

USEPA CONTRACT NO. 68-W6-0042
USEPA WORK ASSIGNMENT NO. 157-RDRD-0132

USEPA Project Officer: Diana King
USEPA Remedial Project Manager: Derrick Golden

**DRAFT FINAL
SOURCE AREA RE-EVALUATION REPORT**

**GROVELAND WELLS NOS. 1 AND 2 SUPERFUND SITE
SOURCE RE-EVALUATION**

GROVELAND, MASSACHUSETTS

VOLUME I

September 2006

Prepared By:

*Metcalf & Eddy, Inc.
701 Edgewater Drive
Wakefield, Massachusetts*

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VOLUME I

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LIST OF ACRONYMS AND ABBREVIATIONS

ACRONYM	DEFINITION
1,2-DCE	1,2-Dichloroethene
1,1,1-TCA	1,1,1-Trichloroethane
ARAR	Applicable or Relevant and Appropriate Requirement
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act,
cis-1,2-DCE	cis-1,2-Dichloroethene
COC	Contaminant of Concern
CY	Cubic Yard
DAS	Delivery of Analytical Services
DEQE	Department of Environmental Quality Engineering
DNAPL	Dense Non-Aqueous Phase Liquid
DQO	Data quality objective
EPH	Extractable Petroleum Hydrocarbons
ERH	Electrical Resistance Heating
ERT	Environmental Research Technology
ESCO	Ex-situ chemical oxidation
EW	Extraction Well
FEMA	Federal Emergency Management Agency
FS	Feasibility Study
g/kg	grams per kilogram
gpm	gallons per minute
GPR	Ground Penetrating Radar
GRC	Groveland Resources Corporation
GWTF	Groundwater Treatment Facility
HGI	Hager GeoScience, Inc.
ISCO	In-situ Chemical Oxidation
ISTD	In-situ Thermal Desorption
ITRC	Interstate Technology and Regulatory Council
KMnO ₄	Potassium Permanganate
LDPE	Low-density polyethylene
LNAPL	Light Non-Aqueous Phase Liquid
M&E	Metcalf & Eddy, Inc.

MassDEP	Massachusetts Department of Environmental Protection
MCL	Maximum Contaminant Level
MEK	Methyl Ethyl Ketone
MOM	Management of Migration
MPC	Measurement Performance Criteria
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mL	milliliters
NaMnO ₄	Sodium Permanganate
NAPL	Non-Aqueous Phase Liquid
NCP	National Contingency Plan, 40 CFR Part 300
O&M	Operation and Maintenance
OEME	Office of Environmental Measurement and Evaluation
ORP	Oxidation-reduction potential
OU1	Operable Unit 1
OU2	Operable Unit 2
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethene or Perchloroethene
PDB	Passive Diffusion Bags
PID	Photoionization Detector
ppb	parts per billion
ppbv	parts per billion volume
PPE	Personal Protective Equipment
ppm	parts per million
PRP	Potentially Responsible Party
psi	pounds per squared inch
PSOD	Permanganate Soil Oxidant Demand
PVC	Polyvinyl Chloride
RAC	Response Action Contract
RCRA	Resource Conservation and Recovery Act
RFW	Roy F. Weston, Inc.
RP	Responsible Party
RPD	Relative Percent Difference
RPM	Remedial Project Manager
RI	Remedial Investigation

RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SITE	Superfund Innovative Technology Evaluation
SOW	Scope of Work
SVE	Soil Vapor Extraction
TCE	Trichloroethene
TOC	Total Organic Carbon
TSD	Treatment, Storage and Disposal
USACE	United States Army Corps of Engineers
USDOD	United States Department of Defense
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
UV	Ultraviolet
VOC	Volatile Organic Compound
VPH	Volatile Petroleum Hydrocarbons
µg/L	micrograms per liter
µg/kg	micrograms per kilogram

1.0 INTRODUCTION

Metcalfe & Eddy, Inc. (M&E) has prepared this Draft Final Source Area Evaluation Report (Draft Final Report) for the Source Area Re-Evaluation conducted at the Groveland Wells Nos. 1 and 2 Superfund Site ("the Site") located in Groveland, Essex County, Massachusetts. The Draft Final Report was prepared under the United States Environmental Protection Agency (USEPA) Response Action Contract (RAC) Work Assignment 157-RDRD-0132 in accordance with USEPA's Statement of Work [USEPA, March 2004 and March 2006] and e-mailed scope clarifications dated April 29, 2004 and April 5, 2006.

The purpose of the Source Area Re-Evaluation was to evaluate the current distributions of soil and groundwater contamination in the Source Area and to determine what actions may be considered to further remediate that contamination. EPA's assumption of the source area remediation follows the bankruptcy of, the responsible party (RP), Valley Manufactured Products ("Valley"), and the subsequent discontinuation of the remedy that Valley had constructed and operated. While the 1988 Record of Decision for Source Control (Operable Unit 2 or OU2) required the RP to construct a series of source-control measures [USEPA, 1998A], the RP bankruptcy left the source contamination cleanup incomplete, leaving a significant amount of contamination that will ultimately impact the Management of Migration remedy (Operable Unit 1 or OU1).

Field work in support of this effort was conducted in two phases, in 2004 and 2006. In 2004, soil and groundwater data were collected and two new bedrock groundwater monitoring wells were installed. Following receipt of this data, data gaps were identified, and follow-up sampling was conducted in 2006. In addition, two pilot tests, in-situ chemical oxidation (ISCO) pilot testing for treatment of contaminated groundwater and ex-situ chemical oxidation pilot testing of unsaturated soils, were conducted.

This Draft Final Report provides an evaluation of data collected during the Source Area Re-Evaluation and provides potential remedial alternatives to address the Source Area contamination.

2.0 SITE DESCRIPTION AND BACKGROUND INFORMATION

This section includes a description of Site history and uses, along with a brief summary of events that led to regulatory action.

2.1 Site Location and Description

The Groveland Wells Nos. 1 and 2 Superfund Site is located in Groveland, Essex County, Massachusetts within the Johnson Creek drainage basin. Johnson Creek is a tributary to the Merrimack River. The Site contains nearly 850 acres, mostly located in the southwestern part of the Town of Groveland ("the Town") [USEPA, 2004].

The Site is bounded to the west by Washington Street and the former Haverhill Municipal Landfill, to the south by Salem Street, to the east by School Street, and to the north by the Merrimack River (Figure 2-1). The Haverhill Municipal Landfill was originally part of the Groveland Wells Site, but it has since been separately listed on the National Priorities List and is no longer part of the Site.

Land uses within the Site boundaries include numerous private residences, some industries and small businesses, and religious and community institutions. The Archdiocese of Boston (Saint Patrick's Church) abuts the Valley property to the south and east. The Groveland Department of Public Works is in the central area of the Site, along with a sand and gravel operation. The former Valley Manufactured Products Company is located to the south on the western border of the Site.

There are several small creeks and brooks flowing through the Site. Johnson Creek originates south of the Site and flows in a northerly direction to Mill Pond, located approximately 450 feet east of the Valley property. Argilla Brook, located to the east of Mill Pond, flows northwest through the Site and discharges to Johnson Creek. Brindle Brook is a small tributary to Johnson Creek that flows northwestward through the southeast corner of the Site area, eventually joining with Johnson Creek near Center Street. There are limited wetland areas at the Site, located mostly next to Mill Pond, Argilla Brook, Johnson Creek, Brindle Brook, and isolated areas east of Johnson Creek. A portion of the Site lies within the 100-year floodplain delineated by the Federal Emergency Management Agency (FEMA).

One of the town's current municipal water supply wells, Station No. 1, and a former municipal supply well (Station No. 2) are located within the Site boundaries. The Site encompasses the approximate limits of the stratified drift aquifer that serves as the source of water for the current and former municipal supply

wells. Groundwater generally flows to the north through the Site toward the Merrimack River. The Site Map is shown in Figure 2-2.

2.2 Site History and Use

Valley Manufactured Products Company, a manufacturer of metal and plastic parts from 1963 until 2001, was located in the southwestern corner of the Site. The original building, in which the Valley Manufactured Products Company was housed, was constructed on the property around 1900 and, prior to 1963, housed agricultural and textile operations [ERT, 1985]. In 1963, Groveland Resources Corporation (GRC) leased the property and began on-site manufacturing of screw machine products. Connected to the original building, reportedly on the southern end, was a 400 square-foot wooden shed that was used to store virgin trichloroethene (TCE), "Solvosol" (an unspecified solvent), and cutting oils. Waste cutting oils and solvents were also stored in the wooden shed. The exact location of the shed has not been verified. GRC reportedly purchased the property in 1966. Valley Manufacturing acquired GRC's on-site operations in August 1979; however, GRC retained property ownership [RFW, 1988].

On-site processes included machining, degreasing, and finishing of metal parts. The machining process used cutting oils and lubricants. After machining, metal parts were cleaned (degreased) in a hydrocarbon solvent vapor degreaser and then spun dry. TCE was used in the vapor degreasing operation from 1963 to 1979. Methylene chloride was used from 1979 to 1983. Solvosol and other solvents were also used. In 1984, Valley discontinued the use of solvents and replaced them with detergent degreasers [RFW, 1988].

If parts required additional cleaning, they were then immersed in either an alkaline cleaning solution (containing caustic soda) or an acid solution ("Brite Dip" process, containing nitric acid). Once cleaned, the parts were rinsed and excess rinse water was discharged to a Brite Dip subsurface disposal system [RFW, 1988]. The Brite Dip subsurface disposal system was one of several such systems that were used on the property. Approximate locations for these subsurface disposal systems are provided on Figure 2-3. The systems are further described below:

1. The Brite Dip disposal system included a distribution box and leaching field located near the southeastern corner of the building. This system accepted rinse waters from degreasing operations and wastes from the Brite Dip process. A floor drain in the former acid-dip room and another floor drain in a material storage area were also connected to this system. The Brite Dip process was reportedly used until 1984 [RFW, 1988].

2. A drainage system for the loading dock (which slopes downward into the interior of the building from street level off Washington Street) consisted of a floor drain within the loading dock, and an oil/water separator and leaching field along the eastern portion of the building. This system may have received storm water runoff, oil from lathes, and TCE-contaminated oil. The following contaminants were detected in a sample collected from the loading dock floor drain: 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethane, methylene chloride (570 parts per billion or ppb), and trans-1,2-dichloroethene (190 ppb). Concentrations of vinyl chloride, 1,1-dichloroethene, 1,1-dichloroethane, tetrachloroethene (PCE), methylene chloride (330 ppb), trans-1,2-dichloroethene (4,800 ppb) and TCE (44,000 ppb) were detected in samples collected from the oil/water separator manhole. The floor drain in the truck loading dock was later sealed and replaced with a drainage trough, located outside the building just west of the entrance to the loading dock area. When not plugged with debris (as it currently is), the drainage trough system presumably intercepted storm water runoff before it entered the loading dock and conveyed via a pipeline beneath the building to the oil/water separator and leach field.
3. A domestic sanitary wastewater disposal system, consisting of a septic tank and leaching field, is located under the parking lot area on the northeastern portion of the property. Although the leaching field is likely in the vicinity of the septic tank, the exact location of the leaching field is not known.
4. Historically, a combination storm water and cooling water collection system discharged to a 12-inch reinforced concrete drain pipe extending from the Town of Groveland drainage system in Washington Street, easterly across the northernmost portion of the Valley Manufacturing parking lot. The drain line discharged to a drainage swale located on the abutting Boston Archdiocese property, which extended easterly from the drain line to Mill Pond. Storm water accumulating on the buildings' roof were collected and discharged via a 4-inch drain line to a drain manhole located beneath the assembly room. Cooling water from an air compressor located in the basement of the facility and condensate water from the plants' air conditioning system were also discharged to the assembly room drain manhole. Storm water and cooling waters discharged from the assembly room manhole via a 12-inch drain pipe extending from the drain manhole to the 12-inch drain line crossing the Site. Storm water collected by catch basins located along Washington Street and by the existing roof drainage system eventually discharged to Mill Pond via the drainage swale [RFW, 1988].

In 1972 and 1973, GRC reportedly installed six underground storage tanks (USTs) for storage of cutting oils, solvents, and mineral spirits at the southern portion of the existing building. A concrete slab was constructed over the USTs. The USTs ranged from 700 gallons to 3,000 gallons. Some of the USTs

contained cutting oil; the 700-gallon UST reportedly contained TCE. Cutting oils were pumped from the USTs into distribution piping running throughout the machining areas of the facility. Recovered oils were re-circulated through the system. Waste oils were reportedly disposed off-site. During October 1983, pressure testing of the USTs was conducted. The USTs exhibited some initial pressure loss that was attributed to leakage occurring at the couplings on the tank vent lines.

From 1972 to 1979, 55-gallon drums of waste cutting oils were stored on the concrete slab. In September 1979, Valley constructed a shed roof over the concrete slab area [Lally, 1985]. This area is known as the material storage area, but has also been referred to as the "porch area" or "shed area."

According to the September 1987 Consent Order entered into by Valley Manufacturing and GRC, the major contaminant released was TCE. In 1973, 500 gallons of TCE were reportedly released in the soil underneath the concrete slab from a UST. No less than 3,000 gallons of waste oil and solvent has been estimated to have been discharged to the environment from several surface and subsurface sources, including the loading dock drainage system, the Brite-Dip disposal system, and the UST, and by routine operations practices [RFW, 1988; USEPA, 1988A]. These releases migrated to groundwater beneath the Valley property and eventually contaminated the aquifer that supplied the town of Groveland's drinking water. In June and October 1979, two Town drinking water supply wells, Groveland Well Station Nos. 1 and 2 (Figure 2-1), were determined to be impacted with TCE. The wells were taken off-line and the Town imposed water rationing. The Town subsequently developed another drinking water supply well, Station No. 3 [USEPA, 2004].

Based on the sampling that led to the Consent Order, the solvent vapor degreasing and Brite-Dip systems were eliminated. The rinse water tanks, cleaner holding tanks, and wastewater treatment system were disassembled and removed. Incoming water supply lines to the system were cut and the existing floor drain was plugged. The subsurface disposal system, consisting of the distribution box and leaching field (the Brite Dip disposal system), was left in place [Lally, 1985].

In 1982, USEPA determined that the contamination in the two Town drinking water supply wells constituted a threat to public health and to the environment. USEPA placed the Site on the National Priorities List in December, 1982. In 1983, USEPA and the Massachusetts Department of Environmental Protection (MassDEP, formerly known as the Department of Environmental Quality Engineering or DEQE) conducted inspections and sampling of the subsurface disposal systems on the Valley property and found elevated concentrations of TCE and some metals. DEQE and Valley entered into a consent agreement in 1983 that was intended to bring plant discharges into compliance with state and federal regulations, and changes to the subsurface disposal systems were implemented by Valley as a result. DEQE and Valley entered into a second consent agreement in March 1984 for the performance of a remedial investigation/feasibility study (RI/FS) and remedial action. USEPA also issued an administrative order to Valley in March 1984 to conduct a remedial investigation. Valley had an RI/FS prepared, but USEPA determined that it was inadequate and did not provide sufficient information to serve as the basis for

selection of a Source Control or Management of Migration remedy. A supplemental RI was performed by Valley's consultant in 1988, after substantial development and negotiation of a detailed work plan with USEPA. USEPA contractors oversaw the supplemental RI and also prepared an endangerment assessment [Alliance, 1987] and an endangerment assessment amendment [CDM, 1988]. A supplemental feasibility study (FS) was also prepared by an USEPA contractor [RFW, 1988].

In July 1985, USEPA approved an initial remedial measure to rehabilitate Groveland Well Station No. 1 by using granular activated carbon treatment to remove VOCs from the groundwater. In 1987, USEPA completed installation of the treatment system. Station No. 1 is used as a supplemental supply to Station No. 3, while Station No. 2 was permanently shut down by the town.

In December 1986, the Valley Site was nominated for a demonstration of the Terra-Vac, Inc. Soil Vapor Extraction (SVE) system under the USEPA Superfund Innovative Technology Evaluation (SITE) program. The demonstration was conducted over 56 days in 1988 and removed an estimated 1300 pounds of VOCs from the unsaturated soil at the Valley Site.

On September 30, 1988, USEPA issued a Record of Decision (ROD) for the Source Control Operable Unit ("Source Control ROD") at the Site. The Source Control Operable Unit is also known as Operable Unit 2 (OU2) but is more commonly identified as the Source Control Operable Unit in Site documents. The Source Control ROD required cleanup of the organic chemical contamination source located on the former Valley Manufacturing property.

The major components of the selected remedy included:

1. Installation, operation, and maintenance of a SVE system to clean all areas of subsurface soil contamination;
2. Installation, operation, and maintenance of a groundwater recovery/re-circulation system;
3. Installation, operation, and maintenance of a groundwater treatment system to treat contaminated groundwater from the recovery/re-circulation system;
4. Implementation of Institutional Controls.

The SVE system was operated by a contractor retained by Valley from approximately December 1992 through April 2002. Historical data for the SVE system indicate that only minimal TCE was being removed; however, it is unclear whether the system was working effectively. Portions of the system (soil vapor points, SVE wells) are currently present at the Site.

USEPA worked on an aquifer-wide Management of Migration (MOM) RI/FS in 1984 and 1985 and completed supplemental MOM RI/FS work in 1990 and 1991. The MOM RI, completed in 1985, explored the nature and extent of groundwater contamination, the potential sources of the contamination, and the pathways by which the municipal wells were contaminated. The Supplemental MOM RI, completed in 1991, described the nature and extent of soil and groundwater contamination at Valley Manufacturing.

The results of these activities revealed that an extensive groundwater plume, containing principally TCE and 1,2-dichloroethene (1,2-DCE), was migrating toward the Merrimack River with the highest contaminant concentration found near the former Valley Manufacturing property and the adjacent property owned by the Boston Archdiocese [USEPA, 2004].

A USEPA-funded groundwater treatment facility (GWTF) was constructed adjacent to the Valley facility and began operation in April 2000. Semi-annual groundwater sampling has been conducted since April 1998 and results indicate that the TCE concentrations in areas North of Main Street, South of Main Street, within the Groveland Highway Department (immediately North of Mill Pond), and South of Mill Pond have been decreasing (Figure 2-2). However, TCE concentrations within the Source Area monitoring wells remain high with some fluctuation, demonstrating no clear trend. The historical maximum TCE concentration was detected in monitoring well TW-17 at 380,000 ppb in Fall 2003. Recently, TCE was detected in this well at 100,000 ppb in Spring 2005, and 12,000 ppb in Spring 2006. TW-17 is located adjacent to the former Valley Manufacturing facility.

3.0 TECHNICAL APPROACH TO THE WORK ASSIGNMENT

The following subsections describe the approach to the work assignment, including problem definition and project overview, a description of the sampling program, and a description of the analytical program. Discussion of analytical results is provided in Sections 4.0 and 5.0; identification of potential remedial alternatives is presented in Section 6.0.

3.1 Problem Definition and Project Overview

The project objective for the Source Area Re-Evaluation was to determine the current distribution of volatile organic compound (VOC) contamination in Source Area groundwater and soil and to determine what actions may be considered to further remediate the contamination. The Source Area evaluation was conducted in two phases. In 2004, accessibility restrictions and the remaining USTs prevented full delineation of the horizontal and vertical nature and extent of contamination beneath the porch area and the main Valley building. In 2006, the demolition of the porch structure allowed a more extensive investigation of the horizontal and vertical extent of contamination. Brief lists of field activities conducted in 2004 and 2006 are provided below. Fieldwork conducted at the Site is further detailed in Subsection 3.2, Sampling Program. Subsection 3.3 discusses analytical requirements for each type of sampling conducted.

Field activities conducted in 2004 included:

- Inventory and screening of remaining SVE wells and vapor points (using a PID) to passively determine relative VOC levels in the remaining system components;
- Performance of subsurface investigations to determine concentrations of chlorinated VOCs in soil in the Source Area;
- Installation of two new bedrock wells to further characterize Source Area groundwater contamination, and repair of bedrock monitoring well TW-12;
- Sampling of groundwater for VOCs (using passive diffusion bag samplers or PDBs) in selected Source Area monitoring wells and collection of total organic carbon (TOC) groundwater samples to characterize concentrations in the Source Area.

