation is to consider the relative advantages and disadvantages of each alternative, in order to select remedies offering the most effective and efficient means of achieving the site remedial action objectives and cleanup goals described in Section 6. In addition to these five criteria, OAR 340-122-080(3)(b)(B) requires that each alternative be evaluated regarding the extent to which they comply with the requirements, criteria, or limitations under federal and state environmental laws. For each criterion, the remedial action that best meets the criteria is presented first. The other options are discussed in order of ranking.

8.1 Protection and Feasibility Requirements

8.1.1 Overall Protection of Human Health and Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each potential exposure pathway are eliminated, reduced, or controlled through treatment, engineering controls, and/or institutional controls. The potential exposure pathways include future ingestion of groundwater as a drinking water supply, direct contact with contaminated soil in source areas, and direct contact with contaminated surface water in Shepard Spring.

Background. None of the alternatives will restore the site to background conditions. At least two soil source areas have physical constraints that prevent direct removal of contamination. Restoration of groundwater to background concentrations is considered unlikely, due to technical limitations of available technologies, heterogeneity of the TGA, and the presence of LNAPL in at least one source area.

Lowest Concentration Feasible and Protective. Based on existing data, soil contamination exceeding risk-based protective levels for direct contact presented in Section 6.2 is limited to Area 1 (former UST location). Alternatives 2 through 5 include treatment to protect against further degradation of groundwater. Soil contamination in those source areas has resulted in contamination of TGA groundwater exceeding groundwater cleanup levels. Alternative 5 will likely result in the lowest concentration feasible for Area 1, as compared to in-situ treatment options, and therefore ranks slightly higher in protectiveness than Alternatives 2 through 4. Alternative 1 ranks the lowest, because it is unlikely that on-site groundwater restoration to protective levels could be achieved, due to long-term releases of contaminants from the unsaturated zone soil.

Alternatives 3 through 5 were equally rated for restoration of groundwater to protective levels, because of the uncertainties on the relative effectiveness of various remedial technologies. Alternative 2 ranks slightly less protective than Alternatives 3 through 5, because passive LNAPL recovery will likely be less effective than enhanced recovery and it does not include groundwater extraction at the source areas. Alternative 1 ranks lowest, because it is highly unlikely that groundwater would be restored to protective levels.

All of the alternatives are equally protective for the surface water exposure pathway, because the off-site hydraulic control system has eliminated discharge of contaminated groundwater to Shepard Spring.

8.1.2 Use of Permanent Solutions and Alternative Technologies

Each of the five alternatives provided some degree of a permanent solution, used one or more technologies, and are estimated to remove different quantities of contaminant mass from soil and groundwater. Alternatives 3, 4, and 5 used the most alternative technologies to permanently remediate the site. Alternative 5 ranks slightly higher than Alternatives 3 and 4, because soil contaminated with TPH is removed from the site.

8.1.3 Cost-Effectiveness

To evaluate the cost-effectiveness of one alternative relative to another, the benefits of the least-expensive alternative were compared with a more-expensive alternative. Because mass removal was a primary benefit of the remedial actions evaluated, the ratio of the cost of the alternative to the total VOC mass removed during the first five years of operations was used as one measure of cost-effectiveness. In addition to a quantitative comparison based on mass removal rates, a qualitative evaluation for the other evaluation criteria (e.g., attainment of RAOs, and protectiveness) was done in the FS.

Table 8-1 shows the mass removal rate for each alternative, the estimated mass of VOCs removed during the first five years of operation, the total cost of the alternative, and the ratio of the total cost to total mass removed. Costs considered in comparing the alternatives included capital costs and the net present value of operation and maintenance costs over the predicted duration of system use. Costs are summarized in Table 7-1. The total cost for Alternative 1 is almost entirely for O&M for the existing hydraulic control system with a normalized cost of $4,170/lb of VOC removed. The capital costs investment associated with the addition of SVE and air sparging in Alternatives 2 and 3, respectively, results in proportional benefits in terms of mass removal in the first 5 years, as evidenced by the decrease in the cost per pound of VOC removed to $440/lb for Alternative 2, and $414/lb for Alternative 3. The capital investment for in-situ bioremediation in Alternative 4, however, results in only minimal increased mass removal compared to Alternative 3, resulting in an increase in the cost per pound of VOCs removed to

$465. The cost per pound of VOCs removed by Alternative 5 increased to $527/lb. On the basis of this analysis, Alternative 3 was found to be the most cost-effective.

8.1.4 Effectiveness

The effectiveness criterion evaluated the overall performance of an alternative, including the extent to which it would reduce the toxicity, mobility, and volume of hazardous substances. Attainment of the RAOs, potential short-term risks, operational reliability, and time required to achieve full protection were also considered.

Magnitude of Residual Risk. Alternative 3 was rated slightly higher in effectiveness (i.e. less residual risk) than Alternatives 4 and 5, due to potential failure of the in-situ bioremediation process which could result in phenol or toluene co-metabolite remaining in the aquifer. Alternative 2 rated lower in effectiveness than Alternative 3, based on an assumed increase in VOC removal efficiency with air sparging provided with Alternative 3, which should result in lower residual contaminant concentrations in groundwater at the site. Alternative 1 would likely result in the highest residual groundwater contaminant concentrations of the 5 alternatives evaluated, and therefore, rated lowest in effectiveness.

Reduction of Toxicity, Mobility, and Volume. Alternative 5 would result in the greatest reduction of TPH contamination in soil. Alternatives 4 and 5 have the potential to produce significant reductions in toxicity through in-situ biodegradation of VOCs in groundwater, but the reliability of this technology has not been demonstrated at this site. Alternatives 2 and 3 should result in significant reduction in the volume of contaminated groundwater exceeding cleanup levels. Alternative 1 should restore off-site groundwater to cleanup levels, but probably would not restore or minimize the extent of groundwater contamination on-site to cleanup levels.

Time until Remedial Objectives Are Achieved. The FS assumed that the groundwater cleanup would take 30 years, based on the presence of LNAPL in at least 1 source area. Alternatives 3, 4, and 5 would increase contaminant removal rates and would be expected to provide the shortest overall time required to clean up groundwater on-site. Alternative 2 would likely take longer than Alternative 3, because enhanced LNAPL recovery should be more effective than passive recovery methods. Alternative 1 would take decades to achieve groundwater cleanup levels.

8.1.5 Implementability

Alternative 1 has already been implemented and, therefore, rates highest under this criterion. Alternatives 2 and 3 would use proven technologies that are relatively easy to implement, and the necessary permits and/or DEQ approvals could be readily obtained. Alternatives 4 and 5 would be somewhat more difficult, because they use in-situ biological treatment, which is an innovative technology that would require field testing for injecting nutrients and cometabolites (phenol or toluene) into the groundwater.

8.1.6 Compliance with Other Regulatory Considerations (ARARs)

Each of the alternatives has been developed to comply with all other regulatory requirements including NPDES, RCRA and air quality. In addition, federal requirements in CERCLA and the NCP were also considered. Alternative 1 was the only alternative that did not satisfy the CERCLA statutory preference for treatment, because some form of treatment for the soil source areas to reduce or eliminate long-term contaminant impacts to groundwater is not included.

8.2 Evaluation Summary

DEQ believes Alternative 3 best satisfies the remedy selection criteria specified in OAR 340-122-090 (5) through (9). Alternative 2 is the next best rated alternative. Alternatives 4 and 5 were rated lower, because in-situ groundwater bioremediation has not been demonstrated beyond bench scale treatability studies and there are potential detrimental effects to cleanup should bioremediation fail and the co-metabolites injected into the aquifer remain. Alternative 1 rated the lowest of the 5 alternatives.

9. THE SELECTED REMEDIAL ACTION

DEQ has selected Alternative 3 as the remedial action for the site. The estimated cost of the selected remedial action is $3.9 million. The estimated capital cost and long-term operation and maintenance costs are $800,000 and $3.1 million, respectively.

9.1 Description of Selected Alternative

The selected remedial action is described in separate sections below and includes modifications of Alternative 3 described in the Cascade FS Report. Modifications to Alternative 3 include the approach to source area characterization described in Section 7.2.2, and the timing and decision criteria for institutional controls discussed in Section 7.2.5. In addition, the contingency measures described in the recommended remedial action have been expanded to address uncertainties in the on-site source area characterization and in the effectiveness of controlling the migration of groundwater contamination between the TGA and TSA off-site.

The description includes the identification of the cleanup goals, the elements of the alternative addressing soil source areas and groundwater, and other regulatory requirements to be addressed in the cleanup. Figure 9-1 shows the locations for the remedial components.

9.1.1 Soil Source Areas Remediation

Soil source area remediation includes: soil vapor extraction to remove the VOCs from the unsaturated zone soil which serve as an on-going source to groundwater contamination; additional characterization of source areas to determine the scope of SVE or containment; containment of residual source area contamination; and institutional controls. Each of these components is described below.

Soil Vapor Extraction. Soil vapor extraction will be conducted in Areas 1, 2 and 3 to remove VOCs from the unsaturated zone soil. The system will include approximately 20 SVE wells in Area 1 (4 existing and 16 to be installed), 9 existing SVE wells in Area 2, and 4 wells (2 existing and 2 to be installed) in Area 3. Based on the additional characterization of Areas 4, 5 and 6, the SVE may be expanded, as necessary, to address VOC sources in these areas. The final number, configuration, and design of the SVE wells will be determined during remedial design.

Soil gasses removed from the SVE well network are projected to contain significant concentrations of VOCs. The SVE system, therefore, will include a treatment system designed to meet air quality discharge requirements. A catalytic oxidation unit with a VOC destruction efficiency of at least 95 percent, or an equivalent technology developed during remedial design, will be used for soil gas treatment prior to discharge to the environment.

The SVE system will be operated until soil gas VOC concentrations are reduced to a concentration of 5 parts per million by volume (ppmv) in each source area. Soil gas monitoring will be performed after achieving 5 ppmv and SVE restarted, if soil gas VOC concentrations rebound above the soil vapor cleanup level.

Additional Source Area Characterization. Additional characterization of Areas 4, 5 and 6, and soil contamination areas identified during plant expansion construction will be conducted to determine whether these areas contain significant levels of VOCs. The characterization will include a soil gas survey in Areas 4 and 6, and along the south side of the production building, and soil gas monitoring from soil vapor probes previously installed near utility trenches located within the production building. If additional characterization shows concentrations of VOCs in unsaturated zone soil that might serve as a long-term source to groundwater contaminant releases, then soil vapor extraction (SVE) will be expanded to address these areas.

Confirmation soil samples will be collected from the north ditch, to verify that no residual contamination exists in the upper 4-foot soil interval. This sampling will be limited to the metals and semivolatile organic chemicals presented in Table 6-2. If the additional characterization determines that these contaminants exceed applicable cleanup levels, then the soils will either be excavated for treatment/disposal or capped in place.

Cap Maintenance. Based on existing information, all the source areas with residual soil contaminant concentrations exceeding the direct contact, risk-based concentrations in Table 6-2 are currently covered by buildings, asphalt, or concrete. The asphalt paved parking lot will be resurfaced after completion of drilling activities associated with SVE, air sparging and well installations. All asphalt pavement covering Areas 1 and 6, and the contingent cap in Area 4 will be maintained and resurfaced as necessary. Concrete surfaces covering other source areas will also be maintained as necessary.

Institutional Controls. A DEQ-approved notice will be recorded in the deed records of Multnomah County. This notice will identify areas where soil contamination above cleanup levels exists and identify special precautions to be undertaken during any future subsurface excavation. The geographic scope of the deed notice will be determined at the completion of the soil remediation.

Remedial Action Duration. Implementation of the SVE system is projected to continue for 7 years. The actual timeframe will be based on achieving and maintaining the 5 ppmv VOC soil gas concentration action level. Completion of the additional source area characterization is expected to take less than 1 year. Cap maintenance and institutional controls will be evaluated periodically, for those areas where residual contaminant concentrations exceed risk-based cleanup levels.

9.1.2 Groundwater Remediation

Groundwater remediation includes: continued operation of the on- and off-site hydraulic control systems described in Section 7.2; LNAPL extraction in Area 1; additional groundwater extraction and air sparging from Source Areas 1, 2, and 3; groundwater monitoring; and contingency measures. Each of these remedial components are described below.

LNAPL Recovery. Two wells will be installed in Area 1 to remove the floating product (LNAPL) in this location. The LNAPL will be removed by co-pumping of groundwater and product. The recovered product will be separated from groundwater and contained in an above ground storage tank, to be located within a hazardous waste storage area to be constructed. The storage area will be equipped with secondary containment, in accordance with hazardous waste regulations. The LNAPL has been characterized as an F001 listed hazardous waste and will be transported off-site for treatment and disposal, in accordance with applicable RCRA regulations.

Additional Groundwater Extraction, Treatment and Disposal. Groundwater will be extracted from Areas 1 through 3, using 8 existing and 1 new well. Additional extraction may be implemented in Areas 5 and 6, based on additional investigations to be performed to assess VOC releases in these areas. The source area groundwater extraction is expected to increase on-site groundwater extraction rates from the current rate of 7-10 gpm to 30-40 gpm. To accommodate the additional flow, the existing air stripper will be replaced with a larger packed air stripper with a 99 percent VOC removal efficiency. No treatment of VOC emissions from the air stripper will be required, because VOC emissions will not exceed DEQ significant emission rates. For the on-site actions, treated groundwater will be discharged to surface water, under the existing NPDES permit. The existing permit will be modified by DEQ to incorporate the increased flow, and add monitoring and discharge limits for chromium and other constituents such as nitrate, orthophosphate and total phospate identified by DEQ's Water Quality Source Control Section. For the off-site system, NPDES discharge requirements will be specified in the consent order for implementation of the selected remedy, pursuant to OAR 340-45-062, or in an NPDES permit. Contaminant discharge limits for VOCs will be established at the MCLs shown in Table 6-1. Monitoring and reporting requirements for other constituents such as nitrate, orthophosphate and total phospate identified by DEQ's Water Quality Source Control Section will be specified in the NPDES discharge requirements of the consent order or NPDES permit.