Field activities conducted in 2006 included:

- Ground Penetrating Radar (GPR) survey to locate the USTs and delineate underground utilities;
- Sub-slab soil gas sampling within the former Valley Manufacturing Building;
- Demolition of the porch structure and installation of fencing;
- Collection of soil and groundwater VOC samples for field screening by the USEPA Office of Environmental Measurement and Evaluation (OEME) mobile laboratory with confirmation samples sent to the OEME fixed laboratory or a Routine Analytical Services (RAS) laboratory;
- Installation of 11 new overburden monitoring wells to further characterize Source Area groundwater contamination;

- Collection of soil TOC samples for analysis by the OEME fixed laboratory;
- Collection of residential soil VOC samples to assess potential impacts to an abutting property;
- Completion of slug testing in eight groundwater monitoring wells installed during June 2006;
- Completion of an ISCO pilot test, including a pre-injection groundwater VOC round and a post-injection groundwater VOC round to assess effectiveness of the injection;
- Removal of six (6) USTs, the former Brite Dip acid leachfield, and excavation of soils for conducting an ex-situ chemical oxidation test;
- Completion of an ex-situ chemical oxidation test on excavated soils;
- Collection of light non-aqueous phase liquid (LNAPL) samples for product identification;
- Completion of an assessment of on-site and neighboring pine trees;
- Completion of in-situ mixing and chemical oxidation on soils on abutting residential property.

Using data collected during these field efforts, M&E prepared an updated conceptual model (see Section 4.0) and identified and evaluated potential remedial alternatives (see Section 6.0).

3.2 Sampling Program

The 2004 and 2006 sampling programs addressed the field efforts requested in the USEPA SOWs [USEPA, March 2004; USEPA, March 2006] and the e-mail scope clarifications dated April 29, 2004 and April 5, 2006. Source Area Re-Evaluation investigative activities were conducted in accordance with USEPA approved Sampling and Analysis plans [M&E, 2004 and 2006]. Table 3-1 provides a summary of samples collected, and highlights any data quality issues for each sampling event performed as part of the Source Area Evaluation. Field notes are provided in Appendix A. Boring logs and chains of custody are provided in Appendix B. VOC analytical results for OEME mobile laboratory are provided in Appendix C. VOC analytical results for OEME fixed laboratory are provided in Appendix D. Analytical results for RAS and DAS laboratory samples are provided in Appendix E.

Borings were drilled at 26 locations as part of the original RI performed by Lally, including a number of locations in the Source Area [Lally, 1985]. The Lally borings were numbered 1 through 26, and the hole number was preceded with a prefix of "TW-" if a monitoring well was constructed or a prefix "B-" where no well or a dry well was installed. The Lally numbering convention was continued for the 2004 and 2006 M&E investigations. Since TW-26 was the highest numbered location used in the original Lally RI, the borings and associated monitoring wells that were drilled as part of M&E Source Area investigation were designated with location numbers starting with 27.

3.2.1 Soil Vapor Point Survey (Existing Soil Vapor Extraction Points), 2004. In 2004, M&E surveyed existing SVE wells and vapor points using a hand-held PID to determine if measurable VOCs (> 1 parts per million or ppm as isobutylene) could be detected in these existing SVE wells

and vapor points (Figure 3-1). SVE wells and vapor points were sealed on June 2, 2004, and the sealed SVE wells and vapor points were allowed to equilibrate for three weeks. The PID screening was conducted on June 23, 2004. Table 4-1 provides a summary of the SVE wells and vapor points that were screened and the recorded PID value for each.

Elevated PID readings were recorded at locations EW-6C (84.3 ppm), EW-6D (58.3 ppm), and TW-9 (2.3 ppm). SVE wells EW-6C and EW-6D were part of an SVE triplet located in the eastern end of the porch area (see Figure 3-1). Monitoring well TW-9 is also located within the porch area.

Due to the nature of the PID survey, it was not possible to collect field duplicate samples. No formal validation of the PID survey data was performed. All of the data collected during the PID survey are useable for project objectives as outlined in the 2004 M&E SAP.

3.2.2 Soil and Groundwater Sampling (Conventional Geoprobe, Standard Drill Rig), 2004. The goal of the 2004 program was to define the extent of VOC contamination above and below a clay layer at the Site. The clay layer is typically three to five, but up to eight, feet thick and is found between approximately 8 to 20 feet below ground surface (bgs) in the Source Area. High levels of contamination have historically been present in a perched zone of water above the clay as well as in the saturated zone below the clay.

Since a conventional rig was unable to access the porch area due to ceiling height restrictions, subsurface exploration in that area and inside the building was conducted using a Geoprobe provided by USEPA. Fourteen shallow Geoprobe holes, designated SB-1 through SB-14, were drilled with that equipment. Due to the dense nature of the soil, the Geoprobe was unable to penetrate below 16.5 ft bgs.

A standard drill rig was used to access three outdoor locations. Three borings were completed without installation of monitoring wells (B-27, B-28, and B-29). Borings B-27, B-28, and B-29 were initially labeled TW-27 through 29, but were subsequently renamed to adhere to site-wide nomenclature.

M&E collected a variety of samples for VOC analysis by the OEME mobile laboratory in 2004, including: water samples collected from the oil/water separator manhole; surface and subsurface soil samples collected from the Geoprobe holes and the standard borings; and groundwater samples collected from existing monitoring wells and, where possible, from the Geoprobe holes and borings. Soil samples were analyzed for TCE, 1,1,1-TCA, and PCE. Aqueous samples were analyzed for TCE, 1,1,1-TCA, PCE, and cis-1,2,-DCE.

It was noted during the investigation that the water table was dropping quickly in the Source Area. In order to acquire data before the water table fell too low to conduct the proposed passive diffusion

bag sampling at a later date, M&E personnel collected groundwater samples from existing monitoring wells, SVE wells, and other monitoring points with bailers. In some cases, samples were collected both before and after purging three well volumes with the bailers (pre-purge and post-purge). The 2004 OEME mobile laboratory results are presented in Table 4-2. No formal validation of the OEME mobile laboratory results was performed. The data are considered useable for project objectives as outlined in the 2004 M&E SAP.

Samples sent to the OEME fixed laboratory in Chelmsford, MA included an oily product sample collected from monitoring well MW-5D (identified as having chromatograms closely matching 30W motor oil) and soil TOC samples to support selection of potential remedial alternatives. TOC results for soil samples were all non-detect at varying detection limits (Table 4-3); however, the reporting limit was elevated and TOC is likely present at concentrations below the reporting limit. OEME fixed laboratory data were not subjected to formal data validation. The data are considered useable for project objectives as outlined in the 2004 M&E SAP.

3.2.3 Bedrock Well Installation, 2004. Two bedrock monitoring wells, TW-30 and TW-31, were installed to the east of the Valley building and to the south of the existing Groveland Wells OU1 GWTF. The bedrock wells were installed using a conventional drilling rig. As proposed in the SAP, existing bedrock monitoring well TW-12 was also repaired.

3.2.4 Groundwater Sampling (Passive Diffusion Bags), 2004. Six Source Area wells (MW-5D, TW-15, TW-17, TW-23, TW-30, and TW-31) were selected for groundwater TOC sampling and PDB deployment for VOC sampling, based on historical VOC concentrations detected in the wells. Each well was sampled for TOC prior to PDB deployment. TOC samples were sent to Southwest Research Institute for analysis by M&E Delivery of Analytical Services (DAS) Specification D-033.1. The TOC results were not subjected to formal data validation. The data are considered useable for project objectives as outlined in the 2004 M&E SAP.

A total of 20 PDBs were deployed in the six wells. The PDBs consist of heat-sealed, low-density polyethylene (LDPE) lay-flat tubing, filled with approximately 220 milliliters (mL) of analyte-free water. PDBs were deployed in series across the well screen. For a 10-foot well-screen, four PDBs were installed in series and the samples were named using the well location and the depth in relation to the screen (denoted A through D, with A being at the top of the screen and D being at the bottom of the screen). For example, the PDB located at the bottom of the screen in well TW-17 would be named TW-17D. PDBs were deployed on October 7, 2004 and were retrieved and sampled for VOCs on October 25, 2004, after an approximate three-week equilibration period. The VOC samples were then released to Weston Solutions personnel for on-site analysis using the Sentex gas chromatograph unit at the Groveland GWTF. Analysis was performed for trans 1,2-dichloroethene, cis-1,2-DCE, 1,1,1-TCA, TCE, and PCE using the on-site Sentex unit. The PDB

VOC results were not subjected to formal data validation. The data are considered useable for project objectives as outlined in the 2004 M&E SAP.

3.2.5 Limited UST Investigation, 2004. During the 2004 field effort, M&E personnel located what appeared to be fill-ports for the former USTs in the porch area. The fill-ports were covered with patches of concrete. At the request of the USEPA Remedial Project Manager (RPM), M&E personnel broke through the concrete patches to inspect the fill-ports. Four of the five fill-ports observed were filled with sand. M&E personnel removed the cap on the fifth fill-port and observed that the fill pipe was not filled. Based on historical information, a total of six USTs were located in the porch area. M&E personnel were unable to locate a sixth UST fill-port during the 2004 investigation. Additional investigation of the USTs was conducted in 2006, as described in Section 3.2.11.

3.2.6 Ground Penetrating Radar Survey, 2006. A GPR survey was performed by Hager Geoscience, Inc (HGI) on April 19, 2006. The purpose of the GPR survey was to locate the six USTs and identify other subsurface structures and obstructions to facilitate subsequent work. The survey included the former Valley Manufacturing Building, the former porch area, and areas outside of the main Valley building to the east and south.

Results of the GPR survey indicated six potential USTs beneath the western portion of former porch, an additional anomaly at the southeast corner of the former porch, the Brite-Dip Acid Leachfield and associated piping, the leachfield located along the eastern wall of the main building (Storm Drain), potential utility pipes, and unidentified flat horizons (possibly soil boundaries). Further details, including a map of possible subsurface obstructions, are provided in the Ground Penetrating Survey report included in Appendix J [HGI, 2006].

3.2.7 Demolition of the Porch Structure, 2006. M&E personnel oversaw the demolition and removal of the porch structure May 8 through May 16, 2006. At the time of the demolition, the concrete floor structure was left in place to facilitate subsequent work. The demolition effort included installation of additional fencing and a gate. The main manufacturing building was left in place and secured to prohibit entry to the building.

3.2.8 Sub-slab Soil Gas Sampling, 2006. On May 23, 2006, M&E conducted a sub-slab soil gas survey within the former Valley Manufacturing Facility to assess potential vapor intrusion. M&E installed eight (8) vapor points throughout the building using a hammer drill to break through the concrete. Samples were collected into 100% certified clean 6-liter SUMMA canisters fitted with a 1-hour flow controller, through a stainless steel sample rod and dedicated Teflon tubing. The stainless steel sample rod was decontaminated between sample locations. Clay was used to seal the sample rod at the surface of the concrete. A total of 10 samples (eight samples, one field duplicate, and one equipment/trip blank) were collected and analyzed for VOCs using DAS Specification D-152.

Samples AR-01, AR-02, AR-07, and AR-08 were located in the main manufacturing area. Sample AR-03 was located in the former gear room. Sample AR-04 was located in the former machine shop. Sample AR-05 was located in a lower level basement. Sample AR-06 was located within the hallway, near the former offices and inspection room. These locations were selected to provide spatial coverage within the building and are shown on Figure 3-1. The sample locations were also selected to avoid potential utilities and potential asbestos floor tiles.

Analytical results for the sub-slab soil gas survey are provided in Appendix E. The soil gas analytical results were subjected to Tier II validation in order to assess potential risk associated with indoor air vapor intrusion. Using this data, an indoor air risk assessment was performed which indicated that potential on-property risks and hazards are within or below EPA risk management guidelines (cancer risk between 10^{-4} and 10^{-6} and noncarcinogenic hazard of one), based on assumed residential property use, and that the future on-property indoor air pathway is unlikely to present a risk of harm to humans. As on-property VOC levels in soil and groundwater are greater than those in off-property locations, the off-property indoor air pathway is also unlikely to present a risk of harm to off-property receptors. Additional details and calculations associated with the indoor air evaluation are provided within Appendix G.

3.2.9 Soil and Groundwater Sampling (Standard and Indoor Drill Rigs), 2006. Additional soil and groundwater VOC sampling was conducted in 2006. The purpose of the additional sampling was to fill data gaps identified following the 2004 field effort, particularly in the porch area (facilitated by removal of the porch structure), inside the Valley building, and at depths beneath 16 feet (limit of the Geoprobe). The additional sampling also provided real-time analytical results to direct monitoring well and injection well installation for the ISCO pilot study.

Sixteen borings, including nine in which monitoring wells were installed, were drilled outside of the Valley building: TW-32I, TW-32D, TW-33, B-34, TW-35D, B-36, TW-37, B-38, B-39, TW-40, B-41, TW-42, TW-43, TW-44D, B-52, and B-53. Seven borings, including two in which monitoring wells were installed, were drilled inside the Valley building: B-45, B-46, TW-47, TW-48, B-49, B-50 and B-51. Since contamination was detected at a depth of 4.4 feet in boring B-34, bordering residential property, an additional location (B-34-F9) in the Source Area was sampled with a hand auger to a depth of 4.5 feet to evaluate contamination along the north side of the wood fence along the residential property at 106 Center Street, nine feet south of the location of boring B-34. Soil boring locations are presented on Figure 3-1.

A standard drill rig was used for work outside the former Valley manufacturing building, and a low-clearance drill rig was used for work within the former Valley manufacturing building. Both drill rigs advanced 2-foot split-spoons and samples were collected from each spoon based on PID readings and the discretion of M&E field team personnel. As in 2004, groundwater samples were collected

from select existing monitoring wells using bailers. Soil and aqueous samples were analyzed by the OEME mobile laboratory for TCE, 1,1,1-TCA, PCE, and cis-1,2-DCE (Table 4-6). The 2006 OEME mobile laboratory results were not subjected to formal validation. The data are considered useable for project objectives as outlined in the 2006 M&E SAP.

Confirmation soil VOC samples were sent to the OEME fixed laboratory or a RAS laboratory at a rate of approximately 10%. Confirmation soil VOC sample data were validated to Tier I.

In addition to VOC sampling, M&E collected 19 soil samples for TOC analysis by the OEME fixed laboratory to support revision of soil cleanup levels and remedial alternative selection. TOC data were subjected to Tier II validation and analytical results are useable for project objectives as qualified. Tier II validation was conducted on these samples, since the TOC values are used in calculating proposed soil cleanup levels. A soil sample for PCB analysis was collected in the vicinity of SVE well EW-5D to confirm a historical PCB detection. The VOC and TOC data are considered useable for project objectives as outlined in the 2004 M&E SAP.

3.2.10 Residential Soil Sampling, 2006. At the request of the USEPA RPM, M&E personnel advanced a total of nine hand-augered soil borings on the 106 Center Street property, during two separate events, to assess potential soil impacts to the property. The property at 106 Center Street abuts the southern boundary of the Valley property. These samples were collected in response to elevated TCE concentrations measured at a depth of 4.4 feet in boring B-34, approximately 10 feet from the fence separating the two properties, and subsequently at a location on the 106 Center Street property (HA-2). The borings were advanced to approximately 4 feet (or refusal) and samples were collected at multiple intervals for each boring. Each sample location begins with the designation "HA", indicating a hand-augered sample. The nine locations are shown on Figure 3-1. Samples were analyzed by the OEME mobile laboratory or a RAS laboratory (Datachem Laboratories, Inc. of Salt Lake City, Utah). All samples sent to a RAS laboratory were subjected to Tier I validation. The data are considered useable for project objectives as outlined in the 2006 M&E SAP.

3.2.11 Tank Removal Activities, 2006. In an effort to remove potential contamination sources, the six USTs and components of the Brite-Dip Leachfield were excavated, decontaminated, and removed from the Site. Charter Environmental, Inc. (Charter), under subcontract to M&E, performed all removal and excavation activities described in this subsection. M&E personnel provided oversight and direction.

During removal activities, all six USTs were observed to be filled with damp, dense sand (similar to a flowable fill type material). The contents of the USTs were removed and initially segregated for screening with a PID. No elevated PID readings were noted of the contents of any tank. The external walls of all six tanks appeared intact prior to removal from the ground.

Each UST feed line was observed to be covered with a pipe sleeve composed of transite. The sleeves were removed and segregated on polyethylene sheeting within the former Valley building for off-site disposal. Approximately 15 ounces of dark liquid was collected from the feed line likely associated with UST No. 5. Approximately eight ounces of an oily liquid were bailed and collected from the feed line to UST No. 2.

A single tank grave, approximately nine to ten feet deep, was excavated for the UST removal. Approximately 10 cubic yards of excavated soil were segregated into roll off containers for use in the ex-situ chemical oxidation test. Soil samples were collected by Charter at the direction of M&E from the sidewalls and base of the UST grave prior to re-filling the excavation with excavated soil, tank contents (flowable fill) and crushed portions of the concrete slab. Laboratory analysis of VOCs, metals, extractable petroleum hydrocarbons (EPH), and volatile petroleum hydrocarbons (VPH) was performed by a laboratory subcontracted by Charter. The top four feet of the backfill were compacted in one-foot thick lifts.

The distribution box and pipes associated with the former Brite Dip leachfield were also excavated and removed. The pipes were 4-inch diameter PVC with one-half inch holes for drainage. The soil surrounding these pipes appeared to be fill material. No elevated PID readings were recorded during the removal. All the pipes removed were decontaminated using a soap and water solution prior to off-site removal. The fill excavated during the pipe removal was placed back in the excavation and compacted.

Based on the GPR survey, an anomaly was located in the southwest corner of the former porch area. The concrete slab in that location was cut, and a test pit was excavated to confirm the nature of the anomaly. No UST or other utility structure was found at this location. A layer of dark brown, loamy soil was observed at approximately six to eight feet below the slab, just below a layer of fill material that included bricks (possible source of the GPR anomaly). The loamy soil had an odor and PID readings were noted as high as 80 ppm when scanning over the soil. The soil removed to create the test pit was backfilled and compacted.

3.2.12 Slug Tests, 2006. M&E completed slug testing on eight groundwater monitoring wells that were installed during June 2006: TW-32D, TW-32I, TW-35D, TW-37, TW-42, TW-43, TW-44D, and TW-48. The tests were analyzed using the Bouwer–Rice method. The results of the slug test are summarized in Table 4-14 and further discussed in Section 4.2.

3.2.13 In-situ Chemical Oxidation Test, 2006. Sodium permanganate was injected into two injection wells on July 24, 2006. Injection of the sodium permanganate was performed by Redox Tech, LLC (Redox), under subcontract to M&E. M&E provided technical direction and oversight. To determine the effectiveness of the injection, groundwater samples were collected from selected

monitoring wells both before the injection, and approximately three weeks and eight weeks after the injection (August 17 and September 20, 2006). Laboratory analysis of VOCs was performed by RAS laboratories: pre-treatment samples by A4 Scientific of The Woodlands, TX and both post-treatment by Mitkem Corporation of Warwick, RI). The ISCO pilot test is further discussed in Section 5.0. The injection locations and the monitoring wells sampled to evaluate the pilot test are shown on Figure 5-1.

During the post-injection groundwater sampling event on August 17, 2006, a LNAPL product was observed on the water table in monitoring well TW-37. Product samples were collected and sent to OEME fixed laboratory for identification.

3.2.14 Ex-situ Chemical Oxidation Test, 2006. M&E performed an ex-situ chemical oxidation (ESCO) test on 55 cubic yards of soil excavated from the Source Area during the UST and leachfield removal efforts. The excavated soil was segregated into eight piles in four roll-off boxes and dosed with four different concentrations of potassium permanganate. Charter, under subcontract to M&E, transported selected soil to roll-off boxes and applied chemical oxidant. M&E provided technical oversight and direction. Pre-treatment soil samples were collected for VOCs analysis, soil oxidant demand, and geotechnical parameters, and post-treatment soil samples were collected for VOC analysis. Laboratory analysis was performed by laboratories subcontracted by Charter. The ESCO pilot test is further discussed in Section 5.0.

3.2.15 White Pine Tree Assessment, 2006. At the request of the USEPA RPM, M&E conducted a brief assessment of several white pine trees located along the fence between the Source Area and the property located at 106 Center Street to determine possible causes of pine needle browning on the trees. Based on the assessment, the pine trees are likely impacted by insect damage, specifically the white pine weevil. The complete assessment is provided as Appendix J.

3.2.16 In-situ Soil Mixing and Chemical Oxidation. At the request of the USEPA RPM, additional treatment was performed by chemical oxidation using potassium permanganate on approximately 100 cubic yards of shallow soil located on a portion of the abutting residential property that is north of the wood fence that separates the properties. Soils were dosed and mixed in place by Charter, under subcontract to M&E. M&E oversaw the treatment activities. The test involved collection of pre-treatment and post-treatment soil samples for VOC analysis. Results of the residential in-situ pilot test will be reported on separately in a technical memo after the sampling data has been evaluated.