Air Sparging. Approximately 25 air sparging wells will be installed in Areas 1, 2 and 3, to increase VOC removal from groundwater. The air sparging will volatilize VOCs from groundwater to the vapor phase, where they will be removed with SVE, and will promote natural degradation of VOCs and TPH in soil and groundwater through the addition of oxygen to the subsurface. The final number, configuration and design of the air sparging wells will be determined during remedial design.

Remedy Performance Monitoring. Groundwater will be monitored to assess the effectiveness of the remedial actions in hydraulic capture and restoration of groundwater to the cleanup levels. The specifics of the monitoring program will be defined during remedial design. The groundwater monitoring network may be expanded, as necessary, to assess impacts to groundwater from additional source areas or to assess remedy performance. Performance evaluation reports will be submitted anually. Detailed performance evaluations will be prepared at a minimum of every five years during remedy implementation.

Cleanup Levels. The goal of the selected remedial action is to restore groundwater to its beneficial use, which is, at this site, a potential drinking water source. The groundwater cleanup levels for the site are the MCLs listed in Table 6-1.

Remedial Action Duration and Contingency Measures. The selected remedy will include groundwater extraction for an estimated period of 15-30 years, during which time the system's performance will be carefully monitored on a regular basis and adjusted as warranted by the performance data collected during operation. Modifications are subject to DEQ approval and may include any or all of the following:

1. Expansion of the off-site hydraulic control trench, if monitoring data indicate that contaminated groundwater is migrating laterally around the trench;

2. At individual wells where cleanup goals have been attained, pumping may be discontinued;

3. Alternating pumping at wells to eliminate stagnation areas; and

4. Pulse pumping to allow aquifer equilibration and to allow adsorbed contaminants to partition into groundwater;

To ensure that cleanup levels continue to be maintained, the aquifer will be monitored at least every 2 years, for a 10-year period following discontinuation of groundwater extraction.

The following contingency measures will be implemented if it is determined that certain portions of the aquifer cannot be restored to the cleanup levels:

1. Hydraulic control of these areas to prevent recontamination of portions of the aquifer previously restored to MCLs;

2. Institutional controls in a form deemed necessary by DEQ to restrict use of groundwater as a drinking water supply;

3. Continued monitoring of specified wells; and

4. Re-evaluation of remedial technologies, such as in-situ bioremediation, for groundwater restoration.

The decision to invoke any of these measures may be made during periodic reviews of the remedial action, which will occur at 5 year intervals, beginning when the remedy is determined to be operational and effective, in accordance with the requirements specified herein.

9.2 Satisfaction of Protection and Feasibility Requirements

9.2.1 Overall Protection of Human Health and Environment

The selected remedy is protective of human health and the environment. There are no current users of TGA groundwater for drinking water supply. Future use of TGA groundwater during remediation can be controlled by Cascade, who owns most of the affected property, with the exception of the land for I-84 and Union Pacific Railroad transportation arterials, which are not considered areas feasible for groundwater use development. Restoration of the TGA to the MCL for TCE is expected to result in residual concentrations for the other VOCs well below MCLs or equivalent risk-based concentrations.

9.2.2 Permanent Solutions and Alternative Technologies

The selected remedy includes SVE and air sparging technologies which, combined with groundwater extraction, will permanently remove contaminants from soil and/or groundwater beneath and downgradient of the site. After completion of all active remedial actions, soil and groundwater contamination is predicted to approach cleanup levels. Cap maintenance, notices in the deed records, and groundwater monitoring will be maintained until cleanup levels are achieved.

9.2.3 Cost-Effectiveness

As discussed in Section 8.1.3, the selected remedial action alternative is cost-effective, because the incremental and total costs are proportionate to the incremental and total results.

9.2.4 Effectiveness

Reduction in Toxicity, Mobility, and Volume. The selected remedy is expected to remove a significant mass of VOCs from soil and groundwater, and to significantly reduce the areal extent of groundwater contamination above cleanup levels. Groundwater hydraulic controls will reduce, if not eliminate, further migration of contamination from the TGA to the underlying TSA. VOCs removed by the SVE system will be destroyed through catalytic oxidation. Product recovery in Area 1 will remove an on-going source of contamination to shallow groundwater.

Short-term Risks

Protection of Community During Remedial Action. The primary potential risk to the community during implementation of the selected remedy is from air emissions from the groundwater and SVE systems. However, VOC emissions from groundwater treatment systems will be minimal and will not pose a significant risk to neighboring residents. Treatment of air emissions from the SVE system will protect the community from significant VOC emissions during system operation.

Protection of Workers During Remedial Action. Compliance with state occupational safety and health codes, and enforcement of site health and safety plan provisions, will ensure the protection of on-site workers during installation of the various remedial systems. Operation, maintenance, and monitoring of these systems will pose only minimal risks to remediation workers.

Environmental Impact. The off-site IRAM, which is a component of Alternative 3, has stopped the discharge of contaminated groundwater to Shepard Spring, eliminating the primary exposure pathway to ecological receptors in this area. Alternative 3 will not cause significant adverse impacts to the environment from discharge of VOCs from groundwater treatment systems or discharge of treated groundwater to surface water bodies.

Time Until Full Protection Is Achieved. Full protection of human health through groundwater restoration may take up to 30 years. Restoration of soil source areas to levels protective of groundwater is projected to take 7 years. Protection of on-site workers from direct contact soil contamination currently exists, because all on-site source areas are paved. Additional investigation and remedial measures for the north ditch can be completed within 6-12 months.

Magnitude of Residual Risks After Implementing Remedial Action. The selected remedy will result in reduction of contaminant concentrations in soil to 1×10^{-6} excess lifetime cancer risk levels for carcinogens and a hazard index of less than 1 for non-carcinogens. Based on existing information, soil contaminant concentrations for PAHs and metals are below protective levels presented in Table 6-2. Cleanup of VOCs in soil to the 5 ppmv total VOC concentration in soil vapor, will result in residual VOC concentrations in soil below the groundwater protection levels presented in Table 6-2. Although the soil remedy will result in containment of TPH contaminated soil above 500 mg/kg, TPH itself will not pose a threat to human health and the environment, because the hazardous constituents (VOCs) should be effectively removed by SVE/air sparging.

Based on the information obtained during the remedial investigation, and the analysis of all remedial alternatives, DEQ believes that the selected remedy may be able to attain the MCLs presented in Table 6-1.

Type and Degree of Long-term Management, Including Monitoring and Operation and Maintenance. Groundwater contamination may be especially persistent in the immediate vicinity of the contaminant source areas, where concentrations are relatively high. The ability of the remedial alternative to achieve cleanup of groundwater throughout the plume area cannot be determined, until the remedy has been implemented, modified as necessary, and plume response monitored over time. Alternative 3 will require intermediate to long-term groundwater monitoring. Long-term operation and maintenance and performance monitoring of the on- and off-site hydraulic control and source area groundwater extraction systems, and maintenance of the existing cap will also be required. The SVE and air sparging systems will require maintenance and performance monitoring for the duration of their operation, which is currently estimated at 7 years.

Long-term Potential for Exposure of Human and Environmental Receptors to Remaining Contaminants. There is a low potential for exposure of receptors to remaining contaminants after completion of Alternative 3. The selected remedy includes contingencies for groundwater use restrictions, for those areas which cannot be restored to protective levels.

Potential for Failure of Remedial Action or for Need to Replace Remedy. The use of proven or demonstrated technologies will limit the potential for failure of the remedial actions included in Alternative 3.

9.2.5 Implementability

Degree of Difficulty. The mass removal and treatment technologies to be used are proven technologies and are readily implementable. The institutional controls (placing notice in deed records), groundwater monitoring, and cap maintenance are also easy to implement.

Expected Operational Reliability. The mass removal and treatment technologies that will be used by Cascade are commonly used, proven, and generally reliable.

Need to Coordinate with and Obtain Approval from Other Agencies. Implementation of the selected remedy will primarily involve the DEQ for permit revisions/waivers. The existing NPDES permit will require modification to increase the rate of groundwater discharge from the source area extraction wells, and to add discharge requirements for metals and possibly other constituents such as nutrients. Authorization from Multnomah County will be needed for increasing the discharge volume to the storm sewer. NPDES discharge requirements for the off-site hydraulic control system will either be issued as part of the consent order for remedy implementation, or issuance of an NPDES permit by DEQ. An air emissions permit from the DEQ, for the discharge of VOCs from the SVE and groundwater treatment systems, will not be required. DEQ will approve the design and construction of the hazardous waste storage facility, to be used for storage of LNAPL product and other wastes generated during remedial action construction activities.

Availability of Equipment and Specialists. Equipment for the on- and off-site hydraulic control systems, and source area groundwater extraction has either been installed or can easily be acquired. Equipment and personnel to operate the SVE, air sparging, and active product recovery systems are also readily available.

Available Capacity and Location of Treatment, Storage, and Disposal Services. Recovered product will be temporarily stored on site before it is transported to an off-site treatment, storage, and disposal facility for treatment. A permitted facility for acceptance for this material has been identified.

Ability to Monitor Effectiveness of Remedy. Periodic inspections of the capped area and extraction and treatment systems, plus groundwater monitoring, will provide the information required to evaluate the effectiveness of the selected remedy.

9.2.6 Compliance with Other Regulatory Requirements

Alternative 3 will comply with the regulatory requirements described in Section 6.3. In addition, the recommended remedy satisfies federal requirements in CERCLA and the NCP.

9.2.7 Consistency with Revised Oregon Environmental Cleanup Statutes

The State of Oregon Environmental Cleanup Statutes (ORS 465.315 through 465.325) were amended in 1995 by the 68th Oregon Legislative Assembly (House Bill 3352). Certain provisions became effective July 18, 1995. Other provisions will not become operative until rulemaking by DEQ is completed. DEQ, nonetheless, is required to select remedial actions consistent with the purpose and intent of the 1995 Cleanup Law, to the maximum extent practicable within the bounds of existing cleanup rules. This section evaluates consistency of the selected remedial action with the amendments in the statute.

Protectiveness. Under the 1995 Cleanup Law, the protectiveness of a remedial action is determined by application both of acceptable risk levels prescribed by the statute and a risk assessment undertaken for the site in question. This provision will not be fully operative until rulemaking is completed. The selected remedial action is nonetheless consistent with this provision of the revised statute and the current rules.

The acceptable risk levels for human health prescribed by the revised statute are $1x10^{-6}$ excess lifetime cancer risk for individual carcinogens and a hazard index of one for non-carcinogens. The selected remedy is expected to achieve these standards in soil, and to restore the TGA aquifer to MCLs for drinking water.

Treatment of Hot Spots. Once the 1995 Cleanup Law becomes fully operative, the treatment of hot spots of contamination will be required to the extent feasible. The selected remedy requires treatment of groundwater contamination Source Areas 1, 2 and 3 using SVE, air sparging and groundwater pump and treat technologies, and utilizes containment for those source areas which pose a low level risk (at or below 10^{-6} excess cancer risk). Although there are no existing beneficial uses of TGA groundwater within 1 mile of the site, the TGA groundwater contaminant plume is considered a hot spot, because it is hydraulically connected to the underlying TSA aquifer, which is currently used as a source of residential drinking water supply.

Remedial Methods. The selected remedy is consistent with the remedial methods described in the 1995 Cleanup Law, in that it includes a combination of containment, removal, treatment using "presumptive or generic" remedies such as SVE, institutional controls, and other measures such as monitoring and maintenance.

Balancing Factors. Under the 1995 Cleanup Law, remedial actions selected by DEQ will balance effectiveness, implementability, long-term reliability, short-term risk, and reasonableness of cost. The evaluation included in Section 8.1 of this document includes consideration of each of these criteria. Alternative 3 provides the best balance against these criteria. As shown in Table 8-1, the increase in cost for Alternative 3, as compared to less expensive Alternatives 1 and 2, is reasonable, because the benefits (e.g. mass removal/risk reduction) are proportionate to the increase in cost. Alternative 4 and 5, however, would not satisfy this criteria in comparison with Alternative 3.

Land Use and Beneficial Groundwater Use. The 1995 Cleanup Law requires DEQ to consider current and reasonably-anticipated future land uses at the facility and surrounding properties, when selecting a remedial action. DEQ considered present and potential future land uses at the facility in determining risk-based cleanup levels for soil (Table 6-2). DEQ has determined that continued industrial use of the Cascade facility is a reasonably likely future use, and has selected soil cleanup levels for direct contact based upon an industrial exposure scenario.

The selected cleanup levels for groundwater are based on potential future use of the TGA aquifer as a source of residential drinking water supply. This determination is based on the hydraulic connection between the TGA and the underlying TSA, which is currently used as a residential drinking water source.

10. PUBLIC NOTICE AND COMMENTS

DEQ's notice of the proposed remedial action was published in the Secretary of State's Bulletin on September 1, 1996, and in the Gresham Outlook and Oregonian newspapers on September 14 and 15, 1996, respectively. On September 1, 1996, DEQ also mailed copies of a fact sheet and proposed plan (summary of the DEQ Staff Report) to people on the DEQ mailing list for the site. Copies of the DEQ Staff Report describing the proposed remedial action, the RI and FS Reports, and other documents in the Administrative Record for the site were made available for public review at DEQ headquarters in Portland and at the Rockwood Public Library. The 60-day public comment period began on September 1, 1996 and ended on October 30, 1996.