3.3 Analytical Program

The DQO for the various field activities performed was to provide data of sufficient quality and quantity to better define the location and extent of the Source Area contamination. Data were collected, analyzed,

and evaluated in accordance with the 2004 and 2006 M&E SAPs. The following section describes the types of data collected and associated data quality objectives. Table 3-1 summarizes sample delivery group information, laboratory information, and data validation criteria for the project.

3.3.1 Project Data Quality Objectives (DQOs). As stated, the data quality objective (DQO) for the various field activities was to provide data of sufficient quality and quantity to better define the location and extent of the Source Area TCE and 1,2-DCE contamination. The field effort also attempted to identify the location and extent of any non-aqueous phase liquid (NAPL) that may be present.

To meet the project DQOs, M&E largely used field analytical data (soil and groundwater VOC analysis by the OEME mobile laboratory with 10% fixed laboratory confirmation sampling). Where more stringent data quality was required M&E utilized the RAC DAS program (groundwater TOC analysis in 2004, soil gas analysis in 2006), the USEPA RAS program (pre-injection and post-injection groundwater VOC analysis in 2006, some Source Area soil and residential soil VOC analysis in 2006), or the OEME fixed laboratory in Chelmsford, MA (confirmation of OEME VOC results in 2006, soil TOC in 2006). In addition, product samples were sent to the OEME fixed laboratory for identification in 2004 and 2006. Table 3-1 provides a summary of information for samples collected during the 2004 and 2006 field events.

3.3.2 Data Validation and Data Usability. Data validation using Region I Functional Guidelines was not performed on field analytical data (PID survey or OEME mobile laboratory data). However, these data were subject to review by M&E during the field effort and during M&E report generation. Where more stringent data quality was required, such as data required for risk assessment or field analytical confirmation, data were validated to Tier I or Tier II Region I Functional Guidelines as outlined in the 2004 or 2006 M&E SAPs. Validation levels for the various data are summarized in Table 3-1.

3.3.3 Measurement Performance Criteria. Performance criteria were defined for the various types of analyses conducted to support project DQOs. Table 3-2 presents Measurement Performance Criteria (MPC) for precision (field, laboratory), accuracy/bias (field, laboratory), representativeness, comparability, sensitivity, and completeness for each general class of analyses conducted.

3.3.4 Documentation, Records, and Data Management. All sampling data were recorded on appropriate data collection sheets or in the field logbook for the Site. Transfer of sample custody between the field team and the laboratory (OEME mobile laboratory, OEME Fixed Laboratory, Sentex unit operator, DAS laboratory, RAS laboratory) was documented using standard COC forms.

4.0 CONCEPTUAL MODEL OF SOURCE AREA CONTAMINATION

A conceptual model of contaminant distribution and migration in the Source Area is needed to properly evaluate remedial alternatives. To develop a conceptual model, the initial RI and follow-up studies from the mid- to late 1980s were first reviewed. Although 25 years have passed since the original RI was done, the geologic information and the original contaminant distribution data are still useful for understanding current subsurface conditions.

Figure 4-1 shows the locations of borings and Geoprobe holes that have been drilled in the Source Area during the previous and current investigations. Other wells that are shown on Figure 4-1 include several now-inactive SVE wells (EW-1 through EW-7), installed in previous Source Area remedial actions; three monitoring wells (MW-3, MW-5D, and MW-5S), installed after the original "TW" series (TW-1 through TW-26); and three groundwater extraction wells (EW-S1 through EW-S3), installed in 1999 as part of the current groundwater remedial action. The locations of geologic cross-sections that are referred to in the discussions of subsurface conditions are also shown on Figure 4-1.

4.1 Original Conceptual Model (1985)

Drilling and soil sampling during the original RI at the Valley Site [Lally, 1985] identified a clay layer beneath much of the Source Area, with the top of the clay lying at a depth of 8 to 16 feet. Between the ground surface and the clay, the soils were found to consist of an upper layer of fill (mostly sand); an intermediate layer of loamy sand (buried topsoil), at a depth of about 4 to 8 feet; and a lower layer of sand (silty just above the clay in some areas).

The clay was reported to be 2 to 10 feet thick in the original remedial investigations. Between the bottom of the clay and the bedrock surface, dense layers of sand, sand and gravel, silty sand, and glacial till were encountered.

The conceptual model of subsurface contaminant movement at the time of the original RI, when only the first 17 wells and borings had been drilled, was that TCE and other solvents had migrated to the east on top of the clay, as well as down through the clay, and into the underlying dense soils. That model was probably based largely on the observation that, at that time, the highest levels of groundwater contamination were detected in TW-9 (located in the former porch area and screened under the clay) and TW-8A (located east of the former porch area, beyond the eastern edge of the clay layer, and screened in the lower overburden).

4.2 Evaluation of Results of Current Investigations

Extensive environmental data was collected to complete the Source Area evaluation, as described in Section 3.0. The results are summarized in Tables 4-1 through 4-14:

- Table 4-1 Photoionization Detector Survey, 2004;
- Table 4-2 USEPA Mobile Laboratory Field Analytical Results, 2004;
- Table 4-3 Soil Sample TOC Analytical Results, 2004;
- Table 4-4 On-Site Sentex Gas Chromatograph Groundwater Analytical Results, 2004;
- Table 4-5 Sub-Slab Gas Survey Results, 2006;
- Table 4-6 USEPA Mobile Laboratory Field Analytical Results, 2006;
- Table 4-7 Confirmation Soil Sample and Residential Soil Sampling Results, 2006;
- Table 4-8 PCBs in Soil Results, 2006;
- Table 4-9 Soil Sample TOC Analytical Results, 2006;
- Table 4-10 UST Grave Sampling Results, 2006;
- Table 4-11 Pre-Injection Groundwater Monitoring Results, 2006
- Table 4-12 Post-Injection Groundwater Monitoring Results, 2006;
- Table 4-13 Groundwater Elevation Data; and
- Table 4-14 Groundwater Slug Test Results.

For the purposes of discussion within this report, the numerous individual strata encountered beneath the Source Area have been grouped into five layers: shallow overburden (fill, former soil horizon, and sand); clay; deep permeable overburden (dense fine to coarse sand and gravel); deep low permeability overburden (fine silty sand and till); and bedrock (see geologic cross-sections in Figures 4-2 through 4-4). Soil and groundwater contamination in each of these layers are discussed in the following subsections.

4.2.1 Shallow Overburden - Soil Contamination. The term “shallow overburden” refers to the soils between the ground surface and the top of the clay layer or, where the clay is absent, an elevation of 63 feet (the average elevation at which the top of the clay layer was found).

Shallow overburden soil samples with TCE concentrations >1,000 ppb were found in the former porch area or within 10 feet south of the remaining slab (SB-1, -2, -8, -10, and -11; B-34, -38, -45, -46, and -52; TW-35D and -44D). TCE concentrations >10,000 ppb were measured at TW-44D, B-34, SB-2, SB-8, and SB-10. As shown on Figure 4-2 and 4-3, at most boring locations where TCE was detected in the soil samples, the highest concentration was found several feet above the clay layer, often in the brown loamy sand that is believed to be a buried topsoil horizon (generally 4 to 8 feet deep). The highest TCE concentrations in the shallow overburden were found at SB-10 at a depth of 7.7 feet (52,000 ppb) and at TW-44D at a depth 3.6 feet (35,800 ppb). This sample from SB-10 was collected in a zone of disturbed soils that included what appeared to be topsoil mixed with sand. SB-10 was drilled within about 5 feet of a former SVE well (EW-6S) that was screened from a depth of 9 to 19 feet, indicating that high concentrations of TCE have persisted despite years of SVE operation.

Elevated TCE concentrations were noted in shallow soil samples collected beneath the main Valley building, especially near the southeastern corner (B-45, B-46, and TW-48). Concentrations decrease

moving north and west from this corner. In addition, while installing a gate along the eastern fence, a soil sample was collected after a portion of PVC pipe was unearthed. The TCE concentration was 900 ppb in soil removed (Pile 1) to construct the gate footing. The subsurface distribution of TCE in shallow overburden soil, from the surface to the top of the clay layer, is shown on Figure 4-8.

In response to the elevated TCE concentration (>10,000 ppb) measured at boring B-34 at a depth of 4.4 feet, approximately 10 feet from the wood fence separating the Valley property from the residence at 106 Center Street, hand auger samples were collected along the fence on both sides. On the north side of the fence, TCE was detected at 11 ppb (B-34-F9); however, immediately south of the fence, TCE was detected at a concentration of 2230 ppb at 2.0 feet (HA-2). In other hand auger samples located on the residential property at 106 Center Street, TCE was not detected or detected at low concentrations (<70 ppb).

TCE concentrations were generally low (<10 to 60 ppb) in the shallow overburden in borings advanced outside the suspected areas of TCE releases to the east, southeast, and south of the former porch area; and inside the building moving northward from the former porch area: SB-04, SB-05, SB-07, B-39, B-50, B-51, B-53, TW-40, TW-32D, and TW-47. TCE concentrations were also low at all hand auger samples except HA-2.

In 1994 and 2000, during the drilling of the pilot borings for the three extraction wells in the Source Area, organic vapors and possible NAPL (EW-S2 only) were detected in soil samples from immediately above the clay layer, at a depth of about 8 feet. Later, during construction of the well vaults and piping in this area, contaminated soils were encountered and had to be removed from the excavations. TCE was not detected in this area in SB-13 during this investigation.

On average, TOC content in soils in the shallow overburden is approximately one percent, which is a fairly low organic fraction for shallow soils. Higher TOC readings (15,000 to 19,000 milligrams per kilogram or mg/kg) were measured in samples collected in the dark brown sandy soil that is a likely a buried soil horizon. TOC concentrations decreased significantly below the buried soil horizon to the top of the clay layer.

During the June 2006 investigations, several other observations were noted while drilling beneath the former porch area. A strong, sweet odor was detected while drilling at TW-35D and TW-44D at depths of 14 to 18 feet. In addition, a foamy substance was noted in the driller's mud tub while advancing through this interval at both locations. A sample of the foamy water from the mud tub (MW-35D-MT) had a TCE concentration of 41 ppb, which was likely diluted by drilling water. An oily sheen was noted on the soil sample within the split spoon collected for the 14 to 16 foot interval at TW-44D, and analysis by the OEME Mobile Lab GC noted several unidentified peaks in the sample collected at 15.9 feet. Several cyclo-alkanes were detected as tentatively identified compounds in soil samples from TW-35D and TW-44D that were analyzed at the fixed lab. In addition, a piece of crushed, black PVC pipe was extracted

from the cuttings from a depth of approximately 16 feet in TW-44D. While drilling at TW-42 and TW-43, the drillers upgraded to Level C personal protective equipment (PPE) due to PID readings of 0.5 to 1.5 ppm in the breathing zone and greater than 75 ppm over the mud tub water.

During the installation of one of the original SVE wells (EW-5D), a soil sample from a depth of 3 to 5 feet was analyzed for PCBs and found to contain Arochlor 1248 at a concentration of 17,400 micrograms per kilogram ($\mu\text{g}/\text{kg}$) [Lally, 1989]. A soil sample was collected in June 2006 in the vicinity of EW-5D to try to confirm the historical PCB detection, but PCBs were not detected.

4.2.2 Shallow Overburden – Groundwater Contamination. It was known from previous investigations that perched groundwater is present above the clay layer, at least seasonally. Where groundwater was noted in the soil samples from several of the shallow Geoprobe holes, attempts were made to collect aqueous samples with bailers before the holes collapsed. Water samples were collected from SB-02, SB-03, and SB-06. The TCE concentrations in these grab samples were 111 $\mu\text{g}/\text{L}$, 82 $\mu\text{g}/\text{L}$, and 26 $\mu\text{g}/\text{L}$, respectively.

Water is consistently noted in one of the former SVE wells, EW-6S, which is screened in the shallow overburden and possibly into the top of the clay layer. Groundwater samples collected from EW-6S in 2004 and 2006 had TCE concentrations of 82 and 95 $\mu\text{g}/\text{L}$, respectively. While these TCE concentrations in the perched water are high relative to the drinking water standard, they are not indicative of the presence of NAPL above the clay in the former porch area. The TCE concentrations in the soil samples from the depths where these water samples were collected ranged from 5 to 217 ppb in SB-02; 27 to 142 ppb in SB-03; and 21 to 66 ppb in SB-06. An additional sample of perched groundwater that was collected from well MW-5S inside the main Valley building had a very low TCE concentration (0.7 $\mu\text{g}/\text{L}$).

4.2.3 Shallow Overburden – Sub-slab Air Contamination. Elevated concentrations of TCE were observed in all eight sub-slab air samples collected below the floor of the main Valley building shown on Figure 3-1 (Table 4-5). The highest concentrations were noted in the northern portion of the Screw Machine Area (AR-02, 1,100 ppbv (parts per billion volume) and AR-07, 470 ppbv) and in the former Cam and Gear Room (AR-03, 850 ppbv). Subsequently, a soil boring, B-49, was advanced between these two air sample locations. The TCE concentration was 298 $\mu\text{g}/\text{kg}$ at soil boring B-49 at a depth of 6.7 feet below grade. The lowest sub-slab air TCE concentration was noted in AR-05, collected from the basement storage room.

4.2.4 Clay – Soil Contamination. A layer of gray clay was encountered at each boring advanced to bedrock, with the exception of TW-40. The thickness of clay layer is generally three to five feet thick but was noted to be greater than eight feet at B-50. The clay layer was generally thinner to the south of the former porch area.

TCE was detected within the clay layer at nearly every boring in the Source Area. In several locations where TCE was found in the clay, the chemical was not detected above or below the clay (B-34, B-46, B-49, B-50, and TW-48). TCE concentrations greater than 1,000 ppb were measured in the clay in borings on the eastern portion of the concrete slab of the former porch area (11,900 ppb at TW-35D; 8,130 ppb at TW-44D; and 1,500 ppb at B-45) and to the east of the main building north of the Storm Drain Leachfield (2,770 ppb at TW-32D). TCE concentrations in the clay increased with depth at borings where more than one sample was collected within this layer. Concentrations of TCE in the clay decrease moving north through the building and southward in the former porch area. TCE was not detected in the clay layer at the northern end of the building (TW-47), along the western edge of the property (B-51 and B-36), or to the south of the former porch and the immediately adjacent area (TW-33, B-38, B-39). In most of the probes advanced in 2004, at least one soil sample was collected for analysis from the upper clay, where TCE concentrations were generally in the range of <5 to 32 ppb. Higher concentrations of TCE were found only at SB-10 (270 ppb) and TW-29 (340 ppb). The subsurface distribution of TCE in the clay layer and in unsaturated overburden below the clay layer is shown on Figure 4-9.

Profiles based on geologic data collected in 2006 (Figure 4-4) suggest that the top of the clay slopes down to the north from the Source Area at the southeast corner of the building towards B-50. Across the concrete slab under the former porch area, the top of the clay tends to slope downward from Washington Street to the east towards TW-44D, then upward towards TW-17. Since the surface of the clay in the former porch area seems to be at a slightly lower elevation in the area of TW-44D, SB-10, EW-6S, EW-6C, and EW-6D (see Figures 4-1 and 4-2), it is possible that TCE may have pooled temporarily above the clay in this area if large spill(s) occurred.

4.2.5 Clay – Groundwater Contamination . One former SVE well (EW-6C) in which water was present was reportedly screened in the lower part of the clay layer. Water samples collected from this well in 2004 and 2006 had TCE concentrations of 15,100 and 7,100 µg/L, respectively. These relatively high concentrations suggest the presence of DNAPL in the vicinity of this well.

4.2.6 Deep Permeable Overburden – Soil Contamination. In general, the highest concentrations of TCE in the deep permeable overburden were detected just below the clay layer, particularly beneath the former porch area and to the east of the building. Concentrations exceeded 10,000 ppb at B-45 and TW-44D in sand encountered beneath the clay. The subsurface distribution of TCE in the clay layer and in unsaturated overburden below the clay layer is shown on Figure 4-9. In general, where TCE was detected in the deep permeable sand and gravel, concentrations decreased with depth. Farther below the clay and into the groundwater, concentrations of TCE were generally fairly low, ranging from not detected to approximately 115 ppb (Figures 4-2 through 4-4). Exceptions to the general trend were found at TW-35D and B-38, where concentrations of TCE in the hundreds of ppb were observed farther down in this layer. TCE was not detected in the deep sand and gravel layer to the south and west of the former porch area or inside the building, with the exceptions of B-45 and B-46 which are inside the building along the wall separating the main building from the former porch area.

A strong, petroleum odor was noted at TW-37 in a split spoon sample collected just below the clay from 23 to 25 feet. A sheen and a high PID reading (160 ppm) were also noted from a two-inch blackish silver lens of fine sand within this interval.

4.2.7 Deep Low Permeability Overburden – Soil Contamination. A layer of fine to very fine sand and silt and/or till was observed at most locations between the deep permeable overburden and bedrock. With the exception of the southeast corner of the building and former porch area, TCE was not detected at significantly high concentrations in this low permeability layer. In borings TW-44D (15,800 ppb), TW-35D (694 ppb), and B-45 (2,660 ppb) high concentrations of TCE were detected in this layer just above bedrock, and these TCE concentrations were significantly greater than those detected in the more permeable sand and gravel above (Figures 4-2 and 4-4).

4.2.8 Deep Overburden – Groundwater Contamination. Within the deep overburden below the clay, contaminant levels in groundwater have been shown to exhibit significant variability in vertical and horizontal direction. The discussion of contaminant distribution in groundwater in this layer is presented by area and depth. Figure 4-10 presents the distribution of TCE in groundwater, in both the upper and lower parts of the deep overburden.

Former Porch Area. Numerous monitoring wells and former SVE wells on the eastern side of the former porch area are screened at varying depths within the dense sand and gravel, fine silty sand, and till strata that comprise the deep overburden. No wells are located beneath the western portion of the former porch area due to the former USTs (removed August 2006).

Several wells are screened in the dense sand and gravel just below the clay. These wells and the corresponding TCE concentrations from summer 2006 sampling are EW-5D (170 $\mu\text{g/L}$), TW-23 (1,000 $\mu\text{g/L}$), TW-37 (52 $\mu\text{g/L}$), TW-18 (4,200 $\mu\text{g/L}$); and EW-6D (1,000 $\mu\text{g/L}$), as shown on Figure 4-5. Three of these wells were also sampled in 2004; the TCE concentrations were 1,400 $\mu\text{g/L}$ (TW-23), 4,420 $\mu\text{g/L}$ (TW-18), and 1,680 $\mu\text{g/L}$ (EW-6D). It should be noted that TCE concentrations were nearly three times higher in pre-purge than in post-purge samples collected at two of the wells (TW-23 and EW-6D) sampled in 2004. When TW-23 was sampled with passive diffusion bag samplers, the TCE concentrations throughout the water column were in the range of 4,000 to 6,000 $\mu\text{g/L}$.

The screen depth at well TW-9, 25 to 35 feet, covers almost the entire interval between the bottom of the clay layer into top of the dense silt (Figure 4-5). TW-9 is adjacent to well TW-18, which is screened from 24 to 27 feet. The concentration of TCE in groundwater at TW-9 was 870 $\mu\text{g/L}$ in 2004 and 2,300 $\mu\text{g/L}$ in 2006, lower than the concentration in the shallower TW-18 (4,200 $\mu\text{g/L}$). These results suggest that at this location, TCE concentrations decrease with depth in the dense sand and gravel layer. This observation may explain the decrease in TCE concentrations when wells in the dense sand and gravel are purged. Under static conditions, the wells may fill with shallower, more contaminated water that is

moving down under the hydraulic gradient. When the wells are purged, this water is replaced by less contaminated water flowing in from deeper soils. Slug tests were conducted in TW-37 to estimate the hydraulic conductivity of the dense sand and gravel. The tests were analyzed using the Bouwer – Rice method. The resulting hydraulic conductivity value of about 3 ft/day is much lower than would be expected for the sand and gravel layer in which this well is screened. A value of about 125 ft/day resulted from using a very brief early portion of the curve from the test, but that analysis is not considered valid because it represents only about a 10 percent recovery of the water level to its static position. The presence of the clay layer immediately above the screened interval may have interfered with the test and caused a data set that cannot be analyzed.

A layer of LNAPL was noted and bailed from TW-37 after post-injection sampling in August 2006. Analysis of this LNAPL indicated that it was a mineral oil. A sheen and high PID readings were noted in a soil sample collected at TW-37 from 23 to 25 feet, within the screen interval, at the time of installation.

The highest concentrations of TCE in groundwater beneath the former porch area are found in the deep layer of dense silty sand and glacial till in the eastern portion. The concentrations of TCE in wells TW-42 and TW-43, both of which are screened just above the bedrock in the layer of silt and fine sand, were 39,000 $\mu\text{g/L}$ and 34,000 $\mu\text{g/L}$, respectively (Figure 4-5). These high concentrations suggest the presence of DNAPL nearby. The screen intervals of the two wells adjacent to TW-42 and TW-43, TW-44D and TW-35D, include the lower part of the dense sand and gravel layer as well as the dense silt and fine sand layer just above the bedrock surface. The TCE concentrations at TW-44D, three feet west of TW-43, and at TW-35D, three feet southwest of TW-42, were 130 $\mu\text{g/L}$ and 46 $\mu\text{g/L}$. The disparity of TCE concentrations in these adjacent wells indicates that the groundwater is considerably less contaminated in the sand and gravel than in the underlying dense layer of silt, fine sand, and glacial till. It also suggests that if DNAPL is present, it may have sunk to the top of bedrock into the low permeability layer.

Slug tests were conducted in wells TW-42 and TW-43 to estimate the hydraulic conductivity of the deep layer of dense silty sand just above bedrock, in which contaminant levels were high. The results of the tests in these two wells were hydraulic conductivities of about 3 to 5 ft/day. Slug tests were also conducted in TW-44D and TW-35D. These wells are screened in both the deep layer of dense silty sand just above bedrock and the overlying dense sand and gravel. The resulting values in these two wells were about 13 to 33 ft/day. These higher hydraulic conductivities reflect the presence of the sand and gravel in the screened interval, a more permeable material than the silty sand below it.

Well TW-16, in the western portion of the former porch area just east of the USTs, is screened in both the dense silty sand and till. TCE concentrations in TW-16 were less than 10 $\mu\text{g/L}$ in 2004 and 2006, suggesting that this well is upgradient of most contamination in the deep overburden (Figure 4-5). A groundwater sample from the deep overburden (till) was also collected at boring B-27, drilled near the southwest corner of the former porch area in 2004. That sample had a TCE concentration of 4.1 $\mu\text{g/L}$, confirming that the plume in the deep overburden does not extend to the southwest.

East of the Former Porch Area. The highest levels of TCE contamination in groundwater have been observed in well TW-17 located ten feet to the east of the former porch area, where a plume emerges from beneath the former porch area and building and flows east-northeast toward the extraction wells (Figure 4-5). TW-17 is screened deep in the overburden in layers of till and dense silt and sand. The passive diffusion bag sampling of TW-17 indicated that, within the saturated screened interval of 8 feet, the groundwater in the lower 4 feet had TCE concentrations in the range of 100,000 to 160,000 $\mu\text{g/L}$. Above that, the TCE concentration was in the range of 4,000 to 6,000 $\mu\text{g/L}$ (Figure 4-5).

Well TW-3 is located about 30 feet southwest of EW-S2, the southernmost extraction well in the Source Area (Figure 4-1) and is sampled regularly as part of the plume remediation. Low concentrations of contaminants in this well (20 $\mu\text{g/L}$) suggested that the southernmost edge of the plume is just south of TW-3. However, a groundwater sample collected in 2006 had a TCE concentration of 966 $\mu\text{g/L}$. Based on these concentrations, the southern most edge of the plume may or may not be captured by the Source Area extraction wells.

Of the three Source Area extraction wells, the highest concentrations are generally measured in EW-S2, which is the southernmost extraction well. The TCE concentration has been as high as 33,000 $\mu\text{g/L}$ in the recent past but was 10,000 $\mu\text{g/L}$ in April 2006 and 1,900 $\mu\text{g/L}$ in July 2006. The TCE concentration in EW-S1, northwest of EW-S2, has been in the range of 2,000 to 7,000 $\mu\text{g/L}$ recently and was 3,400 $\mu\text{g/L}$ in July 2006.

The northern edge of the plume in this area is not well defined (Figure 4-10). Groundwater samples collected in 2004 from the deep overburden in a boring (B-29) about 50 feet north of TW-17 had TCE concentrations of 1,010 $\mu\text{g/L}$ at a depth of 25 feet, just below the clay, and 350 $\mu\text{g/L}$ at a depth of 38 feet, just above bedrock. In June 2006 a pair of wells (TW-32I and TW-32D) was installed just south of boring B-29, near the storm drain leachfield. The concentration of TCE in TW-32I, which is screened from within the bottom of the clay layer into the deep sand and gravel and silt lens found below the clay, was 3,200 $\mu\text{g/L}$. A lower concentration of TCE was noted in TW-32D, which is screened in deep sand and gravel and likely some dense silt above the bedrock surface (330 $\mu\text{g/L}$). The TCE concentration in TW-26A, which is between and slightly upgradient of EW-S1 and EW-S3, was 301 $\mu\text{g/L}$ in June 2006, which is similar to that sampled at TW-32D. Of the three Source Area extraction wells, the concentration of TCE is lowest in EW-S3 (<100 $\mu\text{g/L}$). These results indicate that the plume extends north of wells TW-32D and TW-26A.

South of the Former Porch Area. Groundwater samples were collected from seven wells located to the south of the former porch area. Wells TW-1 and TW-19, which are south of the western half of the former porch area, are screened at the bottom of the dense sand and gravel layer. The TCE concentrations in these wells were 21 $\mu\text{g/L}$ or less in samples collected in 2004 and 2006. Three wells in the upper portion

of the dense sand and gravel (EW-2D, EW-4D, and MW-3) had concentrations of TCE between 58 and 68 $\mu\text{g/L}$ in samples collected in 2004 and 2006.

The screens in wells TW-33 and TW-40 are 15 feet long and extend from the top of bedrock, up through the lower permeability silt and/or till, and into the dense sand and gravel. TCE was not detected in TW-40 at the southwest corner of the property, and the concentration of TCE in TW-33 was 2.3 $\mu\text{g/L}$. In addition, groundwater samples collected from the till layer at boring B-28 at depths 37 and 42 feet had low TCE concentrations of 0.7 and 2.1 $\mu\text{g/L}$, respectively.

The bedrock surface was observed to slope downward to the south along Cross-Section D-C (Figure 4-7). A concern existed that DNAPL might have migrated along that surface southward. The groundwater results from the wells along the southern side of the Source Area, and the absence of TCE below the groundwater table in soil samples collected from TW-33, TW-40, B-39, and B-28, confirms that neither DNAPL nor the contaminant plume has migrated southward.

Main Valley Building. Groundwater samples were collected from five wells located within the main Valley Manufacturing Building. Well TW-47, the northernmost well in the building in the former machine room, is screened in layers of dense silt and till just above the bedrock surface. Wells TW-15, TW-48, and MW-5D are all located, in the former screw machine area. TW-48 is also screened in layers of dense sand and silt above the bedrock surface. Wells TW-15 and MW-5D are screened in dense sand and gravel, with screen depths slightly shallower than TW-47 and TW-48. The concentrations of TCE in these wells were all less than 20 $\mu\text{g/L}$. Concentrations increased slightly moving south through the building towards the former porch area. A number of petroleum hydrocarbons and other unidentified compounds were detected in groundwater collected from well TW-48. The relatively low concentration of TCE in TW-48, which is west of the storm drain leachfield on the east side of the building, suggests that the contamination at the TW-32 wells does not originate beneath the building.

Slug tests were conducted in TW-48 to estimate the hydraulic conductivity of the lower overburden at that location. The resulting value of 0.3 ft/day suggests that the till and the overlying dense sand in that area have a lower hydraulic conductivity than the dense silty sands at TW-42 and TW-43.

West of the Former Porch Area. Three wells are located to the west of the former porch area: TW-20, TW-21, and TW-22. The bottoms of these wells are all 19 to 24.5 feet below grade, and all three have historically been dry.

4.2.9 Bedrock – Groundwater Contamination. Three wells to the east of the Valley Manufacturing property are screened in the bedrock: TW-26, TW-30, and TW-31. TCE concentrations in these wells were in the range of <1 to 33 $\mu\text{g/L}$ during the recent sampling events. To prevent the potential for DNAPL migration from the overburden into the bedrock, no bedrock monitoring wells have been installed in the former porch area, where the deep overburden is highly contaminated.

4.2.10 Groundwater Movement in the Source Area. Water levels were measured in the summer and fall of 2004 and in the summer of 2006 during this investigation. Water level data are shown in Table 4-13. The water level data suggest that steep downward vertical gradients exist in the Source Area.

The uppermost occurrence of groundwater in the former porch area is above the clay. In two former SVE wells (EW-5S and EW-6S) that are screened in the shallow overburden and possibly into the top of the clay layer, groundwater elevations between 63.7 and 64.5 feet were measured in 2004 and 2006. The groundwater that was collected above the clay in 2004 in the three Geoprobe holes (SB-02, SB-03, and SB-05) that had recoverable groundwater occurred at a similar elevation.

One of the former SVE wells, EW-6C, was reportedly screened in the clay layer. The groundwater elevations in this well, 58.5 to 59.7 feet, were lower than the groundwater elevations in wells (EW-6S and EW-5S) screened above the clay. The lower water level observed within the clay seems reasonable, since a downward hydraulic gradient through the clay is expected.

The screened intervals for former SVE wells EW-2D and EW-4D are not known, but the measured depths indicate that these wells penetrate just a short distance below the clay. The bottoms of the wells are at elevations between approximately 53.5 and 55 feet, and the groundwater elevations were between 54.0 and 55.7 feet. These water levels suggest that groundwater exists at a relatively high elevation in the dense deposits beneath the clay.

Groundwater elevations in another series of wells that are just slightly deeper than EW-2D and EW-4D were strikingly similar to one another. In TW-18, TW-23, MW-3, and EW-6D, groundwater elevations in November 2004 were between 53.32 and 53.35 feet. In June 2004, when water levels were about one foot higher, the water elevations in these wells differed by only 0.06 feet. In July 2006, after additional wells had been screened at this depth, the groundwater elevations in TW-18, TW-23, TW-37, MW-3, EW-5D, EW-6D, and EW-7D, were between 55.1 and 55.23 feet. The similarity of the water levels in these wells suggests that no lateral flow is occurring in the upper part of the deep overburden, and that downward flow is predominant.

TW-9 is adjacent to TW-18. The top of the screened interval of TW-9 is within one foot of that in TW-18, but its screen extends 8 feet farther down into the deep overburden where hydraulic heads are lower. The similarity of the water levels in TW-9 and TW-18 suggests that the soils in the upper part of the TW-9 screened interval are more permeable than those in the lower part.

The elevation of the bottom of well TW-19 is about 47 feet. The water elevations in this well in 2004 and 2006 were in the range of 48.07 to 50.99 feet, lower than the shallower wells but higher than the deeper wells.

Most of the remaining overburden monitoring wells have bottom elevations of 32 to 42 feet. The groundwater elevations in those wells, which were in the range of 40 to 48 feet, are lower than those in the shallower wells and represent a zone in which horizontal flow is predominant. These groundwater elevations have been plotted and contoured on Figure 4-12 and show that the direction of groundwater flow at the base of the overburden deposits is to the east-northeast. The relationship between well depth and piezometric head (lower heads at lower elevations in the subsurface) is shown on Figure 4-13.

Water levels in wells in the building were generally higher than those to the south in the former porch area. The highest water levels measured during the investigations, 67.1 to 67.3 feet, occurred in well MW-5S. The water levels in the adjacent well MW-5D, 62.2 to 63.8 feet, were also relatively high.

Both TW-47 and TW-48 have screens 10 feet long that are set just above bedrock. TW-47 is screened in till and dense fine silty sand, while TW-48 is screened in those two layers plus the bottom of the dense sand and gravel layer. The water levels in TW-48, which were between 49.55 and 51.54 feet, are considerably higher than those in TW-35D and TW-44D despite being screened at a similar depth and in similar materials. The higher bedrock elevation beneath the building may be related to the relatively high water levels in TW-48 and TW-47.

Well TW-15, in the building, has ten feet of screen, the bottom of which is at an elevation of about 46 feet. The log from this boring indicates that bedrock was encountered at an elevation of about 43 feet. In late June 2004, the groundwater elevation in this well was 50.8 feet. One month later, in late July 2004, the well was dry, indicating that the water level had fallen by about 5 feet. In 2006, the water level in this well fell 9 feet in 40 days. A review of the data from previous studies indicated that an even more precipitous water level decline occurred in June 1997, when the water level in this well fell almost 8 feet in one week. The reason for these unusually rapid water level declines is unknown, although it is suspected to be related to perched water and well construction.

4.3 Current Conceptual Model

The conceptual model of the Source Area at the Valley Manufacturing property has been updated based on observations of the Source Area re-evaluation, analytical results, and historical information. The TCE contamination observed and its spatial occurrence in soil and groundwater provide evidence of several sources. Historical information of Valley Manufacturing lists releases of TCE from USTs, leaks from drums stored in the former porch area, releases to leachfield(s), and surface releases of chemicals for weed control.

In the shallow overburden beneath and near the former porch area, the highest TCE concentrations in soil samples are often found in a layer of dark brown, loamy sand believed to be a buried soil horizon at a depth of 4 to 8 feet. Extensive surface discharges likely occurred in the eastern portion in the former porch area, where TCE concentrations in soil were >30, 000 ppb (TW-44D and SB-10) and elevated TCE

concentrations were also observed vertically downward through the unsaturated sand to the clay layer. It is stated in the ROD for OU2 that TCE was used a defoliant to the south and east of the Site. TCE may have adsorbed to high organic content in this loamy layer after discrete releases, resulting in contamination to the south and east of the former porch area where TCE concentrations are only elevated in the top four to six feet (SB-1, SB-6, B-33, B-34, and HA-2).

The shallow overburden has a thin zone of perched groundwater just above the clay. The perched water is generally found in the eastern part of the former porch area and to the east. TCE concentrations in this perched water ranged from 0.7 to 111 $\mu\text{g/L}$ and were highest in the eastern portion of the former porch area, where soil concentrations were highest as well.

The clay layer beneath the Site is generally three to five feet thick and tends to thin moving north to south. TCE concentrations were detected within the clay layer at nearly every boring in the Source Area. In several locations where TCE was found in the clay, the chemical was not detected above or below the clay. This observation is likely a result of the SVE system, which extracted soil vapor from unsaturated overburden above and below the clay but had little success in extraction from the clay layer itself. The highest soil concentrations in the clay layer were noted at TW-35D (11,900 ppb), TW-44D (8,130 ppb), and B-45 (1,500 ppb) which are located in the eastern portion of the former porch area below and slightly downgradient of the highest concentrations in shallow soil. Groundwater samples from a former SVE well (EW-6C) reportedly screened within the clay layer had TCE concentrations of 7,100 and 15,100 $\mu\text{g/L}$. This relatively high concentration suggests the possible presence of DNAPL in the vicinity of this well; however, the generally low TCE concentrations in the clay and overburden above the clay suggest that DNAPL is not widespread on the clay surface.

Beneath the former porch area and to the east of the building, high concentrations of TCE in soil (>1,000 ppb) were found just below the clay layer in unsaturated, dense sand and gravel (B-38, B-45, TW-35D, TW-44D, TW-32D). These samples were collected below highly contaminated shallow soil and clay samples, and are likely in the vicinity where TCE traveled through the clay or are near pockets of DNAPL. Groundwater samples collected in wells screened in the dense sand and gravel just below the clay in the central and eastern former porch area were also elevated (1,000 to 6,000 $\mu\text{g/L}$). TCE concentrations in soil and groundwater tend to decrease with depth in the saturated overburden, particularly below the water table in the saturated dense sand and gravel.

Above bedrock, the saturated overburden is composed of a layer of silty fine sand and/or glacial till. The highest TCE concentrations in groundwater, between 34,000 and 160,000 $\mu\text{g/L}$, were observed in this layer in the eastern portion of the former porch area (TW-42 and TW-43) and immediately east of the former porch area (TW-17). Significantly lower TCE concentrations were noted in groundwater samples collected from wells adjacent to TW-42 and TW-43 that are screened in both the dense sand and gravel and the silt and fine sand layers.

Pure-phase TCE is denser than water and, if enough were spilled, it would have sunk by gravity to the top of the bedrock surface or lower. Groundwater flow in the silty sand layer just above bedrock is restricted by the low hydraulic conductivity (3 to 5 ft/day) and is subject to less dilution and transport compared to the overlying layers. The higher TCE concentrations in the silty sand layer just above the bedrock are believed to be the result of these factors.

TCE concentrations in three bedrock wells located downgradient (east) of the former porch area have been fairly low, less than 33 $\mu\text{g/L}$. TW-31 is located east of the three extraction wells, and these concentrations are significantly less than measured in the extraction well influent. No bedrock wells exist below the Source Area. However, with such high concentrations of TCE measured in the deep overburden groundwater, the low concentrations of TCE in the bedrock monitoring wells suggest that any highly contaminated groundwater that may exist in the bedrock fractures below the former porch area is being captured by the extraction wells, which are screened in both the deep overburden and the upper bedrock.

5.0 REMEDIAL PILOT TESTING

Pilot testing was performed during 2006 to evaluate the feasibility of remediating contaminated soil and groundwater using chemical oxidation. ISCO using sodium permanganate was tested for contaminated groundwater. Unsaturated soil from the Source Area was excavated, placed in four roll-off containers, and dosed with potassium permanganate powder. The test procedures and results are described in the subsections below.

5.1 Permanganate Soil Oxidant Demand. Permanganate was selected as the oxidant for the in-situ and ex-situ pilot tests, as it is more persistent and more selective for organic compounds containing double bonds (i.e., chlorinated ethenes) than other oxidants used for remediation. In addition to oxidizing volatile organic compounds in soil and groundwater, permanganate will also oxidize natural organic matter and reduced inorganic material in the subsurface. Permanganate Soil Oxidant Demand (PSOD) is a preliminary screening tool that provides estimates of the amount of permanganate that may be required and information to assist in determining the economic viability of chemical oxidation for a given site. The PSOD is the mass of permanganate consumed per kilogram of dry soil (g/kg) in 48 hours.

Three soil samples, collected during the soil investigation in June 2006, were analyzed for PSOD by Carus Chemical Company (Carus), the manufacturer of the permanganate used for both the ISCO and ex-situ chemical oxidation pilot tests. Two samples were collected from within the saturated zone (TW-44D-32-34 feet and B-50-35-38 feet), and the third sample was collected above the water table just below the buried soil horizon (B-36 8-10 feet). The samples were dosed with three permanganate concentrations: low (2.8 g/kg), medium (13.8 g/kg), and high (27.5 g/kg). In general, PSOD values less than 35 g/kg are favorable for ISCO [Carus, 2006]. The average PSOD of the two samples from the saturated zone for the low, medium, and high doses were determined to be 0.25 g/kg, 0.55 g/kg, and 0.70 g/kg, respectively. The PSOD for the shallow sample from B-36 8-10 feet (0.9 g/kg, 3.0 g/kg, 4.1 g/kg) were at least five times greater than the samples collected from the saturated zone for all three doses. Reaction rate and oxidant consumption can increase with permanganate dose [Carus, 2006]. The PSOD report from Carus is included in Appendix K.

5.2 In-situ Chemical Oxidation for Groundwater. The ISCO injection was performed by Redox Tech, LLC (Redox), under subcontract to M&E. Sodium permanganate was injected into two wells within the Source Area. Sodium permanganate has a higher solubility in water (40%) than potassium permanganate (4%) and was selected as the chemical oxidant to minimize the volume of water required for injection.

5.2.1 Placement and Selection of Injection Wells. The objectives of the ISCO pilot test were to reduce concentrations of TCE by an order of magnitude and to evaluate the radius of influence of the permanganate. Due to the low permeability of the Source Area soils, a five-foot radius was targeted. The ultimate remedial goal for TCE will be the Maximum Contaminant Level (MCL) concentration of 5 µg/L. Injection locations were chosen to target historically high TCE

concentrations such that both new and existing monitoring wells could also be monitored for the presence of permanganate. Two wells, TW-37 and TW-43, were constructed as injection wells during the June 2006 soil investigation of the Source Area.

Well TW-43 has a screen interval of four feet, from 39.5 to 43.5 feet below ground surface. This well is screened entirely within the layer of silt and fine sand where high TCE concentrations were noted in soil in borings TW-35D and TW-44D and that is likely less permeable than the coarser sands immediately above. A series of monitoring wells were installed around TW-43. Well TW-42 is located five feet east (hydraulically downgradient) from TW-43 and is also screened in the layer of silt and fine sand (39.5 to 42.5 feet below grade). Monitoring wells TW-44D and TW-35D are located three feet upgradient and eight feet downgradient, respectively, of TW-43 and are both screened from 34 to 44 feet below grade (in both the silt/fine sand and in the coarser sands and gravel above).