DEQ participated in several public meetings held during the public comment period to describe aspects of DEQ's recommended remedial action for the Cascade Corporation site:

- September 4, 1996 - Friends of Blue and Fairview Lake Community Group
- September 10, 1996 - Portland Water Quality Advisory Committee
- September 24, 1996 - Regional Water Supply Managers Meeting
- October 2, 1996 - Fairview City Council Meeting
- October 17, 1996 - Friends of Blue and Fairview Lake

DEQ held two public hearings to accept verbal comments from the general public on the recommended remedial action for the Cascade site. DEQ issued press releases to the news media several days prior to the public hearings, to remind the public of the scheduled hearings. The first hearing was held on October 10, 1996 from 7:00 PM to 9:00 PM, at the Gresham City Council Chambers, located at 1333 N.W. Eastman Parkway, Gresham, Oregon. The second public hearing was held on October 30, 1996 from 1:30 to 3:00 P.M., at DEQ Headquarters, located at 811 S.W. 6th Avenue, Portland, Oregon. Section 11 provides a summary of the public comments recieved on the proposed cleanup plan for the Cascade site.

11. CONSIDERATION OF PUBLIC COMMENTS

This section summarizes the verbal and written public comments received by DEQ concerning the recommended remedial action for the Cascade site. Written comments were received from Cascade Corporation, the City of Portland, and Friends of Blue and Fairview Lake.

Comment: The staff report states that discharge requirements for treated groundwater from the off-site trench will be specified in the consent order, and will be established at MCLs. This is an order of magnitude lower than the current discharge limit of 50 ppb for the trench and the on-site remedial system.

Response: Effluent monitoring from the existing trench treatment system has shown non-detection of VOCs, since operations began. Therefore, establishing discharge limits consistent with those included in related NPDES permits (e.g. Boeing Portland and for the TSA remedy) is feasible, and readily attainable with the existing air-stripping treatment systems, or the new on-site system to be installed for the final remedy.

Comment: Cascade Corporation does not support continued characterization of Area 6 as a significant long-term source of VOC impacts to groundwater. Past characterization in Area 6 has shown no indication of VOC impacts.

Response: DEQ has determined that additional characterization is necessary for Area 6, as well as for newly identified contamination along the south side of the production building for several reasons. First, soil sampling at the site has rarely shown significant VOC concentrations in soil, due either to the soil matrix (gravels) or to sample collection, preservation and analysis methods. At the Cascade site, soil gas monitoring has been demonstrated to be more reliable in identifying VOC soil source areas at the site than direct soil sampling and analysis methods. Second, the documentation provided by Cascade for the test pits installed in this area is limited and does not define zones of contamination relative to the soil sample collection points. Finally, VOC concentrations have continued to increase in extraction well RW-3 with time. This has not been explained by Cascade, and is difficult to understand with the low sustainable groundwater extraction rates (less than 1 gpm) of the newly installed extraction well RW-4, which suggests the source of the VOCs in RW-3 are not from Area 1. Further investigation is needed to determine whether Area 6 is the source of VOCs in RW-3, and whether other recently discovered soil contamination is a source to groundwater contamination at the site.

Comment: The City of Portland is concerned that the proposed on-site and off-site extraction systems for the TGA at the Cascade site, will not stop the downward leakage of contaminants through CU1 into the TSA, especially in the area north of the Cascade site where CU1 thins. The

City believes that Cascade must be required to implement a monitoring program to ensure that migration from the TGA to the TSA is halted, and be required to enhance the remedy, as necessary to protect the TSA.

Response: DEQ understands the City's concerns and believes that actions have been taken to address those concerns. The off-site trench was designed to hydraulically control the horizontal flow of groundwater across the CU1 outcrop north of the site. The control of the potential vertical seepage of groundwater through CU1 is being accomplished by maintaining water levels within the trench below the TGA/CU1 contact. With the preferential flow in the TGA north of Cascade documented during trench construction, it is difficult to identify what more can be done to control vertical migration. However, the final remedy does include contingencies to expand the trench, and requires additional groundwater monitoring to assess remedy performance.

Comment: The City is concerned about the proposed discharge of treated TGA water to the Columbia Slough. DEQ's Water Quality's Division has determined that the Sough is water quality-limited water body for toxics (including metals), and eutrophication factors such as low dissolved oxygen, elevated levels of nutrients, and biochemical oxygen demand. As a consequence, DEQ is developing total maximum daily loads (TMDLs) for some pollutants discharged to the Slough. Until TMDLs are established, state regulations do not allow new discharges of contaminants contributing to water quality violations. DEQ appears not to have assessed the effects on the Slough of plume co-contaminants, such as metals, naturally occurring compounds, such as phosphorus and other nutrients, iron, manganese, and low levels of dissolved oxygen. DEQ's plan should include a system to monitor for these constituents in the treatment plant discharges, and should incorporate alternate discharge strategies, in case levels exceed TMDLs or other established limits.

Response: Based on exisiting information, nitrates are not elevated in the TGA on-site, but are elevated in the off-site TGA remediation area. However, concentrations are below the drinking water standard of 10 mg/L. The presence of elevated nitrates in off-site remediation area is presumably related to historical agriculture practices there. Effluent from the trench sytem was tested for nitrate and phosphate near the end of the public comment period. Nitrate concentrations in the trench water are approximately one sixth the concentrations detected in Taggart spring located west of the trench; phosphate levels were essentially the same. Taggard spring and the trench efflfuent both discharges to the Slough through the same stormwater drainage system. Flow rates from Taggart spring typically exceed the extraction rate for the trench.

Summer dry periods is when low dissolved oxygen (DO) occurs in the Slough due eutrophication factors elevated levels of nutrients, biochemical oxygen demand. During this time, groundwater extraction rates are 5 gallons per minute or less. The nutrient loading from discharge of effluent from the trench is deminimus in comparison to loading from surface water discharges (e.g. Taggart Spring), or natural groundwater discharge. Because the groundwater is being treated by air stripping, the effluent would contain high levels of oxygen, not low levels as indicated in the comment.

The final remedy will involve an increase in the rate of discharge of treated groundwater to Fairview Lake, via the east ditch and Osbourne Creek, under the existing NPDES permit covering the existing on-site IRAM. The final remedy specifies that DEQ will modify Cascade's existing NPDES permit to include monitoring for chromium or other constituents identified by DEQ's Water Quality Program.

Comment: Monitoring for chromium and other known heavy metal contaminants should be required for treated effluents from the TGA remediation effort at Cascade, and plans for heavy metal removal prior to discharge into nearby surface waters should be developed.

Response: The final remedy requires modification of the existing NPDES permit for Cascade's on-site remediation system, to include monitoring for chromium and other constituents identified by DEQ's Water Quality Program.

12. DOCUMENTATION OF SIGNIFICANT CHANGE

No significant changes were made in the final remedial action selected by DEQ as a result of public comment. However, DEQ expanded the scope of the additional source area characterization to be performed during remedial design, due to the discovery of additional soil contamination at the Cascade plant site during the public comment period. Additional soil and groundwater remediation, using the remedial technologies specified in the selected remedy may be required based on the additional characterization. DEQ also made minor modifications of the NPDES discharge limits and monitoring, to assess nutrient loading to Fairview Lake and the Columbia Slough.

13. FINAL DECISION OF THE DIRECTOR

The selected remedial action for the Cascade Corporation site is protective, and to the maximum extent practicable, uses permanent solutions and alternative technologies, is cost-effective, effective and implementable. It therefore satisfies the requirements of ORS 465.315, and OAR 340-122-040 and 340-122-090. The detailed evaluation of how the selected remedial action meets the regulatory requirements is provided in Section 9.3.

13.1 Director's Signature

Langdon Marsh, Director — Date: 12-31-96

Department of Environmental Quality

TABLES

Table 3-1
Correlation of Geologic & Hydrogeolgic Units

<table>
<tr><th>System</th><th>Series</th><th>Geologic Unit (after Tolan and Beeson, 1984)</th><th>Hydrogeologic Unit (after Hartford and McFarland, 1989)</th></tr>
<tr><td>Quaternary</td><td>Holocene/ Pleistocene</td><td>Alluvium/Unconsolidated Sand and Gravel</td><td rowspan="2">TGA</td></tr>
<tr><td rowspan="7">Tertiary</td><td rowspan="3">Pliocene</td><td rowspan="5">Upper Member Troutdale Formation</td></tr>
<tr><td>CU1</td></tr>
<tr><td rowspan="2">TSA</td></tr>
<tr><td rowspan="4">Miocene</td></tr>
<tr><td>CU2</td></tr>
<tr><td>Lower Member Troudale Formation</td><td rowspan="2">SGA or SRMA [a]</td></tr>
<tr><td>Sandy River Mudstone</td></tr>
<tr><td colspan="4">[a] SRMA = Sandy River Mudstone Aquifer.</td></tr>
</table>

Table 5-1

Cascade Corporation Site

Summary of Compounds Detected in Soil[a]

Compound	No. of Samples	No. of Detects	Range (mg/kg)[b] Min.	Max.	Location of Maximum Concentration.
Volatile Organic Chemicals					
Tetrachloroethene	55	2	0.0008	0.09	Area 4 - North Ditch
Trichloroethene	60	5	0.002	5.5	Area 1 -Former Ust Location
1-2-Dichloroethene	53	7	0.05	10	Area 1 -Former Ust Location
Benzene	56	1	0.3	0.3	Area 1 -Former Ust Location
Toluene	60	13	0.0004	4.5	Area 1 -Former Ust Location
Ethyl Benzene	60	5	0.0063	1	Area 1 -Former Ust Location
Xylenes	55	12	0.01	4.5	Area 1 -Former Ust Location
Semi-Volatile Organic Chemicals					
TPH	52	52	5	35,164	Area 1 - Former UST Locations
PAHs[c]	39	5	0.01	0.21	Area 6 - Sludge Disposal Area
Metals					
Arsenic	15	15	0.35	37	Area 4 - North Ditch
Chromium	39	39	1.2	1,430	Area 3 - Chrome Plating Area
Copper	15	15	9.6	1,300	Area 4 - North Ditch
Lead	4	4	140	200	Area 4 - North Ditch
Nickel	39	39	6.2	170	Area 4 - North Ditch

Notes:

a. Includes data from RI and Supplemental Investigation

b. Includes detected sample results only.

c. Polynuclear aromatic hydrocarbons

Table 5-2 Cascade Corporation Summary of VOCs Detected in Soil Vapor Samples[a]				
	Concentration (mg/m³)			
Sample I.D.	PCE	TCE	1,2-DCE	Source Area
C-106V	ND	584	554	Area 1 - Former UST Location
SV-6	8	86	92	Area 2
C-103V	8.9	10.6	12.4	Area 3
SV-1	2	15	2	Area 5

Note: No soil vapor samples collected from Areas 4 and 6.

Table 5-3
Cascade Corporation
Summary of Groundwater Contaminant Concentrations

Compound	No. of Samples	No. of Detects	Range (ug/L)[b]		Location of Maximum Concentration
			Min.	Max.	
Volatile Organic Chemicals					
Tetrachloroethene	397	208	0.6	920	Area 3 (MW-7s)
Trichloroethene	397	315	0.5	11,000	Area 1 (MW-5a)
1-2-Dichloroethene	384	271	0.5	13,000	Area 1 (MW-5a)
Vinyl Chloride	397	45	0.6	106	Area 1 (MW-28s)
Benzene	43	3	2	3	Area 1 (MW-5a)
Metals					
Chromium	187	24	6	172	Area 3 (MW-7s)
Iron	37	7	25	9,690	Area 2 (MW-15s)
Lead	170	6	2	7	MW-8i (next to I-84)
Manganese	37	15	7	811	Area 1 (MW-5a)

Notes:
a. Includes data through May 1994; max. concentrations lower since IRAM implementation
b. Includes detected sample results only.

Table 5-4

Cascade Corporation
Chemicals Detected in Surface Water
(ppb)

Chemical	Shepard Spring				Taggart Spring			
	Number Detected	Number Analyzed	Concentration		Number Detected	Number Analyzed	Concentration	
			Minimum	Maximum			Minimum	Maximum
Metals								
Chromium	1	13	6	6	2	11	6	6
Lead	2	12	3	28	1	10	5	5
Iron	2	2	64	192	1	2	47	47
Manganese	1	2	6	6	0	2	--	--
VOCs								
1,1-DCE	1	22	1.7	1.7	0	20	--	--
trans-1,2-DCE	14	22	2	14	1	20	1.2	1.2
cis-1,2-DCE	22	22	260	1,200	3	20	0.5	1
Chloroform	1	22	12	12	0	20	--	--
1,2-Dichloroethane	0	22	--	--	1	20	0.8	0.8
TCE	22	22	310	1,000	7	20	0.6	2.3
1,1,2-TCA	1	22	17	17	0	20	--	--
PCE	20	22	9.8	23	2	20	1	1.2

NOTE: Methylene chloride, a common laboratory contaminant, is excluded from this table. Data for methylene chloride are included in Appendix C.

TABLE 5-5

CASCADE CORPORATION SITE
SUMMARY OF POTENTIAL SITE RISKS

	Hazard Index	Excess Cancer Risk
Future Groundwater Ingestion[a]		
Average Case	9.4	4×10^{-5}
Reasonable Maximum	18.4	3×10^{-4}
Future Surface Water Ingestion[b]		
Average Case	0.8	5×10^{-7}
Reasonable Maximum	1.8	5×10^{-6}

NOTES:

[a]Includes consideration of ingestion and inhalation of contaminants in groundwater from upper TGA aquifer through household use.