Well TW-37 has a five foot screen from 23 to 28 feet below grade. That screen interval is within a layer of permeable sand and gravel. The location and screen interval of well TW-37 is approximately six feet west (hydraulically upgradient) from two existing monitoring wells with similar screen intervals where elevated groundwater concentrations have been measured historically : TW-18 (screened 24 to 27 feet below grade) and TW-9 (screened 25 to 35 feet below grade).

The injection locations and the monitoring wells sampled to evaluate the pilot test are shown on Figure 5-1.

5.2.2 Sodium Permanganate Injection. Approximately 140 gallons of 10%, by weight, sodium permanganate solution were injected into each of the two injection wells on July 24, 2006. Redox performed the injection with M&E providing oversight for injection activities. Redox selected the dosage, 1.8 g/kg, from the average PSOD of the high dose, which is more than twice the highest PSOD value from samples collected below the groundwater table.

At well TW-37, the solution was injected under pressure using a double diaphragm pump at approximately 30 to 35 pounds per square inch (psi), and injection was completed in approximately 30 minutes. At well TW-43, a coupling was not properly sealed at the time of construction which prevented injecting under pressure. The injection solution was gravity fed into the well at a rate of approximately one gallon per minute. After the injection, this coupling was sealed using glue and should be able to accept a pressurized injection in the future.

During the initial attempt to pump permanganate under pressure into TW-43, the coupling connection separated, causing a small volume of permanganate solution to leak across the slab and enter wells EW-6D and EW-6C. Water was sprayed over the leak to dilute the concentration, and then a solution of sodium thiosulfate was spread over the leak to neutralize the permanganate. The

resulting liquid was allowed to run off into two shallow trenches that were dug along the southern edge of the concrete slab near the location of boring B-38. At the conclusion of the injection, Redox washed out their pumps with water, and the wash water was also pumped into these trenches.

5.2.3 Radius of Influence Monitoring. Following injections, the radius of influence was monitored by bailing groundwater samples and visually checking for purple color indicative of the presence of permanganate. Sodium permanganate has a distinct purple color that is easily detected at concentrations greater than 0.5 milligrams per liter (mg/L) [Weston Solutions, 2005]. Deep purple water was observed in wells TW-9 and TW-18, located approximately six feet downgradient of the injection point, immediately following the injection into TW-37. Purple solution was noted in well TW-44D, three feet upgradient, after approximately 40 gallons of solution were added to TW-43 and in well TW-42, five feet downgradient, shortly after the injection was complete at TW-43.

Wells were monitored on three occasions following injection and prior to post-injection sampling to further assess radius of influence and to evaluate the progress of the reaction. Unreacted permanganate is deep purple in color, while partially reacted permanganate has a dark brown color. Site wells were visually monitored for purple color by bailing on July 28, four days after injection. Purple was noted in TW-9, TW-18, TW-42, and TW-43, as well as EW-6C and EW-6D. Groundwater bailed from TW-44D was brown with a trace of purple. Purple groundwater was not observed in TW-1 (13 feet south of TW-37), EW-5D (15 feet northwest of TW-37), TW-35D (8 feet downgradient of TW-43) or TW-17 (25 feet downgradient of TW-43).

Subsequent visual inspection of groundwater was performed on August 3. Dark purple groundwater was still noted in TW-42, TW-43, and EW-6D. Only trace purple color was noted in TW-18 and TW-37, and no purple color was noted in TW-9. Well EW-6C was not bailed. On August 10, dark purple groundwater was noted in TW-42 and EW-6C, and the groundwater bailed from TW-43 was much lighter than the previous week. Groundwater in EW-6D was brown with a trace of purple. Trace purple groundwater was noted in well TW-42 on September 20.

The permanganate injected into TW-43, into a layer of fine sand and silt, was observed to have traveled five feet from the injection point. Permanganate was observed to persist around the injection well and a well five feet hydraulically downgradient (TW-42), for greater than eight weeks. Permanganate was never observed in groundwater bailed from well TW-35D, 8 feet downgradient of the injection well, and was only observed in well TW-44D, three feet upgradient of the injection well, on the day of injection. However, these two wells are screened in the lower permeability layer of fine sand and silt as well as the more permeable layer of coarse sand and gravel above. As monitoring was performed by bailing, the lack of visual observation may be a result of higher groundwater flow rates in the more permeable, coarser sand layer and/or limited upward migration of injected permanganate. The radius of influence within the layer of fine sand and silt is likely greater than five feet, especially since deep purple permanganate was still observed five feet from the injection point

after more than eight weeks. Additionally, oxidant consumption by very high concentrations of VOCs between TW-42 and TW-35D may have contributed to why permanganate was not observed in well TW-35D.

The permanganate injected into well TW-37, into a layer of coarse sand and gravel, was observed to have traveled at least six feet from the injection point. Within this radius of influence, permanganate was observed to persist for at least 10 days. The presence of an oily product, noted in TW-37 during post-injection groundwater sampling, may have reduced both the persistence of permanganate in the subsurface as well as the radius of influence. The permanganate did not travel to wells 10 to 15 feet from TW-37 (TW-1, EW-5D). Figure 5-1 presents a spatial plan of the permanganate injection and radius of influence monitoring.

5.2.4 Performance Monitoring. Groundwater samples were collected on June 26 and 27, 2006 as a pretreatment baseline within the Source Area from wells TW-9, TW-18, TW-35D, TW-37, TW-42, TW-43, TW-44D, and EW-6D. Groundwater samples were collected for analysis of VOCs on August 17, 2006, 24 days after permanganate injection, to evaluate the performance of the chemical oxidant injection from wells TW-9, TW-35D, TW-37, TW-42, TW-43, and TW-44D. Samples collected on August 17, 2006 from wells TW-42 and TW-43 were purple in color and had permanganate remaining, so a small amount of sodium bisulfite was added to each of these samples until the purple color disappeared to neutralize the remaining oxidant. No samples were collected from wells TW-18 or EW-6D, which were damaged during the removal of the USTs. Additional post-treatment sampling was performed on September 20, 2006 from wells TW-9, TW-35D, TW-37, TW-42, TW-43, and TW-44D to further evaluate chemical oxidation. A small amount of sodium bisulfite was again added to the groundwater sample collected from well TW-42, where purple color was still noted. Analytical results are not available for inclusion in this report, but will be included in the Final Source Area Re-Evaluation Report.

An objective of the ISCO pilot test was to reduce the concentrations of TCE in groundwater by an order of magnitude within a five foot radius of the injection well. Significant reduction of TCE was noted in samples collected after permanganate injection in the monitoring wells located five feet downgradient of the injection; the TCE concentration in well TW-9 was reduced from 2,300 to 39 $\mu\text{g/L}$, and in well TW-42 the TCE concentration was reduced from 39,000 to 55 $\mu\text{g/L}$. In well TW-37, a small increase in TCE concentration was noted, from 52 to 130 $\mu\text{g/L}$. TCE may have been dissolved in the LNAPL detected in this well, which may have led to this increase.

At well TW-43, the injection well, the TCE concentration was reduced from 34,000 to 19,000 $\mu\text{g/L}$. It was assumed that this sample would have had a significantly lower concentration of TCE, as the groundwater was still purple in color. It is likely that DNAPL is located in the immediate vicinity of well TW-43, such that a sample containing permanganate when collected could still have such a high TCE concentration. The TCE concentrations in wells TW-35D and TW-44D, screened in both

the deep low permeability overburden and the deep permeable overburden, both increased. In TW-44D (upgradient location) the concentration increased from 130 to 9,800 µg/L. In the downgradient well, TW-35D, the post-injection TCE concentration was 32,000 µg/L, up from 46 µg/L in the pre-injection sample. These results from the deeper permanganate injection may have been caused by dissolution of DNAPL mass and/or by the injection advecting high TCE concentration groundwater radially outward and/or upward into the deep permeable overburden. In general, trends of other chlorinated ethenes reflected increases or decreases in TCE concentration, with the exception of TW-43 where cis-1,2-DCE increased slightly from 65 to 120 µg/L. Aqueous concentrations of chlorinated ethenes before and after the pilot test are summarized in Table 5-1.

In addition to contaminant concentrations, the impact on several geochemical parameters from the permanganate injection was monitored. In the vicinity of the deeper injection at TW-43, dissolved oxygen levels generally were reduced, whereas slight increases in dissolved oxygen were noted near TW-37. Increase in oxidation-reduction potential (ORP) was noted at the time of the first post-injection sampling event (August 17) at all wells monitored except for the two deep wells screened in both the lower permeability silt and fine sand and the more permeable sand and gravel, TW-35D and TW-44D. During the second post-treatment sampling event (September 20, 2006), increases in ORP were noted in wells TW-9, TW-37, and TW-44D. ORP decreased slightly in wells TW-42 and TW-43 between the first and second post-injection samples; however, ORP was still greater than the value recorded prior to injection. At well TW-35D the ORP value continued to decrease. Increase in ORP suggests a more favorable environment for oxidizing reactions, including degradation of chlorinated VOCs. The reason for the lower ORP readings at well TW-35D is unknown at this time. A decrease in pH was noted at several of the wells in the vicinity of the permanganate injections on August 17, 2006, and this is likely the result of carbon dioxide generated as a by-product of oxidation of organic carbon chemicals including TCE. The greatest decrease in pH was 2.5 pH units from 5.84 to 3.32 at well TW-42. More acidic groundwater can increase metal mobility, and the pH should continue to be monitored to evaluate this possibility. In wells where groundwater pH was noted to decrease after the permanganate injection, pH was noted to increase between August and September approaching pre-injection pH values.

5.3 Ex-situ Chemical Oxidation of Shallow Soil. A pilot test for ex-situ treatment was performed on approximately 43 cubic yards of unsaturated soil. Potassium permanganate, which has a lower solubility than sodium permanganate, was chosen as the oxidant to increase potential contact with contaminant. In addition, potassium permanganate is less costly and easier to handle than the more concentrated sodium permanganate. Excavation and chemical application was performed by Charter, under subcontract to M&E.

5.3.1 Permanganate Dosage. A range of permanganate doses was selected to determine the optimum dose for site soils. Dosages were chosen based on analysis of PSOD from three samples collected during the June 2006 soil investigation, an in-situ soil remediation project performed at Fort

Riley in Kansas (see Appendix K), input from Carus, and discussions between M&E and Charter. Four nominal dry-basis PSOD values were selected to be performed in duplicate: 2 g/kg (gram permanganate per kilogram dry soil), 3 g/kg, 5 g/kg, and 6 g/kg. A confidence factor of two was applied to each dose to account for variability in contaminant concentrations and soil composition. The actual potassium permanganate dosages were 4 g/kg, 6 g/kg, 10 g/kg, and 12 g/kg, and for a soil volume of approximately five cubic yards, approximately 60, 90, 150, and 180 pounds of potassium permanganate powder were added, respectively.

5.3.2 Ex-situ Soil Screening. Soil for the ex-situ pilot test was segregated based on PID screening, analytical results from boring logs, visual observation (i.e., loam), and direction from M&E personnel, and placed on polyethylene sheeting on the slab area. Excavation was performed by Charter using an excavator with a 1.5 cubic yard bucket. The segregated soil was transported from the former porch area to one of four roll-off containers staged in the parking lot of the GWTF using a Bobcat with a bucket volume of approximately one-half cubic yard. Two piles of approximately five cubic yards, 11 Bobcat bucket loads, were added to each roll-off. In total, approximately 40 cubic yards were excavated from the Source Area for the ex-situ pilot test: 11 cubic yards from the eastern portion of UST tank grave, 21 cubic yards from two areas south of the former porch area based on soil boring results, and 8 cubic yards from a localized area along the south side of the fence on the residential property at 106 Center Street. The soil excavated from the residential property was centered around location HA-2, where the TCE concentration was >2,000 ppb at 2 feet. This excavation was backfilled with virgin loam. An additional three cubic yards of drill cuttings from the soil exploration event of June 2006 comprised the remainder of the soil volume for ex-situ treatment. Figure 5-2 presents the approximate bounds of soil excavated for ex-situ treatment.

A suite of pre-treatment baseline samples were collected by Charter from each pile for laboratory analysis after transfer to the roll-off containers. Three discrete grab samples were collected for VOCs, and two composite samples were collected for PSOD, TOC, and geotechnical properties, including density, grain size, and porosity. Analyses were performed by laboratories subcontracted by Charter: Carus for PSOD and Phoenix Environmental Laboratories for VOCs, TOC, and geotechnical properties. Samples from the soil piles in the roll-offs were collected in Level C PPE to protect against inhalation of VOCs. The PSOD values measured in the shallow soil collected from south of the slab were much higher than in the samples analyzed during the soil investigation in June 2006. PSOD values in the pre-treatment piles ranged from 22.4 to 64.4 g/kg. Of the soil used for the ex-situ tests, the highest TCE concentrations were detected in soil excavated south of the slab near the boring SB-2, as high as 13,000 µg/kg. TCE concentrations were <5 µg/kg in soil segregated from the east wall of the UST tank grave. Very high PID readings (50 to 160 ppm) noted in this soil during pre-screening were likely due to elevated concentrations of VPH and EPH (See Sample UST-5 SW-EAST/TOP on Table 4-10). The TCE concentration in all pre-treatment samples is presented in Table 5-2. cis-1,2-DCE was detected in the soil samples collected from Piles 5, 6, 7,

8, and 9. The highest concentration was 420 µg/kg (Pile 6); however, every other detection of cis-1,2-DCE was ≤ 24 µg/kg.

5.3.3 Ex-situ Soil Pilot Test. M&E oversaw the application of potassium permanganate on the nine piles by Charter on August 16, 2006. Potassium permanganate powder was delivered to the Site in 55-pound pails, and the powder was applied directly to the soil. In a similar ex-situ pilot test, higher TCE removal was observed when adding permanganate powder to the soil compared to applying an equivalent amount of permanganate as an aqueous solution [Regenesis, 2006]. The soil-permanganate mixture was mixed with the excavator arm while water was added with a garden hose at a flow rate of approximately 20 gallons per minute. For Piles 1 and 2, a representative from Charter entered the roll-off to pour the permanganate manually over the piles. For the other seven piles, the permanganate was poured into the bucket of the excavator and spread evenly over the pile and mixed with the bucket. All personnel who entered the roll-off boxes or who sprayed water onto the soil piles operated in Level C PPE. A summary of the permanganate doses and source of soil for each pile is provided in Table 5-3. The piles were covered with polyethylene sheeting, the roll-off covers were secured, and the permanganate was allowed to react with the soil for five days.

Oxidation with permanganate is an exothermic reaction, and steam was noted emanating from Pile 6 after dosage and mixing. This pile was not mixed as thoroughly as others to prevent further spreading of what Charter believed to be combustion of tree roots.

5.3.4 Ex-situ Pilot Test Results. Post-treatment samples were collected on August 22, 2006. The results are summarized in Table 5-2. Five discrete, grab samples were collected from each pile: one from the center and one from each corner. TCE concentrations detected in the post-treatment samples ranged from <5 to 210 µg/kg. The highest TCE concentrations were in Piles 5 and 6, in the source soil from south of the slab near SB-2. The average TCE concentration in Piles 5 and 6 was reduced by almost two orders of magnitude as a result of the permanganate dosage. TCE concentrations in the post-treatment samples from soil in Pile 3 (3 g/kg) and Piles 7 and 8 (2 g/kg) were slightly higher compared to the pre-treatment samples; however, these small increases may be a result of soil heterogeneity within each pile and variability of VOC grab samples. USEPA guidance suggests that duplicate soil samples are equivalent when the relative percent difference (RPD) is less than 50 percent [USEPA, 1996]. The RPD of the average TCE concentrations before and after treatment was between 40 and 60 percent for these piles. In these piles, with the lowest dosages of permanganate, it is possible that the permanganate was oxidized by natural organic matter and oxidation of TCE was negligible. The highest permanganate dose was applied to the soil in Piles 1 and 2 (6 g/kg). The soil in these piles retained a dark purple color following mixing. Both the PSOD and TCE concentrations were very low in the soil in Piles 1 and 2. The maximum cis-1,2-DCE detection in the post-treatment samples was 20 µg/kg. Methyl ethyl ketone (MEK) was detected in almost every post-treatment sample. However, this compound was not detected in any pre-treatment sample and may be the product of the oxidation of organic matter. One possible

explanation is that the use of sodium bisulfate as the low-level preservation method for soil samples with high organic matter or humic material content has been known to result in the formation of acetone and MEK at potentially significant concentrations in samples (>100 µg/kg) [Clausen, et. al., 2000; CTDEP, 2005].

5.3.5 Backfill. The nine soil piles treated by the ex-situ pilot test were extracted from the roll-off containers on September 7, 2006. The soil from Piles 3 through 9 were dumped onto the concrete slab and placed with a bobcat south of the slab between the locations of SB-1 and EW-3, and the open excavations near SB-2 and B-34 were filled. Small portions of purple soil were noted, and the soil was wetted with a hose as the soil was backfilled to promote reaction of any remaining permanganate. While backfilling, portions of the soil appeared drier and less purple, particularly in Piles 1 and 2. It may be possible that the oxidation reaction was contact and/or moisture limited. A large volume of purple water was present around Pile 9 (drilling cuttings); this water was drained into the backfill area between well TW-1 and TW-19. The soil in Piles 1 and 2, which were taken from the UST tank grave, had the largest permanganate dose and retained a deep purple color. A test pit was excavated on September 12, 2006 at the eastern area of the former UST area, and this soil was backfilled to a depth of approximately eight to ten feet. Generally soil was backfilled in the same area from which it was excavated.

5.4 Pilot Test Conclusions and Recommendations. The in-situ groundwater and ex-situ soil pilot tests demonstrated the ability of permanganates to reduce the mass of TCE. For both tests, the post-treatment sampling results presented unexpected results that additional monitoring may help to elucidate. The performance of the two pilot tests will provide valuable information for the remediation of the Groveland Superfund Site.

5.4.1 In-situ Chemical Oxidation for Groundwater. The concentration of TCE was reduced by nearly two orders of magnitude from two wells, but increases were noted in three others. The high concentrations of TCE measured after the injection of permanganate, and in water that visually contained permanganate, suggest that DNAPL is likely present in the vicinity of injection well TW-43. As permanganate was still visually observed in groundwater during the post-injection sampling, it will continue to oxidize TCE, and additional post-treatment groundwater samples should be collected to evaluate if additional degradation or contamination rebound have occurred. A decrease in pH was noted in some wells three weeks after permanganate injection, but the groundwater pH had increased to near baseline conditions in most wells two months after the injection. Future sampling events should include metals analysis and evaluate any additional pH changes. Future permanganate injections should also be considered, due to the potential presence of DNAPL and the possibility of contaminant rebound. Multiple injections are often required to achieve MCLs as a cleanup goal [McGuire, et. al, 2006; ITRC, 2005].

5.4.2. Ex-situ Chemical Oxidation for Unsaturated Soil. The soil pilot test demonstrated that significant reductions of TCE concentration in soil can be achieved using permanganate as an oxidant. While backfilling the treated soil, portions of the soil appeared drier and less purple. It is likely that the oxidation reaction within the roll-off containers was contact and/or moisture limited. In addition, the PSOD in the piles was higher than expected and may have inhibited chemical oxidation of TCE in favor of natural organic matter. For future remediation of unsaturated soils, a dose of at least 30 lb permanganate per cubic yard soil (10 g MnO_4^- /kg) is recommended, particularly in areas when soil TCE concentrations are known to be >10,000 $\mu\text{g}/\text{kg}$, and applying ample water will improve treatment effectiveness. Obtaining PSOD of the soils to be treated in advance would aid in determining the appropriate permanganate dosage. Soil borings to collect samples for PSOD analysis prior to ordering permanganate would help ensure that the dose is sufficient. For future in-situ or ex-situ dosage, adding ample water, until all soil is visibly wet, will improve contact between permanganate and TCE in soil. Due to heterogeneity in soil and variability in analytical results, more grab samples for VOCs should be collected using a systematic grid approach to better evaluate treatment performance. Utilizing the OEME Mobile Laboratory would provide quantitative contaminant characterization for each target area, aid in determining target area dosages, as well as determine where additional treatment may be necessary while a subcontractor may already be mobilized.