[b]Includes consideration of ingestion and inhalation of contaminants in water from Shepard Spring through household use.

TABLE 6-1

CASCADE CORPORATION SITE
GROUNDWATER CLEANUP LEVELS FOR THE TGA

Chemical of Potetial Concern	Groundwater Cleanup Level (µg/L)[(a)]	Corresponding Excess Cancer Risk Level[(b)]	Corresponding Noncancer Hazard Quotient[(b)]
TCE	5	$1x10^{-6}$	0.03
PCE	5	$5x10^{-6}$	0.02
cis-1,2-DCE	70	NC	0.2
vinyl chloride	2	$7x10^{-4}$	NC
Chromium (VI)	100	NC	0.6
Total Estimated Risk at MCLs[(c)]		7x10-4	0.9

Notes: NC Not considered carcinogenic or not calcuable due to lack of reference dose.
(a) Based on Federal MCL.
(b) Based on RME exposure for residential ingestion of, inhalation of, and dermal contact with drinking water.
(c) Cleanup of TCE to MCL should reduce other chemicals of potential concern to levels well below the MCL.

Table 6-2
Cascade Corporation Site
Soil Cleanup Levels

Potential Chemical of Concern	Industrial Direct Contact (mg/kg)[a]	Protection of Groundwater (mg/kg)[b]	ARAR Based Standard[c] (mg/kg)
VOCs			
cis-1,2-Dichloroethene	20,000	4	NA[d]
Trichloroethylene	20	0.4	6.0
Vinyl chloride	0.05	0.008	6.0
Tetrachloroethylene	10	0.3	6.0
Benzene	2	0.1	10.0
Toluene	6,000	80	10.0
Ethylbenzene	20,000	100	10.0
Xylenes	2,500	800	30.0
Carcinogenic PAHs			
Benz(a)anthracene	1	NA	3.4
Benzo(b)fluoranthene	1	NA	6.8
Benzo(k)fluoranthene	1	NA	6.8
Benzo(a)pyrene	1	NA	3.4
Chrysene	1	NA	3.4
Dibenzo(a,h)anthracene	1	NA	8.2
Indeno(1,2,3-cd)pyrene	1	NA	3.4
TPH[e]	NA	500	NA
Chromium (IV)	1,500	NA	0.86[f]

[a] From OAR 340-122-045 (Environmental Cleanup Rules Soil Cleanup Table - Appendix 1).
[b] From OAR 340-122-045 (Environmental Cleanup Rules Soil Cleanup Table).
[c] Source: 40 CFR 268.48 Table UTS (Universal Treatment Standards), and 40 CFR 268 Subpart D, Treatment Standards for Hazardous Waste.
[d] No toxicity data available or chemical not toxic.
[e] From OAR 340-122-335, Matrix Score Level 2
[f] mg/L TCLP.

Table 6-3
Cascade Corporation
Surface Water Protection Criteria

Chemical of Concern	Fresh Water Acute (ug/L)	Fresh Water Chronic (ug/L)
cis-1,2 Dichloroethene	11,600[(a)]	(b)
Trichloroethene	45,000	21,000
Vinyl chloride	(b)	(b)
Tetrachloroethene	5,280	840

[a] Value is for total DCE isomers.
[b] No Chronic Value established.

Notes: Surface Water Protection Criteria Listed only for those contaminants which could result in exceedance of regulatory standards in the absence of remedial action.

Table 7-1
Cascade Corporation - Remedial Alternative Cost Summary

Alternative 1	Years Operation	Capital	O&M	Totals
On- & Off-Site Hydraulic Control Systems	30	$34,000	$1,341,000	$1,344,000
GW Monitoring	30	$0	$651,000	$651,000
Paved Area Maintenance & Deed Notice	30	$43,000	$44,000	$87,000
Engineering & System Install 20%	—	$15,400	—	$15,400
Totals		$90,000	$1,950,000	$2,040,000
Alternative 2				
On- & Off-Site Hydraulic Control Systems	30	$34,000	$1,341,000	$1,344,000
GW Monitoring	30	$0	$651,000	$651,000
Cap Resurfacing and North Ditch Cap	30	$58,000	$44,000	$102,000
Record Notice	30	$5,000	$0	$5,000
SVE System	10	$122,600	$429,000	$551,600
Air Emissions Control	10	$122,500	$267,000	$389,500
Passive Product Recovery System	5	$33,800	$70,000	$103,800
Engineering & System Install 20%	—	$75,200	—	$75,200
Totals		$450,000	$2,710,000	$3,160,000
Alternative 3				
On- & Off-Site Hydraulic Control Systems	30	$34,000	$1,341,000	$1,344,000
GW Monitoring	30	$0	$651,000	$651,000
Cap Resurfacing and North Ditch Cap	30	$58,000	$44,000	$102,000
Record Notice	30	$5,000	$0	$5,000
SVE System	7	$122,600	$333,000	$455,600
Air Emissions Control	7	$122,500	$202,000	$324,500
Active Product Recovery System	2	$33,100	$21,000	$54,100
On-Site Treatment System Upgrade	—	$50,400	$0	$50,400
Air Sparging System	7	$166,600	$168,000	$334,600
Source Area GW Extraction System	15	$72,700	$420,000	$492,700
Engineering & System Install 20%	—	$133,000	—	$133,000
Totals		$800,000	$3,090,000	$3,890,000
Alternative 4				
On- & Off-Site Hydraulic Control Systems	30	$34,000	$1,341,000	$1,344,000
GW Monitoring	30	$0	$651,000	$651,000
Cap Resurfacing and North Ditch Cap	30	$58,000	$44,000	$102,000
Record Notice	30	$5,000	$0	$5,000
SVE System	7	$122,600	$333,000	$455,600
Air Emissions Control	7	$122,500	$202,000	$324,500
Active Product Recovery System	2	$33,100	$21,000	$54,100
On-Site Treatment System Upgrade	—	$50,400	$0	$50,400
Air Sparging System	7	$166,600	$168,000	$334,600
Source Area GW Extraction System	15	$72,700	$420,000	$492,700
In-Situ Bioremediation System	5	$125,000	$452,000	$577,000
Engineering & System Install 20%	—	$158,000	—	$158,000
Totals		$950,000	$3,540,000	$4,490,000
Alternative 5				
On- & Off-Site Hydraulic Control Systems	30	$34,000	$1,341,000	$1,344,000
GW Monitoring	30	$0	$651,000	$651,000
North Ditch Cap	—	$20,000	$0	$20,000
Record Notice	30	$5,000	$0	$5,000
SVE System (Following Excavation)	7	$99,300	$333,000	$432,300
On-Site Treatment System Upgrade	—	$50,400	$0	$50,400
Air Sparging System	7	$166,600	$168,000	$334,600
Source Area GW Extraction System	15	$72,700	$420,000	$492,700
In-Situ Bioremediation System	5	$125,000	$452,000	$577,000
Soil Excavation & Disposal	—	$928,600	$0	$928,600
Engineering & System Install 20%	—	$300,400	—	$300,400
Totals		$1,800,000	$3,270,000	$5,070,000

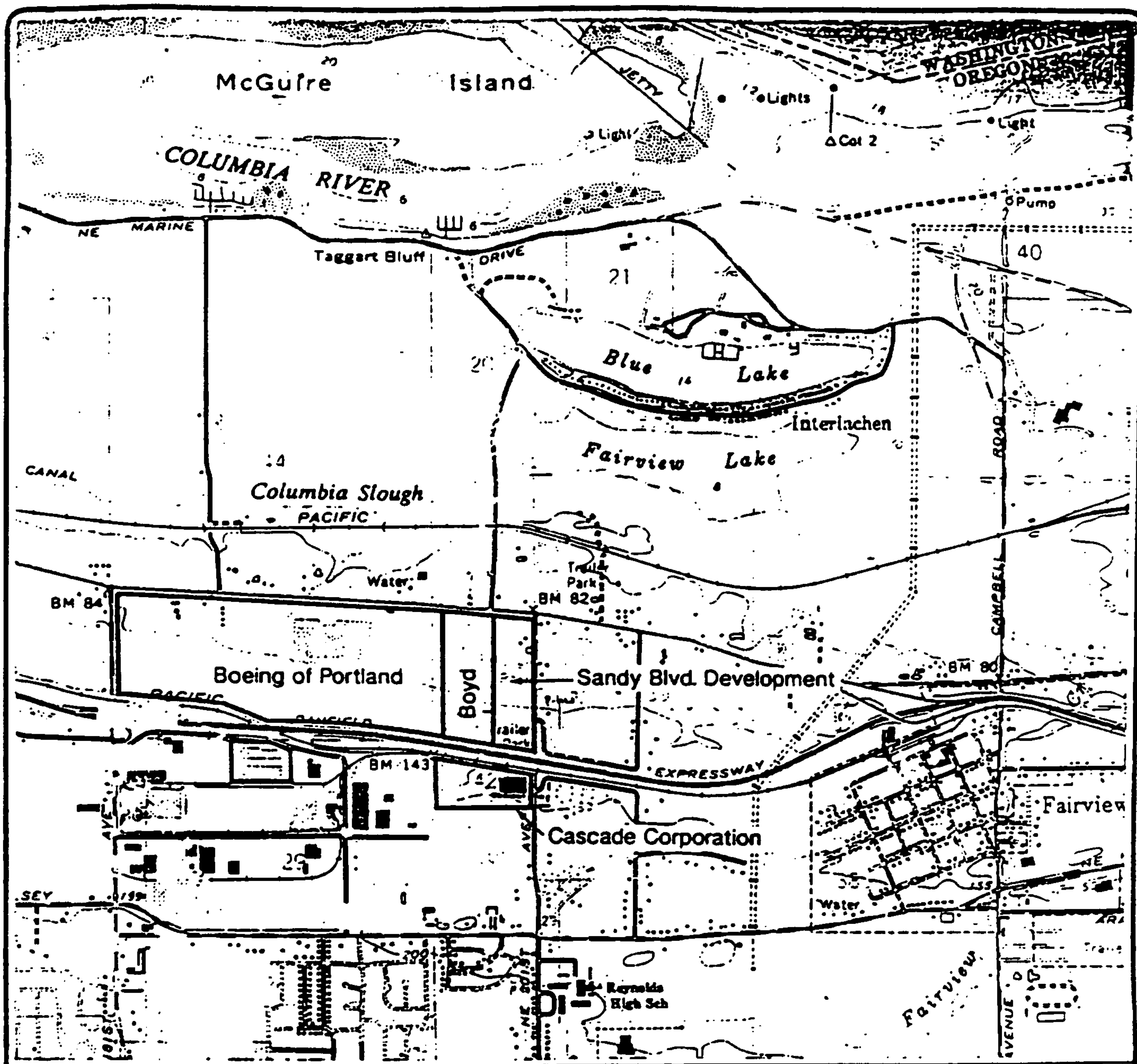
Table 8-1

Cost-Effectiveness Evaluation

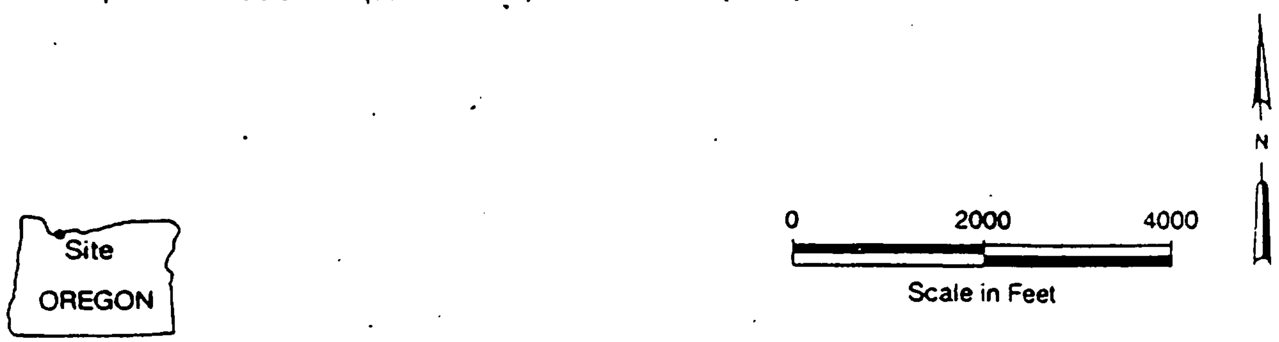
Alternative	VOC Mass Removed in 5 years (lb)[a]		Alternative Cost	Cost per pound removed ($/lb VOC_x)
	Remedial Component	Mass Removed in 5 years (lb)		
1	On-site hydraulic control[b]	300		
	Off-site hydraulic control[c]	180		
	Total mass removed	**480**	$2.0 million	$4,170/lb
2	On-site hydraulic control	300		
	Off-site hydraulic control	180		
	SVE[d]	6,520		
	Passive product recovery[e]	50		
	Total mass removed	**7,050**	$3.1 million	$440/lb
3	On-site hydraulic control	300		
	Off-site hydraulic control	180		
	Source area extraction[f]	420		
	SVE	7,820		
	Air sparging[g]	450		
	Active product recovery[h]	250		
	Total mass removed	**9,420**	$3.9 million	$414/lb
4	Components from Alt. 3	9,420		
	In-situ bioremediation[i]	250		
	Total mass removed	**9,670**	$4.5 million	$465/lb
5	Same as Alternative 4	9,670	$5.1 million	$527/lb

a General approach used to calculate mass removal rates defined in Section 6.1.6 of FS. All calculations based on total mass of 10,000 lb.
b Calculated assuming initial mass removal rate of 5 lb/mo remains constant over 5 year period.
c Calculated assuming initial mass removal rate of 3 lb/mo remains constant over 5 year period.
d Calculated using initial mass removal rate of 240 lb/mo and that this rate declines 30 percent per year (see Section 6.2.2 of FS).
e Removal rate based on best professional judgment. Mass refers only to VOCs contained in LNAPL, not total mass of LNAPL removed.
f Calculated assuming initial mass removal rate of 7 lb/mo remains constant over 5 year period.
g Based on assumption that 90 percent of mass removal attributable to air sparging (500 lb) will occur in first 5 years.
h Removal rate based on best professional judgment. Mass refers only to VOCs contained in LNAPL, not total mass of LNAPL removed.
i Assumes mass removal rate of approximately 4 lb/mo, approximately half the predicted maximum removal rate.

FIGURES



Base Map From: USGS 7.5' quad. CAMAS, WASH.-OREG. (1975)



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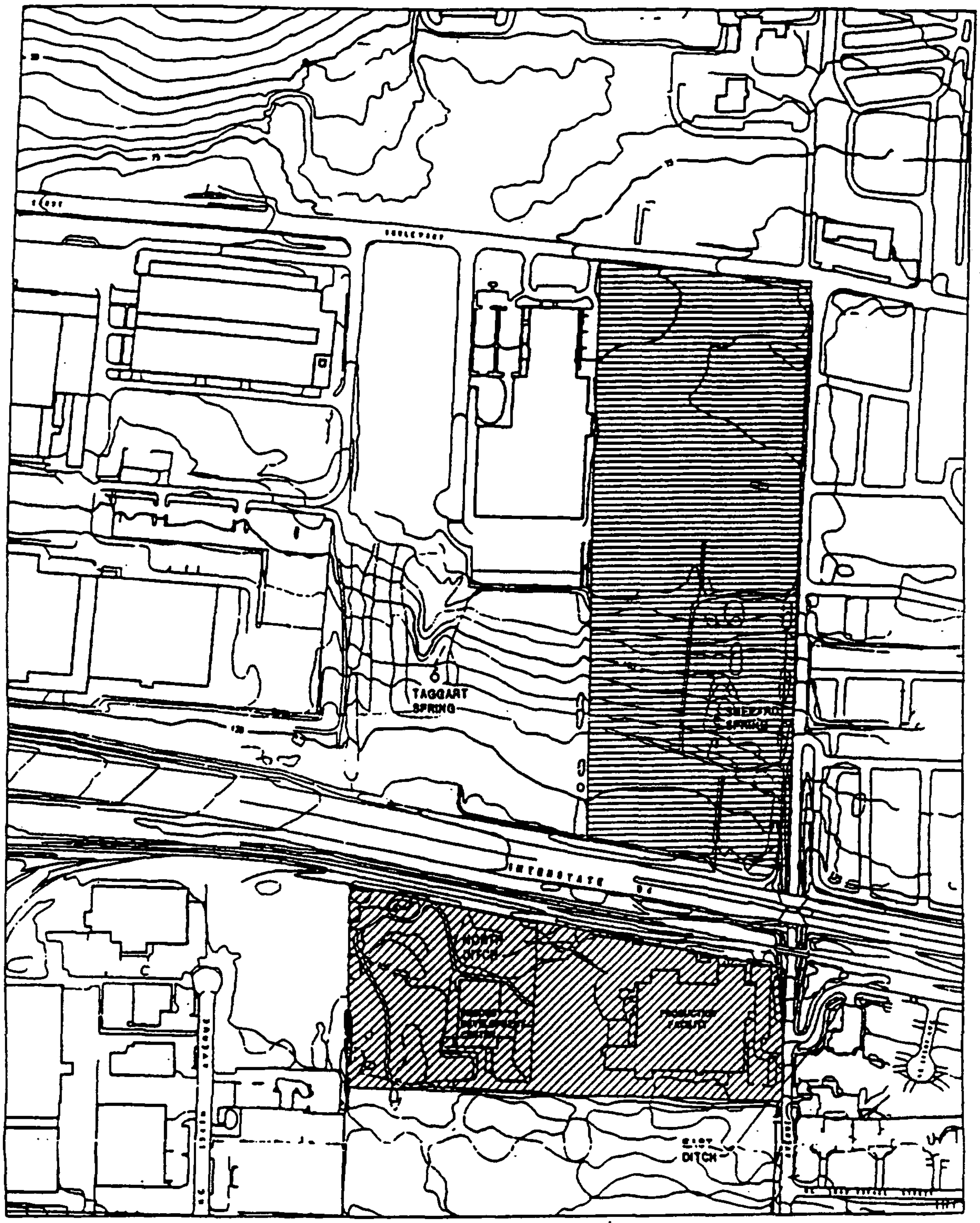
PROJECT NO. 0683003.13

Figure 3-1
CASCADE CORPORATION
TROUTDALE, OREGON

LOCATION MAP



EXPLANATION

Onsite Cascade Property

Offsite Cascade Property

Ground Surface Elevation Contours (Feet, MSL) (Contour Interval 5 Feet)

Vegetation

Fence

N

0 300 600

SCALE IN FEET

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Figure 3-2
CASCADE CORPORATION
TROUTDALE, OREGON

SITE FEATURES

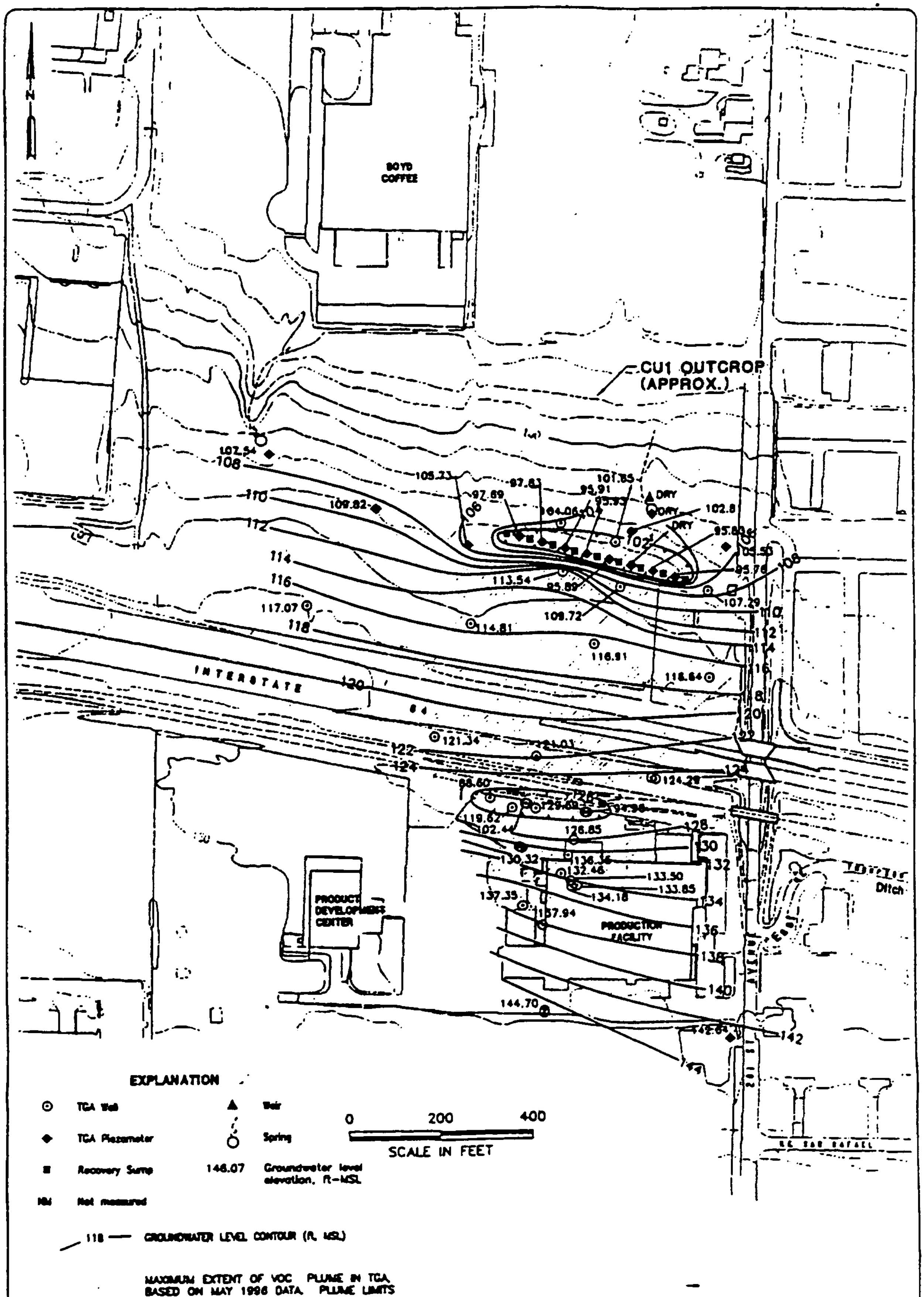

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Figure 3-3
CASCADE CORPORATION
TROUTDALE, OREGON
TGA GROUNDWATER ELEVATION CONTOURS,
MAY 30, 1998