To fully evaluate chemical oxidation of contaminated soil, additional shallow soil samples should be collected from areas of the Site where permanganate treated soil was backfilled from both the ESCO pilot test and from where soil was treated in-situ.

6.0 IDENTIFICATION AND EVALUATION OF REMEDIAL ALTERNATIVES

This section includes a review of potential remedial technologies and alternatives to address the contamination remaining in the Source Area soils and groundwater in order to reduce risk to human health and reduce the time of operation of the GWTF. A total of seven remedial technologies were considered, including four for vadose (unsaturated) zone soils, two for groundwater and saturated soil, and one remedial technology that would address both the unsaturated and saturated zones. A total of five remedial alternatives, combining various technologies to address both the vadose and saturated zones, were evaluated. Implementation and performance monitoring of the pilot tests conducted during 2006 were considered as part of the alternative evaluation. Although this evaluation is not designated as a feasibility study, the format of the evaluation of the potential alternatives has been addressed as a limited feasibility study.

6.1 Prior Source Area Remediation

Previously, the PRPs operated a SVE system to address vadose zone contamination in Source Area soils above and below the clay layer. The SVE system began operation as a pilot operation under the SITE program in 1988 [USEPA, 1989]. The system was later modified to include additional vapor extraction wells and to include the capability of dual-phase extraction and hot-air injection to enhance contaminant removal. In 1997, an assessment of the system found that the mass of contaminants being removed was less than 0.1 pounds per month. USEPA made several recommendations for improving system operation, but, the recommendations were never incorporated into the system. The PRP system was shut down in 2002, after Valley Manufacturing ceased operations. Results from soil sampling conducted under this Source Area re-evaluation indicate that the SVE system was only partially effective, particularly near the former porch area. Evidence of success of the SVE system was observed inside the main Valley building (B-46, B-49, B-50, and TW-48), where TCE was found only in the clay and not above or below the clay. However, residual TCE contamination in the clay layer demonstrates the difficulty in removing VOCs in low permeability media by SVE.

6.2 Site Cleanup Levels

Site cleanup levels for soil and groundwater were established during preparation of the Feasibility Study [RFW, 1988] and the ROD [USEPA, 1988A]. The Safe Drinking Water Act MCLs were selected as target cleanup levels for contaminants of concern in groundwater. For those contaminants for which MCLs were not available at the time of ROD preparation, risk-based cleanup levels were established. Groundwater remediation goals have been updated to be consistent with amendments to MCLs since the ROD was prepared in 1988 [USEPA, 2003].

Proposed target cleanup levels were developed for Source Area unsaturated soils in response to updates made to USEPA soil screening guidance. M&E calculated revised soil cleanup levels for nine

contaminants based on contaminant migration to groundwater, such that contamination leaching from Site soils to groundwater would not exceed target groundwater levels (MCLs) at a downgradient monitoring well. Applying site-specific hydrogeologic data collected during the Source Area Re-Evaluation to current USEPA guidance for developing soil screening levels [USEPA, 2002], the resulting proposed soil cleanup concentrations for these chemicals are less stringent than cleanup concentrations in the ROD [USEPA, 1988]. All calculations associated with revised soil cleanup goals are provided within Appendix H. The revised remediation goals are based on chemical-specific parameters as well as site-specific data collected, including total organic carbon in soil, hydraulic conductivity, hydraulic gradient, and aquifer thickness. The proposed soil cleanup values calculated during this study were further evaluated to determine that these concentrations are protective of direct contact exposures (i.e., incidental ingestion, dermal contact, and inhalation of dust released from soil), and risks associated with the subsurface vapor intrusion pathway (i.e., the inhalation of impacted air). Based on this evaluation, the proposed cleanup level for TCE, which is the primary contaminant of concern, was identified as 77 µg/kg. This proposed cleanup concentration is slightly higher than the USEPA Region IX PRG of 60 µg/kg, but is lower than the MassDEP Method 1 Soil Cleanup Standard for Category S-1 soils in a GW-1 (drinking water) aquifer of 300 µg/kg [MassDEP, April 2006].

Groundwater and soil cleanup concentrations calculated during this study are presented in Table 6-1. The more stringent values identified in the ROD are also presented for comparison. Maximum concentrations detected in unsaturated soil during the 2004 and 2006 sampling program are shown on Figures 4-8 and 4-9. The area that would require remediation to achieve the 77 µg/kg proposed cleanup level for unsaturated soils is depicted on Figure 6-1 with approximate contamination depths. The area requiring remediation for groundwater and saturated soil is shown in Figure 6-2. Approximately 4,400 cubic yards of unsaturated soil would be targeted for remediation. The area requiring remediation of groundwater and saturated soil is approximately 6,600 square feet and contains 230,000 to 300,000 gallons of groundwater.

6.3 Initial Screening

The remedial technologies are presented and screened in this subsection. Several factors were used to determine feasibility and, in turn, to screen out those technologies that clearly should not be considered for use at the Site. The factors used in this screening process were based on the current USEPA guidance for conducting an FS under CERCLA [USEPA, 1988B] and included, but were not limited to, the following:

- Effectiveness in handling the estimated areas or volumes of media and in meeting the remediation goals
- Potential impacts to human health and the environment during construction and implementation
- Proven effectiveness and reliability with respect to the contaminants and conditions at the Site
- Implementability in terms of both the technical and administrative feasibility

- Relative costs as far as technologies or process options that accomplish the same result

Technologies considered for the Groveland Source Area remediation include those that will address unsaturated soils and those technologies that could be used to treat saturated soils and groundwater. For unsaturated or vadose zone soils, excavation with either off-site disposal or on-site chemical oxidation of soils, in-situ gaseous chemical oxidation, and soil vapor extraction have been considered. For saturated soils and groundwater, ISCO and bioremediation (in-situ enhanced reductive dechlorination) have been considered. Thermal treatment has been considered for treating both the unsaturated and saturated zones.

A brief description of the technologies is presented below, along with rationale for eliminating or retaining the technology for further consideration. Generally, only technologies that would likely achieve the desired results were considered, therefore most technologies were retained for consideration as part of a remedial alternative.

6.3.1 No Further Action. The No Further Action alternative has been considered to establish a baseline. No further remedial activities would be implemented in the Source Area. The groundwater extraction and treatment system would continue to operate with continued monitoring. The No Further Action alternative would not reduce leaching to groundwater or health risks associated with exposure to TCE contamination in shallow soil, and this alternative is expected to fail to meet the proposed soil cleanup goal for TCE of 77 µg/kg. Under the No Further Action alternative, residual contamination in the Source Area would continue to dissolve into the groundwater flowing through that area, eventually reaching the extraction wells for removal and treatment. In order to estimate the time that the GWTF would have to continue to operate under this alternative, several methods were used to estimate the period of time for residual contamination to be flushed from the aquifer. All calculations resulted in durations in excess of 100 additional years (See Appendix I). The calculated cleanup times are considered highly uncertain; for example, the likely presence of DNAPL would increase anticipated cleanup time, but cleanup time would decrease if the estimate of remaining contaminant mass were lowered. In addition, reduction of residual contamination in unsaturated soil would be slow and could only occur by leaching associated with infiltration. Due to the long cleanup times predicted, the No Further Action was not retained for detailed evaluation; however, costs associated with continued GWTF operation and groundwater monitoring have been developed and are presented for comparison with the remedial alternatives in Table 6-7.

6.3.2 Excavation. Two excavation alternatives were considered for remediation of unsaturated soil with TCE concentrations exceeding the proposed cleanup goal of 77 µg/kg. In one alternative, all soil exceeding the proposed cleanup goal would be excavated and disposed of off-site. The second alternative would treat the contaminated soil with a chemical oxidant on-site, and the treated soil would be backfilled.

Unsaturated soils exceeding the proposed cleanup goal of 77 µg/kg are located beneath much of the former porch area and under the southern portion of the main Valley building. It is estimated that approximately 4,400 cubic yards of soil exceeding 77 µg/kg TCE would require excavation and disposal or chemical oxidation treatment, and demolition of the main Valley building would be required to safely access all contaminated soil. For the off-site disposal option, it has been assumed that soil would be disposed of as a RCRA listed hazardous waste (F001) and that clean fill would be used to backfill the excavation. Alternatively, reduction of TCE contamination by chemical oxidation would allow the soils to remain on-site. Permanganate would likely be selected as the oxidant, similar to the pilot tests described in Section 5.3, where up to 99 percent removal of TCE was observed. These excavation alternatives would remove TCE from unsaturated soils in the Source Area, thereby eliminating risks associated with direct exposure, inhalation, and mobility to groundwater. Excavation of soils exceeding the 77 µg/kg proposed cleanup goal has been retained for further consideration.

6.3.3 Soil Vapor Extraction. Soil vapor extraction is an in-situ vadose zone soil remediation technology in which a vacuum is applied to the soil via extraction wells to induce the controlled flow of air and remove volatile and some semivolatile contaminants from the soil. The gas leaving the soil would be treated to remove the contaminants prior to discharge to the atmosphere.

Based on results of the soil sampling program, it appears that the existing SVE system, which was operated by the PRPs for over 10 years, was only partially effective in remediation of Source Area soils. High levels of contaminants remain in soils at locations within 10 feet of the SVE wells. For example, at boring SB-10, located about 5 feet from SVE well EW-6S, TCE was detected at 52,000 µg/kg at a depth of 7.7 feet and at 2,460 µg/kg at 8.2 feet (EW-6S is screened from 9 to 19 feet). At boring SB-08, located approximately 7 feet from SVE well EW-5, TCE was detected at a concentration of 10,800 µg/kg at a depth of 7.8 feet (EW-5S is screened from 8 to 18 feet). Lower concentrations, ranging from a low of 5 to 793 µg/kg TCE, were detected in soil boring depths corresponding to the screened intervals of these wells. Both wells are located beneath the cement slab of the former porch area. It is noted that the highest levels of contamination remaining are in the loamy soil layer found at depths ranging from 6 to 8 feet below ground surface. Due to the heterogeneity of the soils, it is likely that remediation proceeded in the more porous sandy soil and fill, and that remediation of the loamy soil layer was limited to diffusion through the soil media.

The existing system has been off-line and not maintained for nearly five years and was disassembled prior to the demolition of the porch structure. In addition, several SVE extraction wells were destroyed during the removal of USTs and soil pilot testing. If this technology were to be implemented, it is likely that a new, enhanced SVE system would be installed, rather than attempting to use portions of the previous SVE system. However, if remediation by SVE had previously become diffusion-limited in the areas of highest remaining contamination, then an enhanced SVE system would be expected to achieve only a slight improvement in the contaminant removal rate. SVE was not retained for detailed evaluation.

6.3.4 In-Situ Gaseous Oxidation of Vadose Zone Soils. In-situ gaseous oxidation (a form of chemical oxidation) involves the injection of a gaseous oxidant into soil or groundwater to break down contaminants into non-hazardous by-products such as water, salt, and carbon dioxide. In the case of TCE, oxidation proceeds to 1,2-DCE, vinyl chloride, and ultimately to non-hazardous by-products. The most commonly used chemical oxidant in gas form is ozone. For vadose zone soils, ozone injection can be accomplished with relative ease and is, therefore, being considered for vadose zone remediation. Variations of this technology are available. The Perozone™ system employs microbubbles of ozone coated with hydrogen peroxide, which results in greater production of the hydroxyl radical than ozone alone. To promote degradation of contaminants in the vadose zone, ozone would be introduced via injection points targeting depths where high levels of contamination remain. In-situ gaseous oxidation has been retained for detailed evaluation.

6.3.5 In-Situ Thermal Treatment. In-situ thermal treatment technologies, such as electrical resistance heating (ERH) and in-situ thermal desorption (ISTD), use heat applied directly to the subsurface to strip volatile and semivolatile contaminants from both vadose and saturated zones. The vapors are collected through wells for treatment. One advantage of these technologies over SVE is that they are applicable to poorly permeable or dense soils, clay layers, and heterogeneous soils.

ERH uses three-phase electricity to increase subsurface temperatures beyond the boiling point of water and most VOCs, creating steam and causing VOCs to transition to the vapor phase and rise toward recovery wells placed above the heated region. Since electricity will take the pathway of lower resistance, such as silt or clay, when moving between electrodes, these pathways are heated faster. As a result, areas of low permeability where chlorinated compounds tend to become trapped are heated slightly faster than areas of higher permeability. Consequently, contaminants are stripped from subsurface soils, irrespective of soil permeability [Thermal Remediation Services, Inc., 2005]. Electricity is delivered to the subsurface using electrodes which are installed using standard drilling practices.

ISTD is based on thermal conduction through the soil, providing uniform heat transfer. Heat is applied using thermal wells, along with heated extraction wells, which can be placed at any depth or in any media, creating a zone of very high temperature (over 1000 °F) [TerraTherm, Inc.]. Extraction wells and vapor-phase carbon are used to remove the contaminants.

Successful ERH and ISTD remediation projects have been demonstrated at similar sites in both unsaturated and saturated soils. Other forms of in-situ thermal treatment include steam and hot air injection; however these technologies would be less effective due to the heterogeneity and low permeability of the soils. In-situ thermal remediation has been retained for further consideration.

6.3.6 In-Situ Chemical Oxidation, Groundwater. In-situ chemical oxidation involves the injection of an oxidant into the saturated zone to break down contaminants into non-hazardous by-products such as water, salt, and carbon dioxide. In the case of TCE, oxidation proceeds to 1,2-DCE, vinyl chloride, and

ultimately to non-hazardous by-products. The chemical oxidants most commonly employed to date include peroxide (Fenton's Reagent), ozone, and sodium or potassium permanganate. These oxidants have been able to cause the rapid and complete chemical destruction of many toxic organic chemicals. Other organics undergo partial degradation, leaving by-products that are amenable to subsequent bioremediation. In general the oxidants have been reported to achieve greater than 90 percent treatment efficiencies for TCE, with very fast reaction rates. Field applications have clearly affirmed that matching the oxidant and *in situ* delivery system to the contaminants of concern (COCs) and the site conditions is the key to successful implementation and achieving performance goals [USDOD, 2002]. For the Groveland Site, possible oxidants include hydrogen peroxide, which is available on-site at the GWTF, and potassium or sodium permanganate. Permanganate is more stable than peroxide, which would allow more time for contact with contaminants in the dense soils found in the Source Area.

6.3.7 In-Situ Enhanced Reductive Dechlorination. Nutrient enhanced reductive dechlorination is intended to progressively destroy TCE and the breakdown products by accelerating the biodegradation rates of site contaminants through anaerobic reductive dechlorination processes. Naturally occurring microorganisms create hydrogen, which replaces chlorine on chlorinated ethenes, eventually producing ethene. Without enhancements, the process is slow and unstable. The addition of an electron donor and/or dechlorinating microbes results in acceleration of the naturally occurring process. Several amendments are available. There are several technology vendors that sell proprietary formulations of electron donors, including HRC® (or Hydrogen Release Compound, Regensis) and EOS® (Emulsified Oil Substrate), and dehalogenating microbes, including KB-1 (SiREM) and CL-OUT (CL Solutions). Also available are technologies that use non-proprietary materials, such as molasses, lactate, and soluble oils. Cost of the proprietary amendments is greater than for the non-proprietary; however the vendors state that proprietary amendments result in a more extended release, thereby requiring fewer applications [Dajak, 2006; Regensis; 2006]. A disadvantage of this technology includes the generation of a reducing environment in the aquifer, which could result in mobilization of naturally occurring metals, such as arsenic. Enhanced Reductive Dechlorination has been retained for further consideration.

6.4 Potential Alternatives

Five remedial action alternatives were developed and screened in this subsection. Alternatives were developed by combining technologies, as appropriate, to address both vadose and saturated zone soils. These include

- Alternative 1A Excavation/On-site Chemical Oxidation of unsaturated soils
In-situ Chemical Oxidation for saturated soils and groundwater
- Alternative 1B Excavation/Off-site Disposal of unsaturated soils
In-situ Chemical Oxidation for saturated soils and groundwater
- Alternative 2 Excavation/On-site Chemical Oxidation of unsaturated soils
Enhanced Reductive Dechlorination for saturated soils and groundwater
- Alternative 3 In-situ Gaseous Chemical Oxidation of unsaturated soils
In-situ Chemical Oxidation for saturated soils and groundwater

- Alternative 4 In-situ Thermal Treatment for soil and groundwater

The following statutory NCP criteria were used to evaluate the alternatives.

- Overall Protection of Human Health and the Environment

This criteria addresses how the alternative provides overall human health and environmental protection.

- Compliance with ARARs

This criterion addresses the degree to which chemical-specific, action-specific, and location-specific ARARs will be met by the application of the alternative. It further addresses compliance with other appropriate criteria, advisories, and guidance that may be available. Preliminary ARARs are presented in Appendix F.

- Long-Term Effectiveness and Permanence

This criterion addresses the magnitude of the residual risks and the adequacy and reliability of any controls.

- Reduction of Toxicity, Mobility, and Volume Through Treatment

This criterion addresses whether a treatment process is used and if the materials of concern are treated. It also addresses the volume of hazardous materials destroyed or treated, and the degree of expected reduction in toxicity, mobility, and volume. Furthermore, it addresses the degree to which treatment is irreversible and the type and quantity of residuals remaining after treatment is complete.

- Short-Term Effectiveness

This criterion addresses the protection of the community and on-site workers during remedial actions. It also addresses environmental impacts that may occur during the implementation and the time required to achieve the remedial action objectives.

- Implementability

This criterion addresses three main areas including technical feasibility, administrative feasibility, and the availability of materials and services. It addresses the ability to construct and operate the technology and the reliability. It also addresses the ease of undertaking

additional action if it were necessary. This criterion further addresses the ability to monitor the effectiveness, obtain approvals, and coordinate with outside agencies. Finally, this criterion addresses the availability of off-site treatment, storage, and disposal (TSD) services, necessary equipment and specialists, and the basic availability of the technologies proposed.

- Cost

This criterion addresses the costs projected for the alternative including capital and operation and maintenance, and the estimated present worth costs. Order of magnitude cost estimates were developed for each alternative. Budgetary quotes for equipment were obtained from technology vendors. When multiple quotes were obtained for the same product, the quotes were either averaged or one quote was selected for presentation. Contingency, project management, design, and construction management costs were estimated as percentages of total capital and operation and maintenance (O&M) costs, using the percentages suggested in *A Guide to Developing and Documenting Estimates During the Feasibility Study* [USACE/USEPA, 2000]. Based on estimates of the additional time for operation of the GWTF, approximate GWTF operation costs are included for the cost evaluation of each alternative.

- State Acceptance

This criterion addresses the expected likelihood of acceptance from the State regulatory agency.

- Community Acceptance

This criterion addresses the expected likelihood of acceptance from the local community.

6.4.1 Alternative 1A: Excavation/Oxidation of unsaturated soils and In-situ Chemical Oxidation

This alternative includes excavation and treatment of impacted soils above the water table and in-situ treatment below the water table in an attempt to achieve proposed cleanup levels. Treatment by chemical oxidation of Source Area soils will eliminate potential for contaminants to continue to leach into groundwater. Contamination in the saturated zone will be destroyed in-situ by chemical oxidation. By removing the source of constituents impacting the Site and decreasing the mass of contaminants in Source Area groundwater, it is anticipated that a decrease in the number of years of GWTF operation will be realized and overall remediation will be achieved in a more timely manner.

The goal for chemical oxidation of contamination in soil and groundwater is to achieve significant mass removal, with the intent of eventually achieving MCLs in groundwater and meeting the proposed soil

cleanup goal. As the basis for this analysis, chemical oxidation with permanganate was considered for unsaturated soils in addition to saturated soils and groundwater. For the Groveland Wells Site Source Area, permanganate offers the following advantages:

- Permanganate is more persistent in the subsurface than peroxide, persulfate, or ozone; therefore, it has a wider range of options for field application/subsurface delivery.
- Permanganate has a strong affinity for oxidizing organic compounds containing double carbon bonds, aldehyde groups, or hydroxyl groups. Peroxide and ozone are less selective oxidizers. As a result, the effective radius of treatment would likely be greater for permanganate than it would be for the other oxidants, because it is less likely to be consumed as quickly by natural organic matter in the subsurface.
- Permanganate is a more stable oxidizing agent, so dangers of rapid decomposition are not as great as with peroxide and ozone; however, fire or explosion hazards still exist if concentrated permanganate contacts reducing agents or combustible/flammable materials.
- Diffusive transport through low permeability zones is possible with permanganate due to its higher stability, compared to other oxidants.
- The optimum pH range for chemical oxidation with permanganate is 7 to 8, but it is still effective over a wide pH range; therefore, pH adjustment is not typically required.