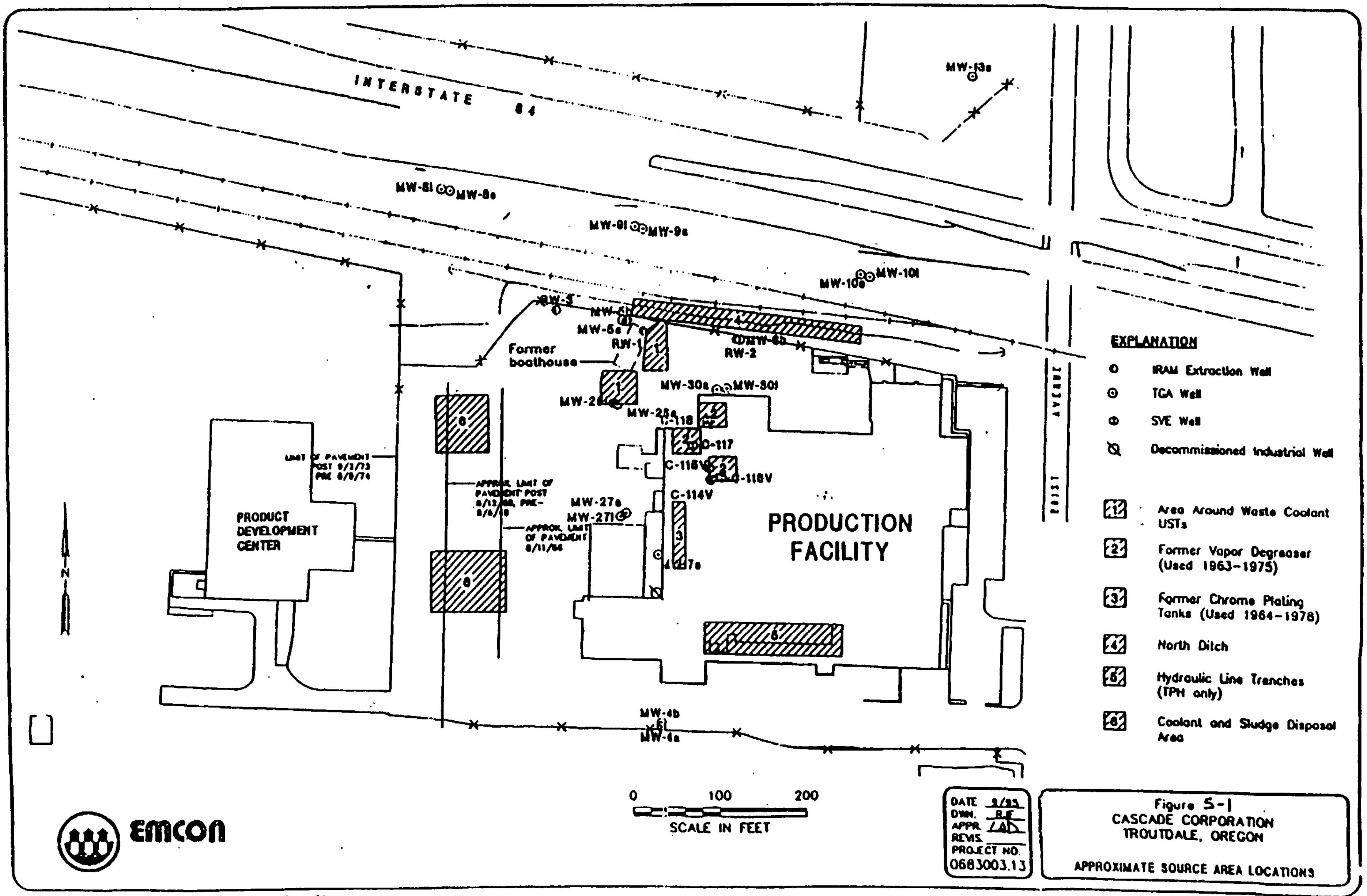

Figure 5-1
CASCADE CORPORATION
TROUTDALE, OREGON
APPROXIMATE SOURCE AREA LOCATIONS

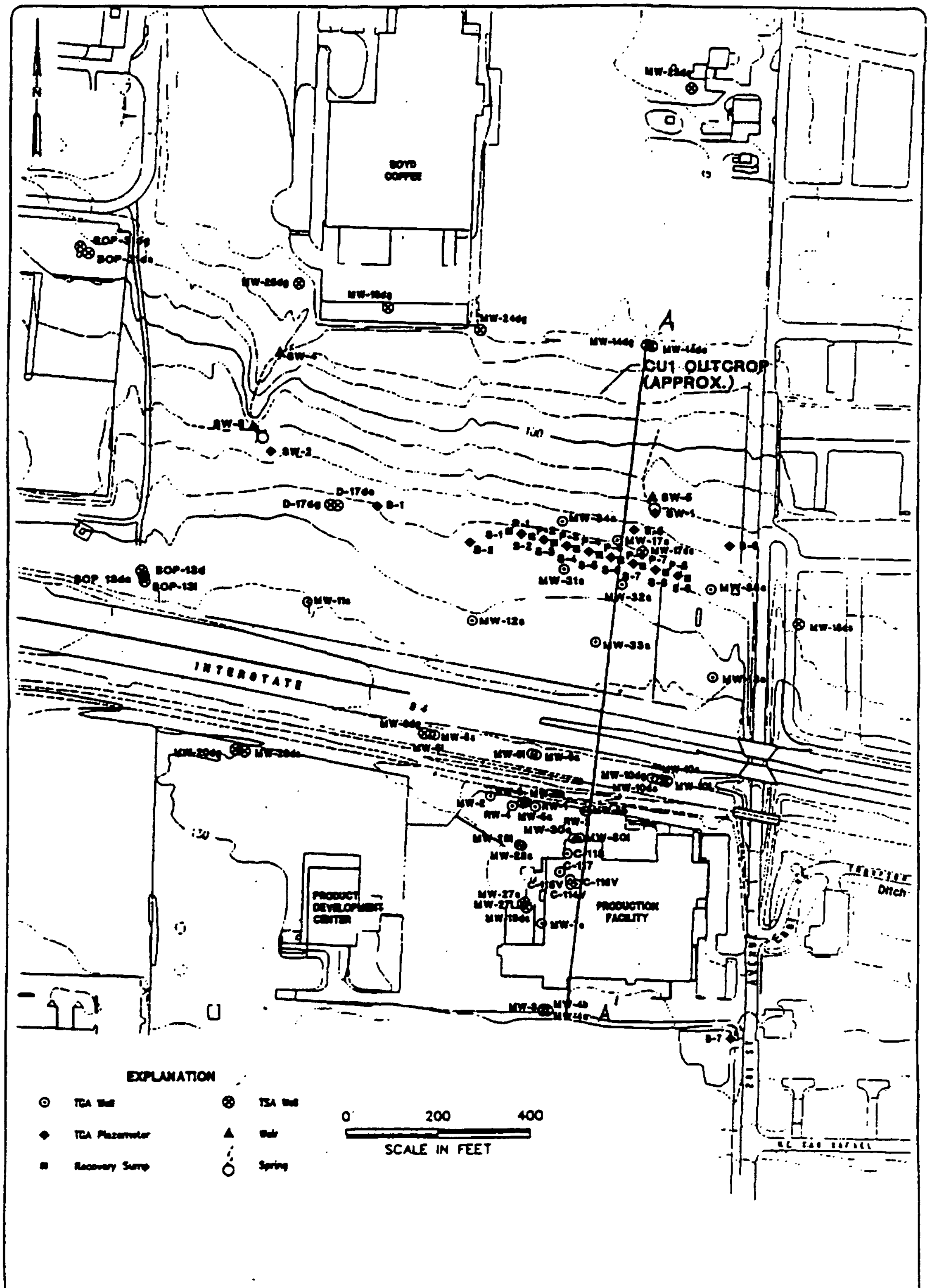

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Figure 5-2
CASCADE CORPORATION
TROUTDALE, OREGON
TCA IRAM EXTRACTION AND MONITORING LOCATIONS

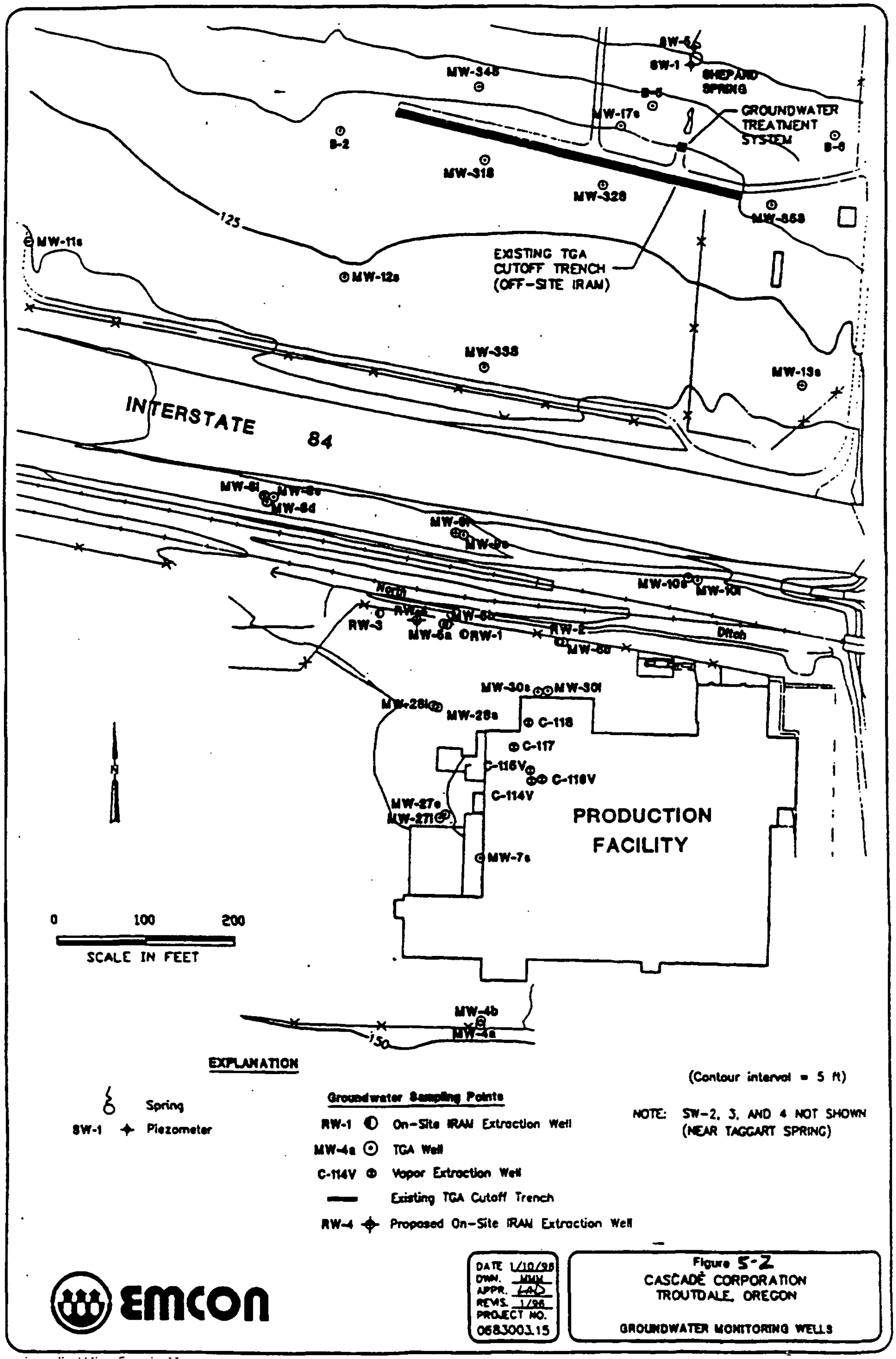

Figure 5-2
CASCADE CORPORATION
TROUTDALE, OREGON
GROUNDWATER MONITORING WELLS

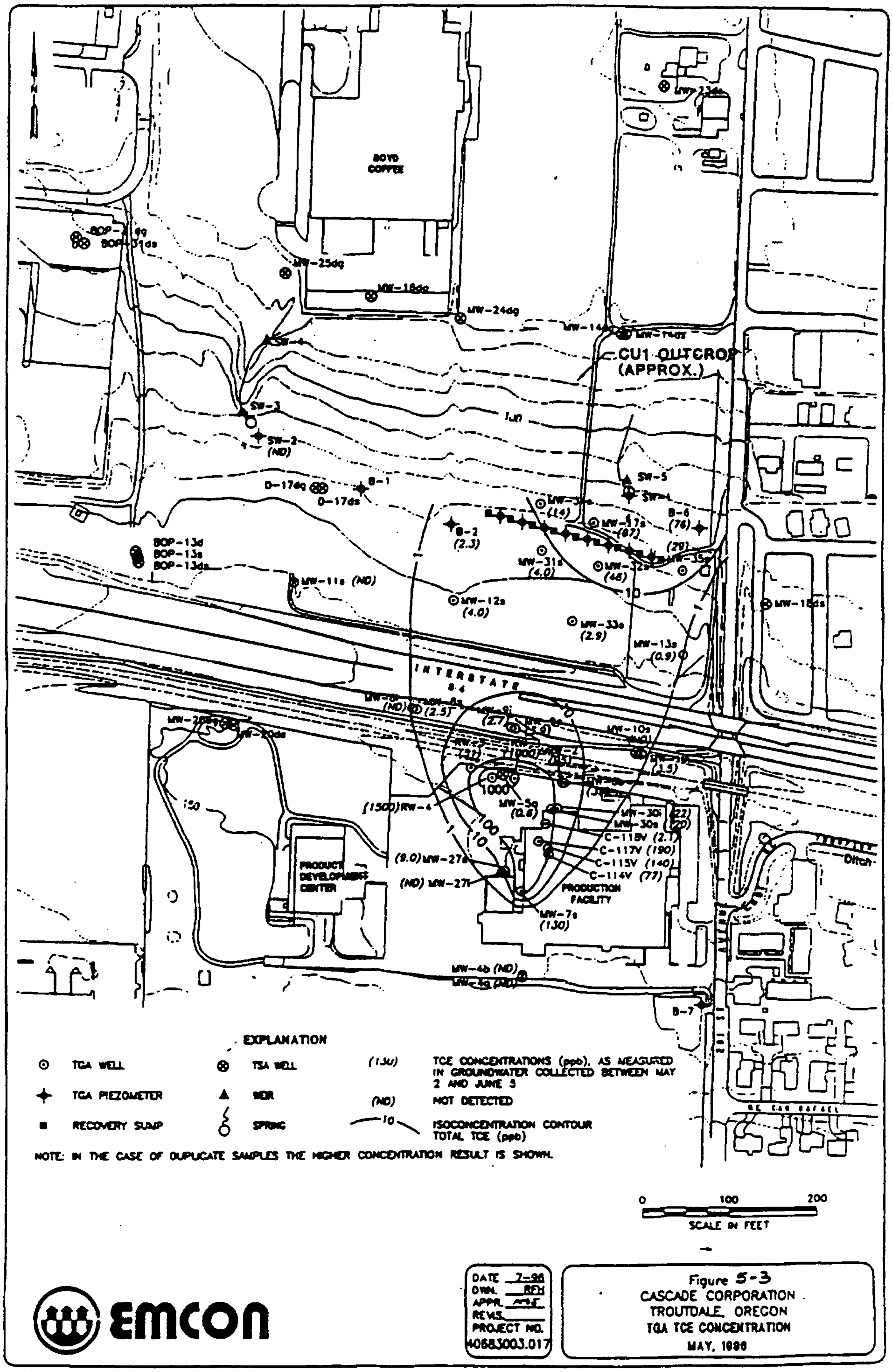

Figure 5-3
CASCADE CORPORATION
TROUTDALE, OREGON
TGA TCE CONCENTRATION
MAY, 1996

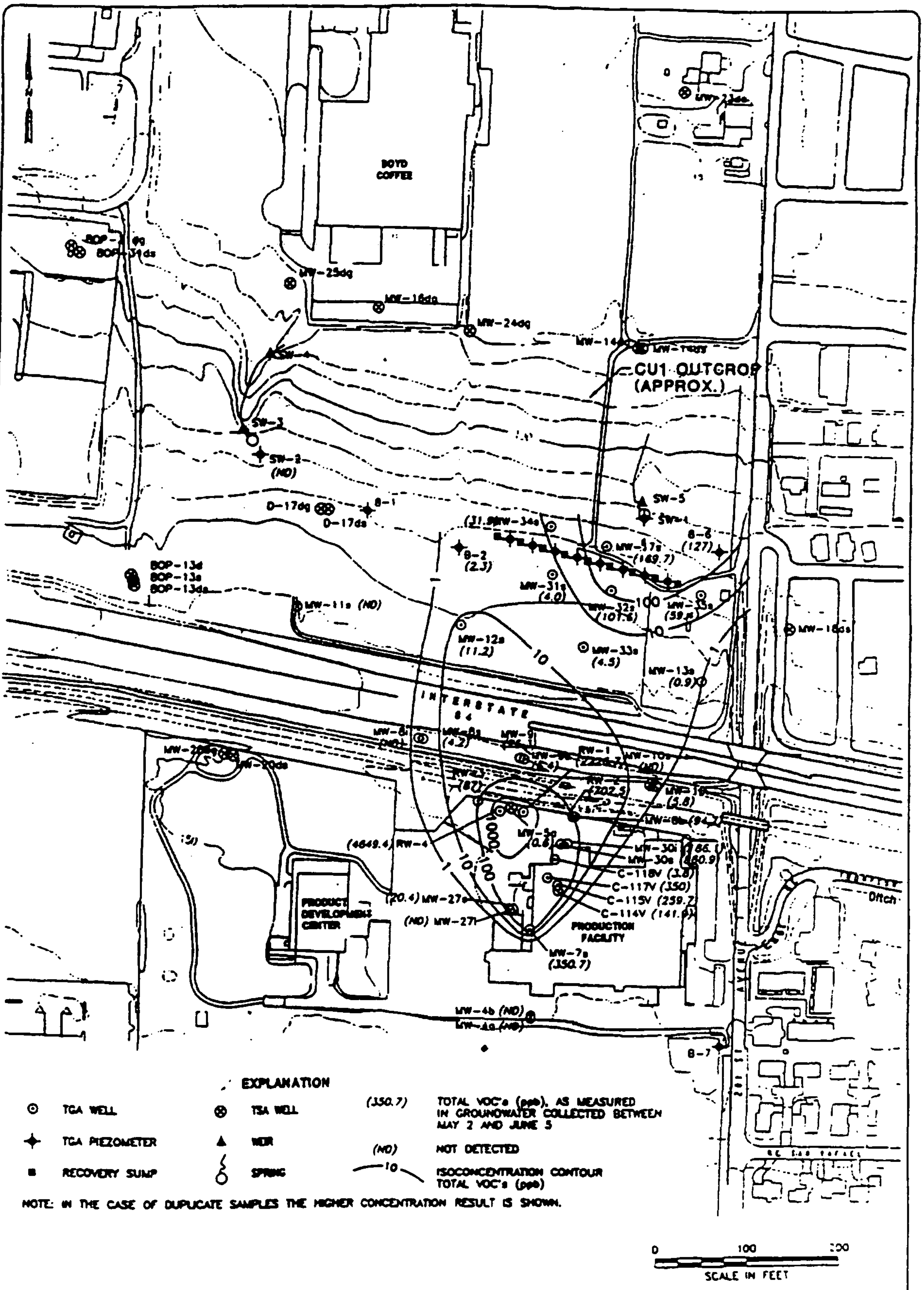

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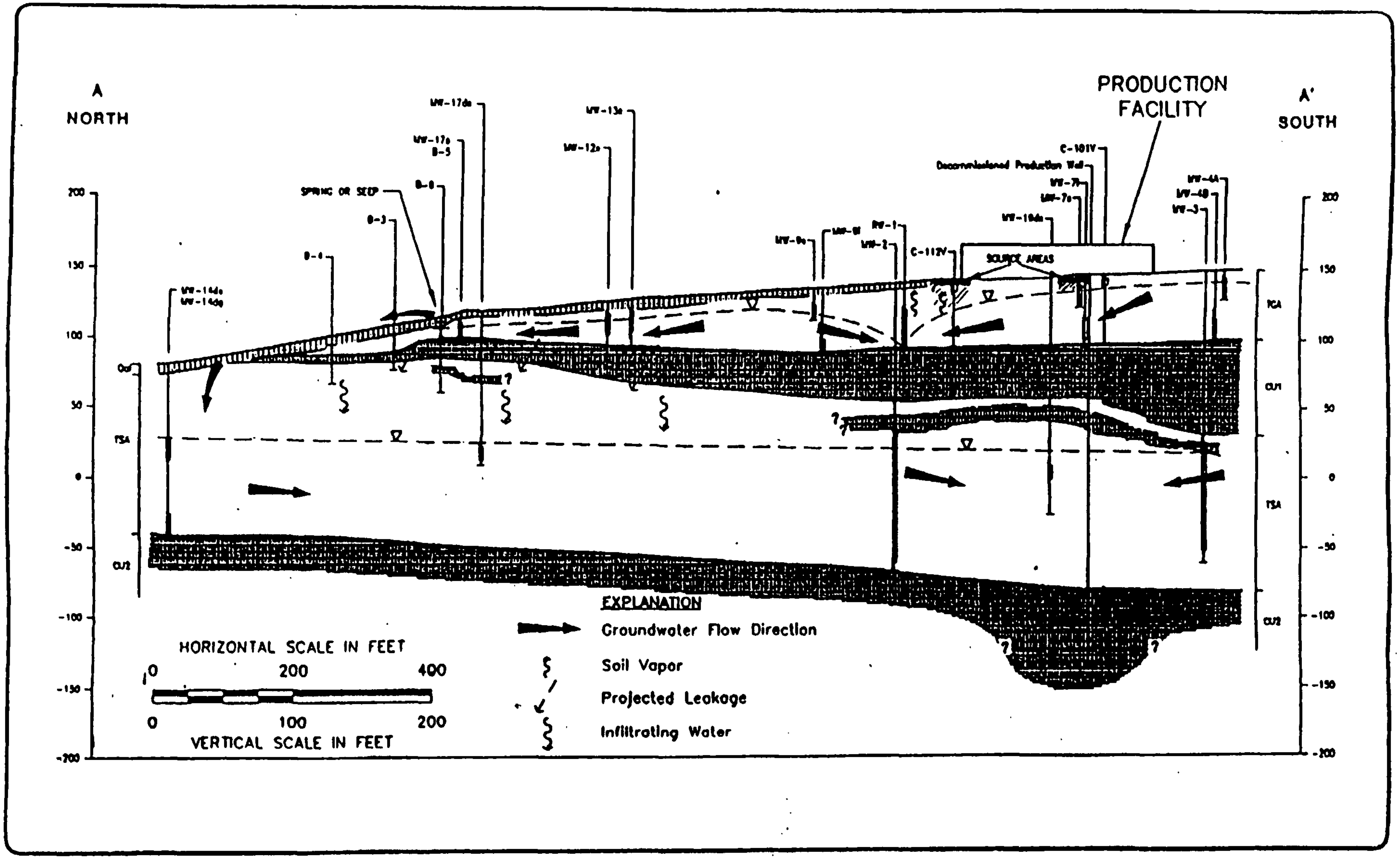
Figure 5-4
CASCADE CORPORATION
TROUTDALE, OREGON
TGA VOC_x CONCENTRATION
MAY, 1996



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PROJECT NO.
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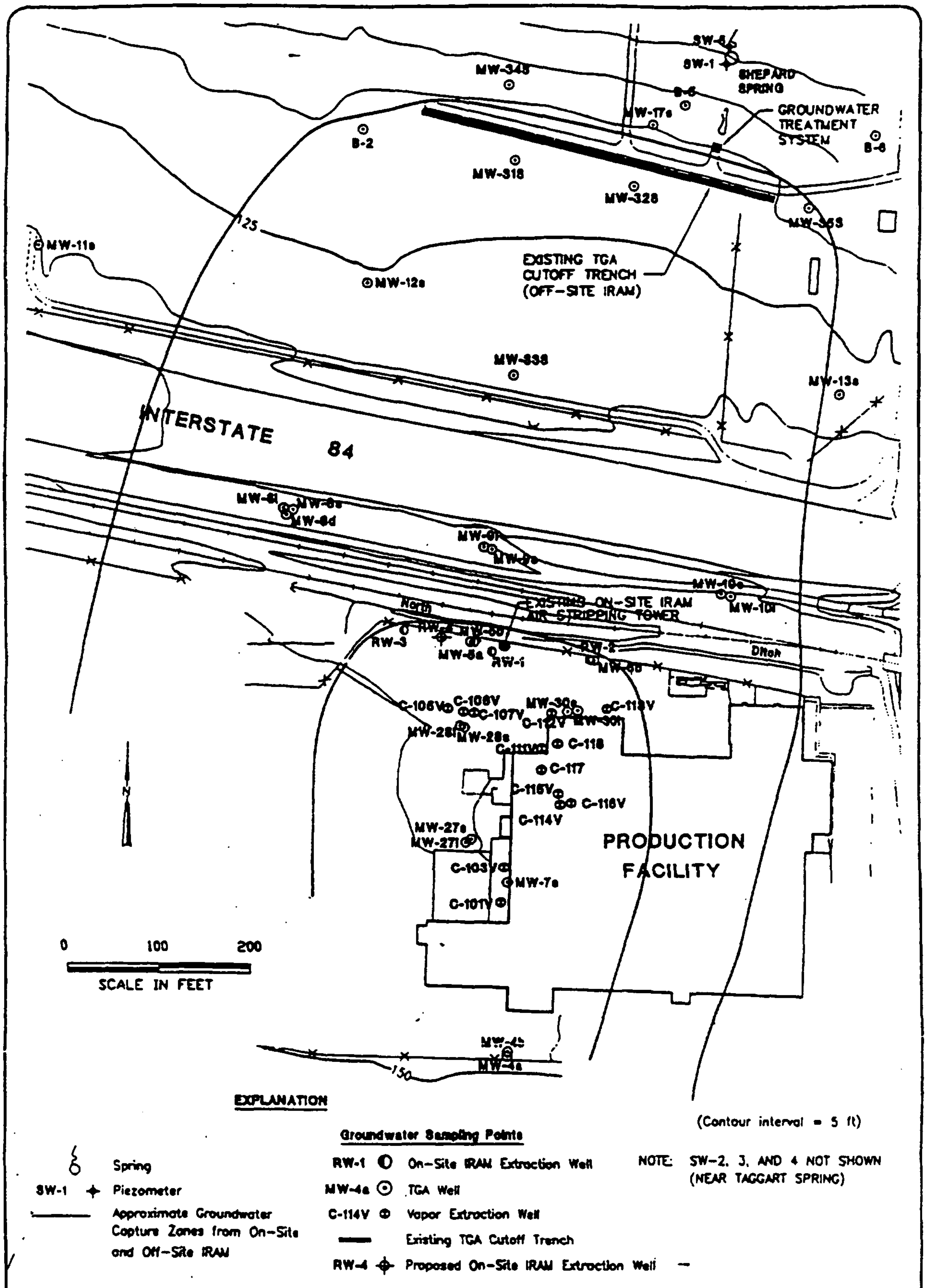
Figure 5-5
CASCADE CORPORATION
TROUTDALE, OREGON

CONCEPTUAL SITE MODEL



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REVIS.	
PROJECT NO.	

Figure 7-1
CASCADE CORPORATION
TROUTDALE, OREGON

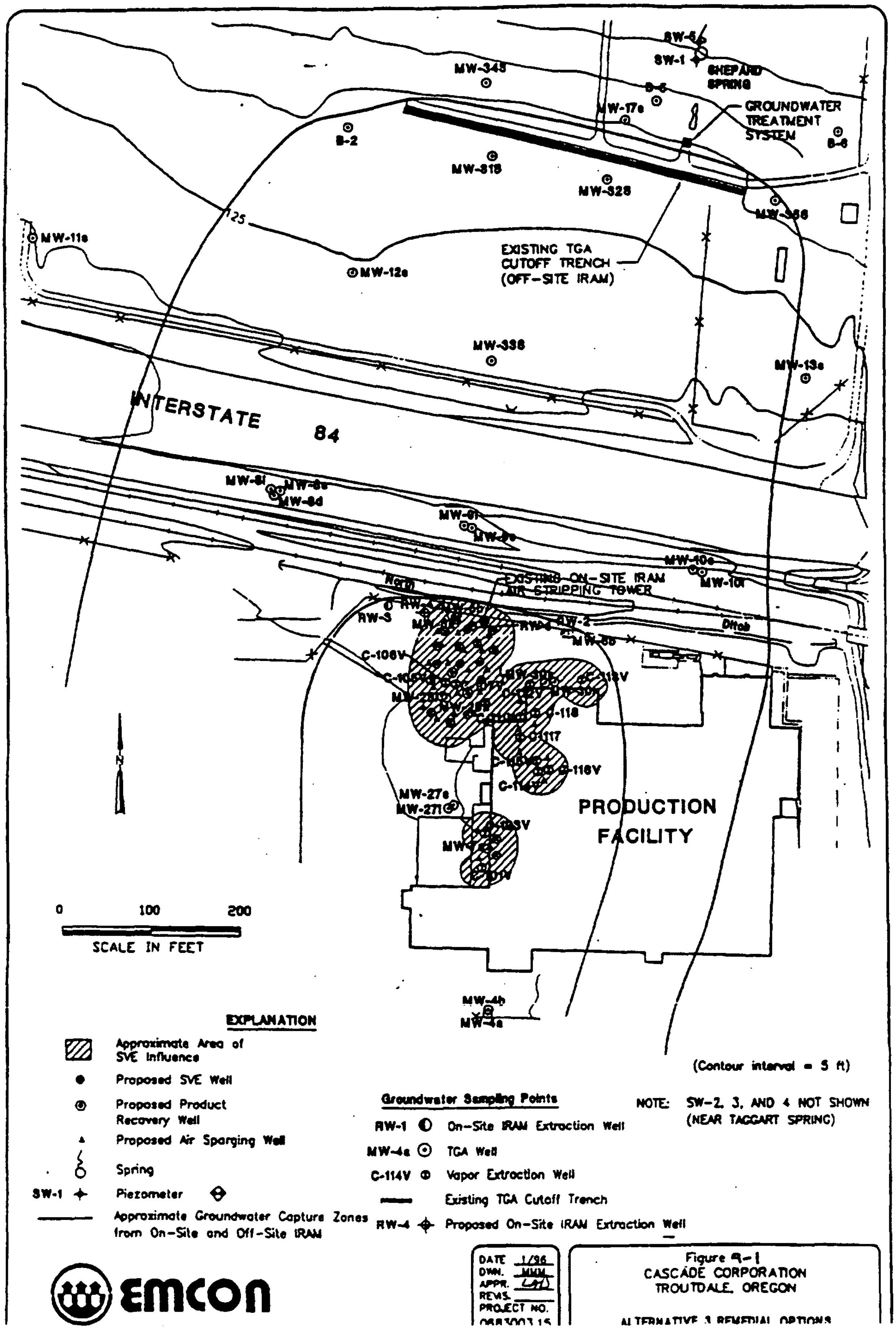

Figure 9-1
CASCADE CORPORATION
TROUTDALE, OREGON
ALTERNATIVE 3 REMEDIAL OPTIONS

APPENDIX A - CASCADE CORPORATION ADMINISTRATIVE RECORD INDEX

Site-Specific Documents

Date	Author	Document
14 Jul 88	DEQ	Order on Consent No. ECSR-NWR-88-01, Cascade Corporation.
25 Aug 88	Dames & Moore	*Preliminary remedial investigation plan for Cascade Corporation Troutdale facility.*
3 Feb 89	Oregon DEQ	*Preliminary assessment, Cascade Corporation* (ORD 009031378).
31 Mar 89	Dames & Moore	*Final preliminary remedial investigation report: Cascade Corporation, Troutdale facility.*
15 Jun 89	Century West	*Excavation plan, north drainage ditch, Cascade Corporation.*
28 Aug 89	DEQ	Order on Consent No. ECSR-NWR-89-11, Cascade Corporation.
19 Oct 89	Century West	Letter (re: Results of north receiving ditch excavation and soil analysis, Cascade Corporation facility) to P. Burnet, DEQ, from J. Snell.
Dec 89	Century West	*Final work plan, remedial investigation/feasibility study for Cascade Corporation Troutdale facility.*
6 Mar 90	Century West	Letter (re: Hydraulic system upgrade) to A. Pollock, DEQ.