Permanganate can be applied to the subsurface in the form of potassium permanganate (KMnO_4) or sodium permanganate (NaMnO_4). Potassium permanganate is less expensive, but has a maximum solubility in water of 4%, which is substantially less than the 40% solubility of sodium permanganate. Sodium permanganate can be injected into the subsurface at concentrations up to 40%. However, because of health and safety concerns, it is typically diluted to 10 or 20% solution prior to in-situ injection into the subsurface. A 20% solution of sodium permanganate would require only 20% of the water necessary to deliver the same amount of oxidant as a 4% solution of potassium permanganate. In low permeability formations, injection of excess water can substantially lengthen the injection period, and potentially cause migration of groundwater contaminants to areas outside of the treatment zone. Therefore, in order to prevent injection of excess volumes of water into the subsurface, sodium permanganate is recommended as the ISCO reagent at the Groveland Wells Site Source Area. Conversely, as the oxidation of TCE occurs in an aqueous-phase reaction, potassium permanganate would be preferred for on-site treatment of unsaturated soil by chemical oxidation. A larger volume of less concentrated, permanganate solution would likely increase contact with contaminated soil.

Excavation of all unsaturated soils with TCE concentrations above the proposed cleanup goal of 77 $\mu\text{g}/\text{kg}$ was evaluated for this alternative, with all soil treated on-site. The approximate areas with estimated excavation depths are presented on Figure 6-1. It is estimated that approximately 4,400 cubic yards of soil exceeding 77 $\mu\text{g}/\text{kg}$ TCE would require excavation and chemical oxidation treatment. The average excavation depth is approximately 14 feet. In some areas, excavation would be required to be as deep as 24 feet and would include the clay layer. It has been assumed that sheeting or trench boxes would be required to access the southern portions of deeper soil noted on Figure 6-1, and sheeting has been

assumed for developing the cost estimate. For the excavation alternatives, demolition of the main Valley building would be required in order to safely access all contaminated soil.

Chemical oxidation of unsaturated soils would reduce the mass of TCE contamination and allow the soils to remain on-site. Potassium permanganate would likely be the oxidant, similar to the pilot tests described in Section 5.3. Determining the correct dose of permanganate is vital for successful treatment, and additional soil samples would need to be collected for PSOD analysis. Mixing permanganate with soil in-situ or applying permanganate ex-situ and backfilling would be evaluated during the remedial design. In-situ soil mixing may be more feasible for areas where contaminated soil is shallow; however, deeper soils may require excavation and ex-situ application of oxidant.

As the basis for this analysis, chemical oxidation using sodium permanganate was considered for saturated soils and groundwater. The primary factors that control the effectiveness of contaminant oxidation in the subsurface are geologic conditions, transport of the oxidant through the subsurface, and the natural oxidant demand of the formation. At the Groveland Wells Site Source Area, it is anticipated that a full-scale ISCO application of the permanganate solution would be accomplished using a series of injection wells similar to standard groundwater monitoring wells.

A permanganate injection system, complete with the necessary tanks, pumps, piping, fittings, and controls would be constructed to safely and effectively inject a solution of NaMnO_4 into approximately 50 subsurface injection points. In most locations, separate wells screened at two different depths may be necessary in order to maximize the distribution of the oxidant throughout the contaminated zones. The injection grid would extend slightly upgradient of the plume source and continue along the approximate width and length of the plume, including inside the former porch area and inside the former manufacturing building. Each row of wells would be offset by 10 feet, based on observations of the ISCO pilot test performed in July 2006, to produce a staggered effect that would help to provide even distribution of the oxidant in the subsurface. Injection points would be determined by Source Area groundwater and soil samples collected during 2006 to target areas where contamination exceeds proposed cleanup goals for soil and groundwater.

Sodium permanganate solution (40% by weight) would be delivered to the Site in drums and diluted on-site with potable water to a 10% solution prior to injection, similar to the pilot test. Dilution to 10%, compared to 20% which is also a commonly applied dosage, allows for a slightly larger hydraulic radius of influence as a larger volume is pumped into the subsurface. During the ISCO pilot test in July 2006, 10% sodium permanganate solution was injected into shallow, saturated overburden (TW-37) at a rate of four to five gallons per minute at a pressure of 30 to 35 psi. Permanganate was gravity fed into the deep, low permeability silt layer above the bedrock (TW-43) at approximately one gallon per minute. With a more secure coupling, the solution could have been pumped in under pressure at a slightly higher flow rate.

Concerns have been raised that the oxidizing nature of permanganate can mobilize certain metals such as chromium, increasing groundwater concentrations to unacceptable levels. A decrease in groundwater pH was noted following the permanganate pilot test, and many metals are more mobile under acidic conditions. Such conditions make mobilization of metals theoretically possible, although this does not appear to have been documented at sites where permanganate has been injected [Weston Solutions, 2005]. If metals are mobilized from the Source Area, it is anticipated that they would be removed via the groundwater extraction and treatment system. Monitoring of metals concentrations in groundwater is recommended for a full scale application. Trace metals may also be present as contaminants in the permanganate solution, so analysis of the solution being injected should be performed to ensure that such metals are not inadvertently added to the subsurface.

Post-injection monitoring of permanganate and VOCs would be performed to evaluate the distribution of permanganate in the subsurface, assess contaminant destruction, and determine progress towards attainment of remedial objectives. Visual inspections of groundwater in the monitor well network would be conducted weekly following injection events to monitor for the presence of permanganate. Sodium permanganate has a distinct purple color that is easily detected at concentrations greater than 0.5 milligrams per liter (mg/L) [Weston Solutions, 2005]. In addition to visual inspections, manganese and chloride levels would be monitored with test kits to estimate the remedial progress for a full-scale ISCO application. Once the permanganate dissipated within the monitor wells, groundwater samples would be collected and analyzed for VOCs to determine whether additional injections are required. A second set of groundwater samples would be collected and analyzed six to twelve months following injection to assess contamination rebound in groundwater, which could potentially occur when DNAPL is present [McGuire, et. al., 2006]. Additional permanganate would be injected in the vicinity of any monitor wells where TCE concentrations exceed the groundwater cleanup goal (MCLs). This process of monitoring and injection would be repeated until the VOC concentrations consistently meet cleanup goals. It is estimated that as many as three injections may be required to complete treatment of the entire area of the plume [Weston Solutions, 2005].

Once VOC concentrations throughout the treatment zone meet the cleanup goals (MCLs), groundwater monitoring for VOCs and metals would be conducted on a quarterly basis for one year to confirm that concentrations of VOCs do not rebound, and that no metals were mobilized as a result of the oxidant injection. Based on experience at other sites in New England with similar subsurface conditions, it is not anticipated that metals mobilization would be an issue at this Site. However, it is prudent to document the metals concentrations in groundwater before and after an ISCO program, and verify compliance with groundwater criteria. After one year of post-remedial monitoring has verified attainment of the remedial objectives, the remedial action completion report for the Site would be prepared, and injection system would be decommissioned [Weston Solutions, 2005].

The period of performance for this alternative is estimated to be five years, including three annual injections of permanganate, additional post-remedial monitoring, and injection system decommissioning

[Weston Solutions, 2005]. The components of this alternative are presented in general detail as part of the cost estimate in Table 6-2.

Overall Protection of Human Health and the Environment

Excavation of unsaturated Source Area soils with on-site treatment will eliminate potential for contaminants to continue to leach into groundwater. Treatment of groundwater will occur by injecting an oxidant to destroy contaminants in-place. It is projected that this action will reduce the contaminant concentrations in groundwater over time. Overall, this alternative will provide a high degree of protection of human health and the environment.

Compliance with ARARs

Over time, the aquifer will achieve compliance with chemical specific ARARs for the chemicals of concern over most of the Source Area.

Long-Term Effectiveness and Permanence

Chemical oxidation of unsaturated soils can effectively reduce contaminant mass with the application of sufficient dose of permanganate and ample water to allow aqueous phase contact with TCE. The complex hydrogeologic conditions beneath the Site may make it uncertain whether some areas within the saturated zone have been restored to appropriate standards. The geology and hydrogeology present several key challenges, and successful delivery of the oxidant to the contaminant, the primary factor controlling performance of the remedy, will be dependent upon geologic conditions, transport, and natural oxidant demand in the subsurface. Relatively low PSOD values from analysis performed on saturated and unsaturated soil prior to the pilot testing, provided further evidence that chemical oxidation by permanganate would be favorable within the Groveland Wells Source Area. However, significantly higher PSOD values were measured in shallow soil south of the slab, where natural organic matter may consume permanganate limiting potential reaction with TCE. In addition, the potential presence of DNAPL may limit effectiveness of ISCO and could lead to rebound contamination in groundwater. Confirmatory sampling will be conducted to verify cleanup. After compliance with groundwater standards is achieved, residual risk would be within an acceptable range.

Reduction of Toxicity, Mobility, and Volume Through Treatment

Contaminants in the vadose zone and in saturated soil and groundwater will be destroyed through chemical oxidation producing innocuous substances such as carbon dioxide, water, and inorganic chloride. Short term water quality may be degraded by injection of permanganate, including purple color, addition of manganese, and pH changes. However, over time these conditions will be buffered by

groundwater flow and reactions occurring in the subsurface. Once removed or destroyed, the reduction of the mass and volume of TCE in soil and groundwater is permanent.

Short-Term Effectiveness

During building demolition and excavation of soil above the water table, limited risk to construction workers exists due to use of heavy equipment and direct exposure to contamination. Limited risk to the community would be posed by truck traffic. Excavation and treatment of unsaturated soil by chemical oxidation will be completed in the first year. Potassium permanganate powder poses an inhalation hazard, and site workers should be dressed in Level C PPE, during execution of chemical oxidation of contamination in unsaturated soil. Steam may be generated by exothermic oxidation reactions, which may contain elevated concentrations of VOCs creating an inhalation risk to site workers and potentially nearby residents. Air monitoring should be included to ensure a safe breathing environment for site workers and that VOCs are not migrating off-site.

During the implementation of ISCO, expected to occur in three injections conducted over a three year period, minimal risk would be posed to the local community and ecosystems. Contaminant destruction would occur in-situ. Minimal risk is posed to workers constructing the alternative and maintaining the mechanical systems once in place. Care must be taken when handling oxidants; however, the periodic injections of the permanganate will pose minimal risk to the workers.

Implementability

The technologies employed in this alternative are well proven to have been technically feasible at similar sites. Services such as demolition and excavation, drilling and pressure injection are readily available. Techniques are well established to monitor the effectiveness of the alternative.

Cost

The primary capital costs associated with this alternative are demolition of the main Valley building, excavation and treatment of contaminated unsaturated soil with permanganate, and installation of ISCO injection wells. Labor and materials for ISCO injections were included as O&M expenses as three injections were assumed over a period of three years. Additional O&M costs include performance monitoring, procurement, and project management. An additional consideration includes the potential decrease of operation of the GWTF as a result of source area remediation. It is estimated that following completion of source remediation (five years), the GWTF will continue to operate for approximately 10 additional years after completion of source remediation activities to remove residual contamination in the plume. Costs for this alternative are developed in Tables 6-2 and are compared with other alternatives in Table 6-7.

State Acceptance

It is anticipated that the State regulatory agencies will accept this alternative.

Community Acceptance

There would be some short-term impacts on residences in the immediate vicinity of the Site during demolition and excavation, including noise and dust associated with excavation of soils. Also, some truck traffic will impact local roadways during removal of debris and mobilization of remediation equipment to the Site. However, it is anticipated that the community will likely accept this alternative since contaminants will be permanently destroyed.

6.4.2 Alternative 1B: Excavation/Disposal of unsaturated soils and In-situ Chemical Oxidation

This alternative is identical to Alternative 1A, with the exception that unsaturated soil exceeding the proposed cleanup goal of 77 $\mu\text{g}/\text{kg}$ would be excavated and disposed off-site. It is assumed that when disposed off-site, excavated soil would be RCRA listed hazardous waste (F001), although not all of the soil is expected to be hazardous in nature. Clean fill would be used to backfill the excavation. Including post-remedial monitoring, the period of performance for this alternative is estimated to be five years. The components of this alternative are presented in general detail as part of the cost estimate in Table 6-3.

Overall Protection of Human Health and the Environment

Excavation of unsaturated Source Area soils with disposal will eliminate potential for contaminants to continue to leach into groundwater and risks associated with direct exposure and inhalation. Treatment of groundwater will occur by injecting an oxidant to destroy contaminants in-place. It is projected that this action will reduce the contaminant concentrations in groundwater over time. Overall, this alternative will provide a high degree of protection of human health and the environment.

Compliance with ARARs

Over time, the aquifer will achieve compliance with chemical specific ARARs for the chemicals of concern over most of the Source Area.

Long-Term Effectiveness and Permanence

Excavation provides an effective and permanent solution for soil in the unsaturated zone. The complex hydrogeologic conditions beneath the Site may make it uncertain whether some areas within the saturated zone have been restored to appropriate standards. The geology and hydrogeology present several key challenges, and successful delivery of the oxidant to the contaminant, the primary factor

controlling performance of the remedy, will be dependent upon geologic conditions, transport, and natural oxidant demand in the subsurface. Relatively low PSOD values from analysis performed on saturated soil prior to the pilot testing, provided further evidence that chemical oxidation by permanganate would be favorable within groundwater below the Groveland Wells Source Area. In addition, the potential presence of DNAPL may limit effectiveness of ISCO and could lead to rebound contamination in groundwater. Confirmatory sampling will be conducted to verify cleanup. Once compliance with groundwater standards is achieved, residual risk would be within an acceptable range.

Reduction of Toxicity, Mobility, and Volume Through Treatment

Contaminants in the vadose zone will be removed from the Site through excavation, but will not be destroyed with off-site disposal. Contaminants in the groundwater will be destroyed through chemical oxidation producing innocuous substances such as carbon dioxide, water, and inorganic chloride. Short term water quality may be degraded by injection of permanganate, including purple color, addition of manganese, and pH changes. However, over time these conditions will be buffered by groundwater flow and reactions occurring in the subsurface. Once removed or destroyed, the reduction of the mass and volume TCE in groundwater and saturated soils is permanent.

Short-Term Effectiveness

During building demolition and excavation of soil above the water table, limited risk to construction workers exists due to use of heavy equipment and direct exposure to contamination. Limited risk to the community would be posed by truck traffic. Excavation and disposal of unsaturated soil would be completed in the first year.

During the execution of chemical oxidation, expected to occur in three injections conducted over a three year period, minimal risk would be posed to the local community and ecosystems. Treatment would occur in-situ. Minimal risk is posed to workers constructing the alternative and maintaining the mechanical systems once in place. Care must be taken when handling oxidants, however, the periodic injections of the permanganate would pose minimal risk to the workers.

Implementability

The technologies employed in this alternative are well proven to have been technically feasible at similar sites. Services such as demolition and excavation, drilling and pressure injection are readily available. Techniques are well established to monitor the effectiveness of the alternative.

Cost

The primary capital costs associated with this alternative are demolition of the main Valley building, excavation and disposal of unsaturated soils with TCE contamination exceeding 77 µg/kg as a listed RCRA waste (F001), and installation of ISCO injection wells. Labor and materials for ISCO injections were included as O&M expenses as three injections were assumed over a period of three years. Additional O&M costs include performance monitoring, procurement, and project management. An additional consideration includes the potential decrease of operation of the GWTF as a result of source area remediation. It is estimated that following completion of source remediation (five years), the GWTF will continue to operate for approximately 10 additional years after completion of source remediation activities to remove residual contamination in the plume. Costs for this alternative are developed in Tables 6-3 and are compared with other alternatives in Table 6-7.

State Acceptance

It is anticipated that the State regulatory agencies would accept this alternative.

Community Acceptance

There would be some short-term impacts on residences in the immediate vicinity of the Site during demolition and excavation, including noise and dust associated with excavation of soils. Also, heavy truck traffic would impact local roadways during removal of contaminated soil and delivery of clean fill. However, it is anticipated that the community would likely accept this alternative since contaminants would be permanently removed or destroyed.

6.4.3 Alternative 2: Excavation/Oxidation of Unsaturated Soils and Enhanced Biodegradation

This alternative includes excavation and treatment of impacted soils above the water table and in-situ treatment below the water table in an attempt to achieve proposed cleanup levels. Treatment by chemical oxidation of Source Area soils would eliminate potential for contaminants to continue to leach into groundwater. Contamination in the saturated zone would be destroyed in-situ by bioremediation via enhanced reductive dechlorination. By removing the source of constituents impacting the Site and decreasing the mass of contaminants in Source Area groundwater, it is anticipated that a decrease in the number of years of GWTF operation would be realized and overall Site remediation would be achieved in a more timely manner.

Similar to Alternative 1A, excavation and treatment by chemical oxidation of unsaturated soils with TCE concentrations above the 77 µg/kg TCE proposed cleanup goal was considered. The areas and volumes of soil would be the same as described for Alternative 1A, and would include the demolition of the main

building. The goal for enhanced reductive dechlorination is to achieve significant mass removal of contamination in groundwater.

Treatment of groundwater would occur by amending the groundwater to create reducing groundwater conditions conducive to the progressive dechlorination of TCE. Injection of an electron donor, such as soluble oil, molasses, or a proprietary material such as HRC® would be conducted to stimulate biological activities and create more reducing conditions. It is possible that during the reduction, chemical species that are considered more toxic, such as vinyl chloride, would accumulate and would require additional amendment before being further reduced. Laboratory analysis should be performed to determine if sufficient concentrations of dehalogenating microbes (Dehalococcoides) and vinyl chloride reductase enzyme are present. To increase rates of degradation, injection of a microorganism culture that can fully dechlorinate TCE to ethene is recommended, and this culture would likely be added during the second, and possibly the third, round of injection after observation of reducing conditions. Microbial degradation rates are optimal within a pH range of 6 to 8. Injected soluble oil would likely have to be buffered for pH, due to slightly acidic groundwater (see pre-treatment pH results in Table 5-1) and that soluble oil can lower pH in groundwater [M&E experience with reductive dechlorination].

Creating reducing conditions in the groundwater and saturated soil may be slowed or inhibited by application of a strong oxidant to unsaturated soils. Permanganate applied to unsaturated soils should be consumed by oxidation of TCE and natural organic matter. To minimize the potential for residual permanganate in unsaturated soil to stop inhibit generation of reducing conditions in groundwater, treatment of unsaturated soil should be completed prior to commencement of in-situ injections. It is recommended that a period of six months be allowed after soil treatment before injecting soluble oil or another electron acceptor.

This alternative may result in temporary mobilization of some metals, including arsenic, due to reducing conditions generated in the aquifer. If metals are mobilized from the Source Area, it is anticipated that they would be removed via the groundwater extraction and treatment system. Monitoring should be performed prior to commencement of groundwater remedial activities and during performance monitoring to evaluate this potential effect. Some of the materials to be injected would require special handling although the hazard is considered low. The required equipment above the ground surface is minimal and temporary.

Equipment requirements would be similar to those identified for ISCO. An injection system consisting of chemical tanks, pumps, piping, fittings, and controls would be constructed to inject the electron donor and inoculant into approximately 50 subsurface injection points. The injection wells would be spaced approximately five to ten feet apart, based on observations of the NaMnO₄ pilot test performed in July 2006, and, in some locations, separate wells screened at different depths may be necessary in order to maximize the distribution of the treatment materials. Use of soluble oil as an electron donor has been

assumed for the cost estimate. It has also been assumed that an inoculant microorganism culture would be injected during the second and third years of operation.

Post-injection monitoring of the electron donor would be performed to evaluate the distribution of the electron donor in the subsurface, assess contaminant destruction, and determine progress towards attainment of the cleanup objectives. It is estimated that as many as three injections may be required to complete treatment of the entire area of the plume. Monitoring of biological degradation parameters, including ethene, ethane, methane, and chloride, as well as VOCs and some metals, would be conducted annually following injection and for up to two years after completion of injection to monitor remedial progress.

Once VOC concentrations throughout the treatment zone meet the cleanup goals, groundwater monitoring for VOCs and metals would be conducted on a quarterly basis for up to three years to confirm that concentrations of VOCs do not rebound, and that no metals were mobilized as a result of the electron donor injection. After one year of post-remedial monitoring has verified attainment of the remedial objectives, the remedial action completion report for the Site would be prepared, and the injection system would be decommissioned.

Including post-remedial monitoring, the period of performance for this alternative is estimated to be seven years [Weston Solutions, 2005]. The components of this alternative are presented in general detail as part of the cost estimate in Table 6-4.