1 Feb 91	Century West	*Phase 1 interim data report, remedial investigation/ feasibility study, Cascade Corporation Troutdale facility.*
1 Feb 91	Century West	*Phase 2 work plan amendments, RI/FS Cascade Corporation.*
29 Mar 91	Century West	*Phase 2 unknown source investigation: soil vapor survey report of findings, remedial investigation/feasibility study, Cascade Corporation Troutdale facility.*
15 May 91	Century West	*Revised aquifer test report, Troutdale Gravel Aquifer, Cascade Corporation, Troutdale, Oregon.*
4 Jun 91	Century West	*Industrial well abandonment plan, remedial investigation/ feasibility study, Cascade Corporation, Troutdale, Oregon.*
21 Jun 91	Century West	*Phase 2 Troutdale Gravel Aquifer plume characterization report, remedial investigation/feasibility study, Cascade Corporation Troutdale facility.*
7 Aug 91	Century West	*Phase 3 unknown source investigation soil vapor survey report, remedial investigation/feasibility study, Cascade Corporation Troutdale facility* (draft report).
27 Sept 91	Century West	*Interim removal action measures report: remedial investigation and feasibility study, Cascade Corporation.*
Oct 91	E&E	*Site inspection report for Cascade Corporation site, Troutdale, Oregon.*
8 Nov 91	Century West	*Industrial well abandonment report, remedial investigation /feasibility study, Cascade Corporation, Troutdale, Oregon.*
11 Dec 91	NeoMedia/SE/E	*Interim removal action measures implementation workplan, Cascade Corporation.*

23 Mar 92	EMCON/NeoMedia	*Phase 3 remedial investigation and feasibility study workplan for the Cascade Corporation facility, Troutdale, Oregon.*
23 Mar 92	EMCON	Letter (re: IRAM implementation workplan amendment, Cascade Corporation, Troutdale, Oregon) to B. Gilles, DEQ, from D. Mills.
2 Oct 92	EMCON	*Off-site source receptor survey, Cascade Corporation, Troutdale, Oregon.*
30 Jul 93	EMCON	*IRAM performance evaluation, Cascade Corporation* (draft report).
5 Nov 93	EMCON	*Feasibility study workplan, Troutdale facility.*
23 Nov 93	EMCON	*Preliminary remediation goals, Troutdale facility.*
12 Jan 94	DEQ	Letter (re: DEQ comments to Cascade Corporation RI/FS preliminary remediation goals) to J. Miller, Cascade, from B. Gilles.
2 Feb 94	EMCON	Letter (re: Final workplan, on-site source investigation, Cascade Corporation) to B. Gilles, DEQ, from D. Mills.
16 Feb 94	EMCON	Letter (re: Response to DEQ comments on the Cascade Corporation Troutdale facility preliminary remediation goals [PRGs]) to B. Gilles, DEQ, from T. Foster and D. Mills.
18 Feb 94	DEQ	Letter (re: Cascade Corp. RI/FS, preliminary remediation goals) to J. Miller, Cascade, from T. Foster and D. Mills.
26 Apr 94	EMCON	Letter (re: Revised workplan, evaluate off-site TGA control options: Cascade Corporation) to B. Gilles, DEQ, from L. Downs.

21 Jun 94	EMCON	Letter (re: Phase 3 RI/FS workplan amendment, final workplan for the endangerment assessment: Cascade Corporation) to B. Gilles, DEQ, from D. Mills and T. Foster.
19 Jul 94	EMCON	*Bench testing for in situ bioremediation, Cascade Corporation, Troutdale, Oregon.*
24 Aug 94	EMCON	Letter (re: Amended groundwater tracer study workplan, Cascade Corporation) to B. Gilles, DEQ, from T. Todd and L. Downs.
21 Dec 94	EMCON	Letter (re: Workplan for the installation of additional on-site TGA monitoring wells near the former vapor degreaser) to B. Gilles, DEQ, from D. Mills and L. Downs.
23 Feb 95	EMCON	Letter (re: Installation and sampling of additional on-site TGA monitoring wells near former vapor degreaser at Cascade Corporation) to B. Gilles, DEQ, from A. St. John and L. Downs.
10 Mar 95	EMCON	*Phase 3 remedial investigation and feasibility study, Troutdale Gravel Aquifer.* Part 1: *remedial investigation* (final report).
10 Mar 95	EMCON	*Phase 3 remedial investigation and feasibility study, Troutdale Grave.* Part 2: *endangerment assessment* (final report).
10 Mar 95	EMCON	Letter (re: Response to DEQ comments on the draft Phase 3 remedial investigation report dated December 2, Cascade

		Corporation) to B. Gilles, DEQ, from D. Mills.
13 Apr 95	EMCON	*Groundwater tracer study, Cascade Corporation, Troutdale, Oregon* (interim technical memorandum).
23 May 95	EMCON	*Pilot test for Troutdale Gravel Aquifer control.*
7 Jun 95	EMCON	Letter (re: Amendments to test pitting program and monitoring well abandonment and replacement workplan, Cascade Corporation) to B. Gilles, DEQ, from L. Downs.
14 Aug 95	EMCON	*Revised workplan, expansion of off-site TGA control trench recovery system, Cascade Corporation, Portland, Oregon.*
24 Aug 95	EMCON	Letter report: *Test pitting program and monitoring well abandonment and replacement, Troutdale Gravel Aquifer.*
24 Oct 95	DEQ	Addendum to order on consent, DEQ No. ECSR-NWR-89-11, with attachment AA: NPDES discharge limitations, monitoring, and reporting requirements. Issued for TGA control trench operation.
15 Jan 96	EMCON	*Phase 3 remedial investigation and feasibility study, Troutdale Gravel Aquifer.* Part 3: *feasibility study* (final report).
25 Jan 96	EMCON	Letter (re: Modify phase 3 RI/FS workplan: decommission MW-28i and install additional on-site TGA recovery well) to B. Gilles, DEQ, from L. Downs and D. Mills.
28 Feb 96	DEQ	Letter (re: Comments on final RI/FS reports) to J. Miller, Cascade, from B. Gilles.

1 Mar 96	EMCON	*Cascade TGA Control Trench Construction Report - Troutdale, Oregon.*
29 Mar 96	EMCON	Letter (re: Technical memorandum responding to DEQ comments on Cascade site-specific RI/FS) to B. Gilles, DEQ, from E. Tuppan and L. Downs.

Guidance Documents and Technical Literature

Apr 88	USEPA	*Superfund exposure assessment manual.* Office of Solid Waste and Emergency Response. OSWER Directive 9285.5-1.
Oct 88	USEPA	*Guidance for conducting remedial investigations and feasibility studies under CERCLA.* Interim final. Office of Emergency and Remedial Response. EPA 540G-89-004.
Mar 89	USEPA	*Risk assessment guidance for Superfund.* Vol. 2: *environmental evaluation manual.* Interim final. EPA 540/1-89/001.
Jul 89	USEPA	*Exposure factors handbook.* Office of Health and Environmental Assessment. EPA/600/8-89/043.
Jul 89	USEPA	*Risk assessment guidance for Superfund.* Vol. 1: *human health evaluation manual* (part A). Interim final. Office of Emergency and Remedial Response. EPA/540/1-89/002.
Sept 89	USEPA	Physical processes controlling the transport of non-aqueous phase liquids in the subsurface. By C. D. Palmer and R. L. Johnson. In *Fate and transport of contaminants in the subsurface.* Technology Transfer Seminar Publication, Center for Environmental Research Information, Cincinnati, Ohio, and Robert S. Kerr, Environmental Research Laboratory, Ada, Oklahoma. EPA/625/4-89-019.

90	J. B. Andelman	*Total exposure to volatile organic chemicals in potable water.* Eds. N. M. Ram, R. F. Christman, K. P. Cantor (Boca Raton, Fla: Lewis).
Mar 91	USEPA	*Human health evaluation manual, supplemental guidance: standard default exposure factors.* Office of Solid Waste and Emergency Response. OSWER Directive 9285.6-03.
Dec 91	USEPA	*Risk assessment guidance for Superfund.* Vol. 1: *human health evaluation manual* (part B, *development of risk-based preliminary remediation goals*).
Mar 91	USEPA	*Ground water issue, dense nonaqueous phase liquids.* By S. G. Huling and J. W. Weaver. Superfund Technology Support Center for Ground Water, Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma. EPA/540/4-91-002.
91	C. Zheng, G. D. Bennett, *Water* C. B. Andrews	Analysis of ground-water remedial alternatives at a Superfund site. *Ground* 29(6)838-848.
22 Dec 92	USEPA	40 CFR part 131. *Water quality standards: establishment of numeric criteria for priority toxic pollutants; states' compliance.* Final rule.
Sept 93	USEPA	*Presumptive remedies: site characterization and technology selection for CERCLA sites with volatile organic compounds in soils.* Office of Emergency and Remedial Response. EPA 540-93-048.
93	USEPA	*Wildlife exposure factors handbook.* Office of Research and Development. EPA/600/R-93/187a.

93	R. M. Cohen, J. W. Mercer	*DNAPL site evaluation* (Boca Raton, Fla: CRC Press).
Jul 93	G. D. Hopkins, L. Semprini, P. L. McCarty	Microcosm and in situ field studies of enhanced biotransformation of trichloroethylene by phenol-utilizing microorganism. *Applied and Environmental Microbiology*
Mar 94	USEPA	Health effects assessment summary tables. Annual update. EPA 540/R-94/020.
May 94	USEPA	Drinking water regulations and health advisories.
Jun 94	DEQ	*Environmental* cleanup *manual.*
Jul 94	USEPA	Integrated risk information system (IRIS). Database.
95	USEPA	Risk-based concentration table, January-June 1995. Technical Support Section, EPA region 3, Philadelphia.

East Multnomah County Groundwater Investigation

Oct 91	E&E	*East Multnomah County groundwater study,* Gresham, *Oregon.* Prepared for EPA region 10, Seattle.
Oct 91	E&E	*East Multnomah County vadose zone gas survey, Portland, Oregon.* Final report. Prepared for EPA region 10, Seattle.
Jul 91	Parametrix	*East Multnomah County database and model: final geologic interpretation, detailed modeling area.* Prepared for DEQ.
11 Dec 92	DEQ	*East Multnomah County regional groundwater project, DEQ master plan.* Environmental Cleanup Division.

Jun 93	SSP&A/Parametrix	*East Multnomah County database and model: groundwater flow model report*. Prepared for DEQ.

Remedy Selection Public Notice and Comment

Aug 96	DEQ	Staff Report DEQ Recommended Remedial Action for the Cascade Corporation Site.
Aug 96	DEQ	Proposed Cleanup Plan for the Cascade Corporation Site, Gresham, Oregon.
Oct 96	Scott A. Wells	Letter of comment on DEQ Recommended Remedial Action for Cascade Corporation Site from Scott Wells, Portland State University, to Bruce Gilles, DEQ Project Manager, dated October 28, 1996. Prepared on behalf of Friends of Blue and Fairview Lake.
Oct 96	Terrence L. Thatcher	Letter of comment on DEQ Recommended Remedial Action for Cascade Corporation Site from Terrence Thatcher, City of Portland Deputy City Attorney, to Bruce Gilles, DEQ Project Manager, dated October 30, 1996. Prepared on behalf of the City of Portland.
Oct 96	David L. Blount	Letter of comment on DEQ Recommended Remedial Action for Cascade Corporation Site from David L. Blount, Copeland, Landye, Bennett and Wolf, LLP, to Bruce Gilles, DEQ Project Manager, dated October 30, 1996. Prepared on behalf of Cascade Corporation.
Nov 1996	DEQ	Memorandum to East Multnomah County Project File from Bruce Gilles, Project Manager, dated November 21, 1996. Memorandum summarizes public hearings held on the DEQ Recommended Remedial Action Plans for the Cascade Corporation Site and the East Multnomah County Troutdale Sandstone Aquifer Site.

Nov 96	DEQ	Memorandum to Bob Baumgartner and Neil Mullane, DEQ Northwest Region Water Quality Program, from Bruce Gilles, DEQ Project Manager, dated November 25, 1996. Memorandum summarizes NPDES issues related to permitting of discharge of treated groundwater in preparation of the final remedy Record of Decision.

Century West = Century West Engineering Corporation, Portland, Oregon.
Dames & Moore = Dames and Moore, Inc., Portland, Oregon.
DEQ = Oregon Department of Environmental Quality.
E&E = Ecology and Environment, Inc., Seattle, Washington.
NeoMedia = NeoMedia, Beaverton, Oregon.
Parametrix = Parametrix, Inc., Kirkland, Washington.
SE/E = Sweet Edwards/EMCON, Portland, Oregon.
SSP&A = S. S. Papadopulos and Associations, Bethesda, Maryland.
USEPA = U.S. Environmental Protection Agency.