Overall Protection of Human Health and the Environment

Excavation of unsaturated Source Area soils with on-site treatment would eliminate potential for contaminants to continue to leach into groundwater. Enhanced reductive dechlorination of the Source Area groundwater would accelerate cleanup of the aquifer to conditions that are protective of human health and the environment.

Compliance with ARARs

Over time, it is expected that the aquifer would achieve compliance with ARARs for the chemicals of concern over most of the Site. Incomplete degradation may occur if conditions are not sufficiently reducing or there are insufficient electron donors or dehalogenating microbes available. Some of the degradation products are considered more toxic than the parent compounds being addressed, notably vinyl chloride.

Long-Term Effectiveness and Permanence

Once compliance with groundwater standards is achieved, residual risk would be within an acceptable range. The possibility exists that complete degradation may not occur, resulting in chemicals that have greater toxicity (vinyl chloride). Microbes can only degrade aqueous contamination and have limited success degrading pure product (DNAPL) which can be lethal to microbes. Enhanced biodegradation rates may be limited by slightly acidic groundwater observed (pH 5.5 to 6.5), and a pH buffer would likely need to be added to create conditions more amenable to microbial activity. In addition, the complex hydrogeologic conditions beneath the Site may make it uncertain whether some areas have been restored to appropriate standards.

Reduction of Toxicity, Mobility, and Volume Through Treatment

TCE would be progressively reduced within the treatment zones. During this process compounds that may be considered more toxic would be produced, including vinyl chloride. With progressively more reducing conditions and sufficient population of the necessary microbes, vinyl chloride would degrade. Short term water quality may be degraded (pH changes, toxic reaction by-products, and/or mobilization of metals) as a result of injection. However, over time these conditions would be buffered by the groundwater. Once destroyed, the reduction of the TCE is permanent. The residual TCE in the majority of the plume would be below appropriate standards.

Short-Term Effectiveness

During the execution of this alternative, expected to be seven years, minimal risk would be posed to the local community and ecosystems. Excavation and treatment of unsaturated soil by chemical oxidation would be completed in the first year. Potassium permanganate powder poses an inhalation hazard, and site workers should be dressed in Level C PPE during execution of chemical oxidation of contamination in unsaturated soil. Steam may be generated by exothermic oxidation reactions, which may contain elevated concentrations of VOCs creating a potential inhalation risk to site workers and nearby residents. Air monitoring should be included to ensure a safe breathing environment for site workers and that VOCs are not migrating off-site. Treatment of groundwater and soil below the groundwater table would occur in-situ. Accumulation of degradation products including vinyl chloride may occur. This would be addressed through the normal course of operation by the addition of microbes capable of complete dechlorination to ethene. Minimum risk is posed to workers constructing the alternative and maintaining the mechanical systems once in place. Periodic injections of the electron donor would be required posing minimal risk to the workers.

Implementability

This alternative is reasonably well proven to have been technically feasible at similar sites. Techniques are well established to monitor the effectiveness of the alternative. There are several technology vendors that sell proprietary formulations of electron donors and/or dehalogenating microbes. Each of these has unique benefits, some of which may be appropriate for this Site. There are several companies with experience with the technology that utilize non-proprietary materials such as molasses, lactate, and soluble oils to serve as electron donors and control the chemical conditions.

Cost

The primary capital costs associated with this alternative are demolition of the main Valley building, excavation and treatment of contaminated unsaturated soil with permanganate, a treatability study for enhanced biodegradation, and installation of injection wells. Labor and materials for injection of microbes, nutrients, electron donors, and soluble oils were included as O&M expenses as several injections were assumed over a period of three years. Additional O&M costs include performance monitoring, procurement, and project management. An additional consideration includes the potential decrease of operation of the GWTF as a result of source area remediation. It is estimated that following completion of source remediation (seven years), the GWTF will continue to operate for approximately 10 additional years after completion of source remediation activities to remove residual contamination in the plume. Costs for this alternative are developed in Tables 6-4 and are compared with other alternatives in Table 6-7.

State Acceptance

It is anticipated that the State regulatory agencies would accept this alternative.

Community Acceptance

There would be some short-term impacts on residences in the immediate vicinity of the Site during demolition and excavation, including noise and dust associated with the excavation of soils. Also, some truck traffic would impact local roadways during removal of debris and mobilization of remediation equipment to the Site. However, it is anticipated that the community would likely accept this alternative since contaminants would be permanently removed or destroyed.

6.4.4 Alternative 3: In-Situ Gaseous Oxidation of Vadose Zone Soils/In-Situ Chemical Oxidation of Groundwater and Saturated Soils.

This alternative includes destruction of contaminants through in-situ gaseous chemical oxidation via ozone injection in impacted soils above the water table and ISCO using sodium permanganate below the water table in an attempt to achieve a permanent solution.

In-situ gaseous chemical oxidation in the vadose zone is accomplished through delivery of a reactant gas, ozone, to the subsurface. No additional chemical reagents are required since ozone is produced on-site from air or oxygen passed through a commercially available generator. Ozone is injected into the subsurface under pressure produced by the generator. Utilities required include water and electrical power. The process can be enhanced by coating injected ozone gas with hydrogen peroxide (Perozone™). Injection wells would be installed at several depths throughout the Source Area vadose zone. Depths would be selected to target areas where high levels of contamination remain. Specifically, ozone would be injected directly into or just below the loamy soil horizon and into and just below the clay, where highest levels of TCE were detected, as well as at other depths where concentrations exceed proposed cleanup levels. A Perozone™ system was used as the basis for the cost estimate since the combination of ozone and peroxide would be expected to provide a higher degree of treatment than ozone alone. To remediate soil with TCE concentrations exceeding the 77 µg/kg proposed cleanup goal for TCE, approximately 25 injection wells would be required [Kerfoot Technologies, 2005]. The target remediation volume would be approximately 4,400 cubic yards, similar to that described in Section 6.4.1 for Alternative 1A (Figure 6-1). Applying this in-situ technology for remediation of unsaturated soils using injection points would preclude the need for demolition of the main Valley building to access all contamination. It is assumed that most of the vadose zone remediation would occur during the first year of operation; however, operation may need to continue into years two and three in some more heterogeneous soil and/or lower permeable areas. Soil sampling would be periodically conducted to monitor progress.

Groundwater remediation would occur by applying ISCO. The goal for chemical oxidation of contamination in groundwater is to achieve significant mass removal, with the intent of eventually achieving MCLs. As the basis for this analysis, chemical oxidation using sodium permanganate was considered for saturated soils and groundwater. See Section 6.4.1, Alternative 1A, for details of the permanganate injection system.

Including post-remedial monitoring, the period of performance for this alternative is estimated to be five years. The components of this alternative are presented in general detail as part of the cost estimate in Table 6-5.

Overall Protection of Human Health and the Environment

In-situ oxidation via ozone injection is expected to destroy contaminants in the vadose zone soil over time, effectively eliminating the potential for continued leaching from soil into groundwater. There is the potential that some areas may not be effectively remediated to proposed cleanup levels, however, periodic soil sampling should identify areas requiring further treatment. Treatment of groundwater would occur by injecting an oxidant to destroy contaminants in-place. It is projected that this action would reduce the contaminant concentrations in groundwater over time. Overall, this alternative would provide protection of human health and the environment.

Compliance with ARARs

Over time, the aquifer would achieve compliance with chemical specific ARARs for the chemicals of concern over most of the Source Area.

Long-Term Effectiveness and Permanence

Chemical oxidation, via ozone injection in the vadose zone and permanganate injection in groundwater, provides an effective and permanent solution for the Source Area soil and groundwater. Delivery of the oxidant to the contaminant is the primary factor controlling performance of the remedy for both ozone and permanganate. The complex geologic and hydrogeologic conditions beneath the Site may make it uncertain whether some areas both within the vadose and saturated zone have been restored to appropriate standards. TCE concentrations in unsaturated soil above, below, and in the clay layer exceed the proposed cleanup goal, and this clay layer and heterogeneities within the vadose zone soils may inhibit the ability of gaseous ozone to reach the contamination. Confirmatory sampling would be conducted to verify cleanup. Once compliance with groundwater standards is achieved, residual risk would be within an acceptable range.

Reduction of Toxicity, Mobility, and Volume Through Treatment

Contaminants in the vadose zone and in the groundwater would be destroyed through chemical oxidation producing innocuous substances such as carbon dioxide, water, and inorganic chloride. Short term water quality may be degraded by injection of permanganate. However, over time these conditions would be buffered by the groundwater. Once removed or destroyed, the reduction in mass of TCE is permanent.

Short-Term Effectiveness

During the execution of chemical oxidation, expected to occur in three injections conducted over a three year period, minimal risk would be posed to the local community and ecosystems. Treatment would occur in-situ. Minimal risk is posed to workers constructing the alternative and maintaining the

mechanical systems once in place. Care must be taken when handling oxidants, however, the periodic injections of the permanganate would pose minimal risk to the workers.

Implementability

The technologies employed in this alternative are well proven to have been technically feasible at similar sites. The geology and hydrogeology present several key challenges that may inhibit oxidant delivery. Services for drilling, ozone generation, and pressure injection are readily available. Techniques are well established to monitor the effectiveness of the alternative.

Cost

The primary capital costs associated with this alternative are treatability testing for ozone injection and installation of ISCO injection wells. Labor and materials for ozone and ISCO injections, including ozone generation, were included as O&M expenses as three ISCO injections were assumed over a period of three years. Additional O&M costs include performance monitoring, procurement, and project management. An additional consideration includes the potential decrease of operation of the GWTF as a result of source area remediation. It is estimated that following completion of source remediation (five years), the GWTF will continue to operate for approximately 10 additional years after completion of source remediation activities to remove residual contamination in the plume. Costs for this alternative are developed in Table 6-5 and are compared with other alternatives in Table 6-7.

State Acceptance

It is anticipated that the State regulatory agencies will accept this alternative.

Community Acceptance

There would be some short-term impacts on residences in the immediate vicinity of the Site during drilling of injection wells. Installation of the ozone and permanganate injection systems is not expected to cause much disruption. It is anticipated that the community will accept this alternative.

6.4.5 Alternative 4: In-Situ Thermal Treatment

This alternative involves the installation and operation of an in-situ thermal treatment system for destruction or removal of VOCs in both the unsaturated and saturated soils. Several technologies are available; however, this evaluation was based on use of either ERH or ISTD since these technologies have been shown to perform well at other sites with heterogeneous and low-permeability soils. Remediation of the Groveland Source Area using ERH would involve the installation of electrodes, installed from 6 feet to 45 feet below ground surface. A 2,000 kW power control unit would be used to

direct three-phase electrical power into the treatment area. Vapor recovery wells would be co-located with the electrodes to remove vapors to an above grade treatment system. It is assumed that VOCs would be removed from extracted vapors via carbon and that spent carbon would be regenerated off-site. To achieve the 77 µg/kg proposed cleanup level in vadose zone soil, approximately 36 electrodes and 36 recovery wells would be required [Thermal Remediation Services, Inc., 2005; Dajak, 2006]. Applying this in-situ technology for remediation of unsaturated soils using electrodes injection points would preclude the need for demolition of the main Valley building to access all contamination. The period of operation is estimated to be approximately five months to reduce contamination below 77 µg/kg TCE in soil; additional time, up to eight months, could be required to achieve MCLs in groundwater [Thermal Remediation Services, Inc., 2005]. Technology representatives for ERH have made guarantees that groundwater concentrations will not exceed MCLs; however, such guarantees increase the cost of the technology by 10 to 30 percent [Dajak, 2006].

Remediation using ISTD would involve the installation of ISTD heater wells, steam injection wells, and water and vapor extraction wells. To achieve the MCLs in groundwater, approximately 35 ISTD heater wells, 16 steam injection wells, and seven extraction wells would be required [TerraTherm, Inc., 2005]. A high-temperature resistant cap would be installed where necessary over the treatment area. A steam generator and electrical distribution gear would be used to provide the steam and electrical power to heat the wells. Vapors would be treated using a thermal oxidizer and a vacuum blower. Condensate produced from the operation of either system would be piped to and treated by the Groundwater Treatment Facility. Depending on the thermal treatment system used, between 4 and 25 gallons per minute of highly concentrated water would be sent to the GWTF, where contaminants would be destroyed by the existing UV oxidation system. GWTF operating costs could potentially increase in treating this additional flow, particularly if VOC concentrations are high in this influent

Overall Protection of Human Health and the Environment.

Through in-situ heating of saturated and unsaturated soils, contaminants will be removed via recovery wells, and vapors and condensate will be treated on-site. It is projected that this action will reduce the contaminant concentrations in groundwater over time. Overall, this alternative will provide a high degree of protection of human health and the environment.

Compliance with ARARs

Over time, the aquifer will achieve compliance with chemical specific ARARs for the chemicals of concern.

Long-Term Effectiveness and Permanence

This remedy is expected to provide an effective and permanent solution for soil in both the unsaturated and saturated zones. The complex hydrogeologic conditions beneath the Site may make it uncertain whether some areas within the saturated zone have been restored to appropriate standards; however, ERH could apply heat preferentially to zones of low permeability (i.e., silts and clays) where TCE was detected at highest concentrations. Monitoring will be required to confirm that proposed cleanup levels have been met. Once compliance with groundwater standards is achieved, residual risk would be within an acceptable range.

Reduction of Toxicity, Mobility, and Volume Through Treatment

TCE and other contaminants will be removed from the subsurface for treatment in the above grade vapor treatment system and the existing GWTF. Once removed, the reduction of VOCs is permanent.

Short-Term Effectiveness

Once installation is complete, minimal risk would be posed to workers monitoring the system. The ERH systems produce less than 15 volts of electricity at ground surface, which is below the OSHA standard for safe working voltages at ground surface of less than 50 volts. An inhalation risk may be posed to nearby residents if gas extraction wells do not function properly; periodic air monitoring would be performed to ensure that VOCs in air do not increase to hazardous concentrations as a result of thermal remediation.

Implementability

A number of case studies indicate that the thermal remediation technologies identified in this alternative have performed well at similar sites [TerraTherm, 2005; Dajak, 2006]. Utilities required by the technologies, including 3-phase, 480 volt power, water, and natural gas, are available at the Site. There are a limited number of vendors that provide the technologies.

Cost

The primary capital costs associated with this alternative are installation and implementation of the thermal treatment technology, including electrodes, electricity, and carbon [Dajak, 2006]. O&M costs include system operation, performance monitoring, confirmatory sampling, and project management. An additional consideration includes the potential decrease of operation of the GWTF as a result of source area remediation. It is estimated that following completion of source remediation (one year), the GWTF will continue to operate for approximately 10 additional years after completion of source remediation activities to remove residual contamination in the plume. Costs for this alternative are developed in Table 6-6 and are compared with other alternatives in Table 6-7.

State Acceptance

It is anticipated that the State regulatory agencies will accept this alternative.

Community Acceptance

There would be some short-term impacts on residences in the immediate vicinity of the Site during drilling for installation of electrodes. A community relations fact sheet and information session will likely be necessary to address concerns and respond to questions about the use of heat and, possibly, electrical voltage in the Source Area. However, it is expected that the community will accept this alternative since contaminants will be permanently removed.

6.5 Comparative Analysis

A comparison of the alternatives is presented in Table 6-8. All of the alternatives considered will result in permanent removal or destruction of TCE and other VOC contaminants; however, under Alternative 1B, contamination in unsaturated soil would be removed but not destroyed. With Alternatives 1A, 1B, and 2 demolition of the main Valley building would likely be required to access all contaminated soil Alternatives 1A, 1B, and 2; Alternatives 3 and 4 would apply only in-situ remedial technologies and would likely not require demolition. In the case of Alternative 2 (Enhanced Biodegradation), it is possible that vinyl chloride will accumulate under certain circumstances requiring further amendment additions to create chemical conditions that are favorable for complete destruction. There is also potential to mobilize certain metals, including arsenic, in some cases, above regulatory standards, due to the creation of a reducing and/or acidic environment. Injection of certain amendments used in Alternatives 1A, 1B, 2, and 3 create minor water quality changes that would be expected to dissipate over a short period of time with mixing with upgradient groundwater flowing into the Source Area.

Services and equipment needed for Alternatives 1A, 1B, and 3 are widely available, and the market is relatively competitive. The solutes required for Alternative 2 are also available although there are only a few suppliers of commercial proprietary electron donors and inoculants. Different media, such as soluble oils, molasses or lactate, are more widely available on the open market. Material and services for Alternative 4 are available to a lesser degree than the other alternatives.

The complexity of the soil matrix and hydrogeologic system presents challenges for Alternatives 1A, 1B, 2, and 3. The contamination distribution and hydrogeologic heterogeneities may have less effect on treatment in Alternative 4.

The estimated costs to implement the alternatives are presented in Table 6-7. The additional length of time estimated to operate the GWTF and continue MOM monitoring is also taken into account based on performance experience of the remediation technologies evaluated.

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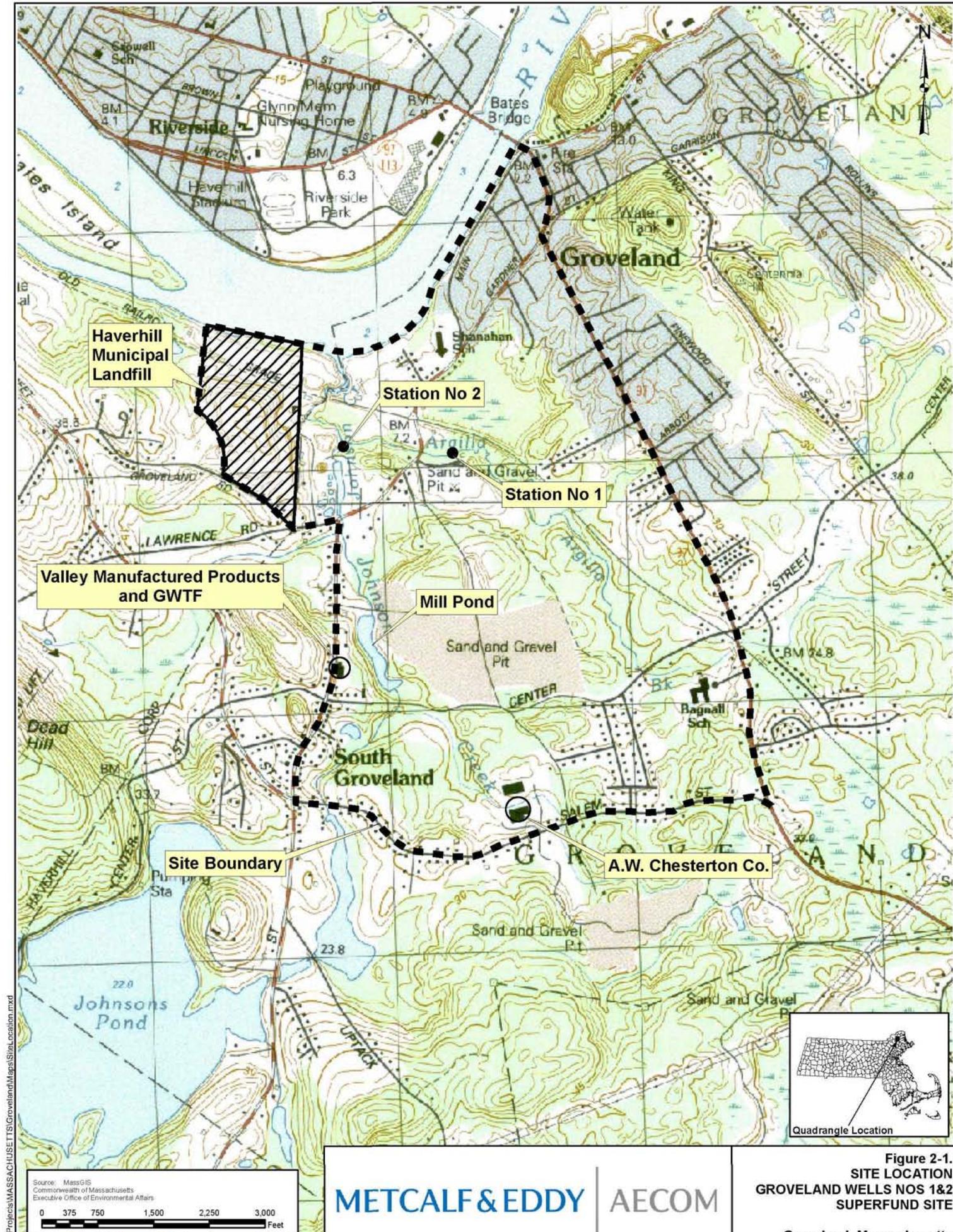
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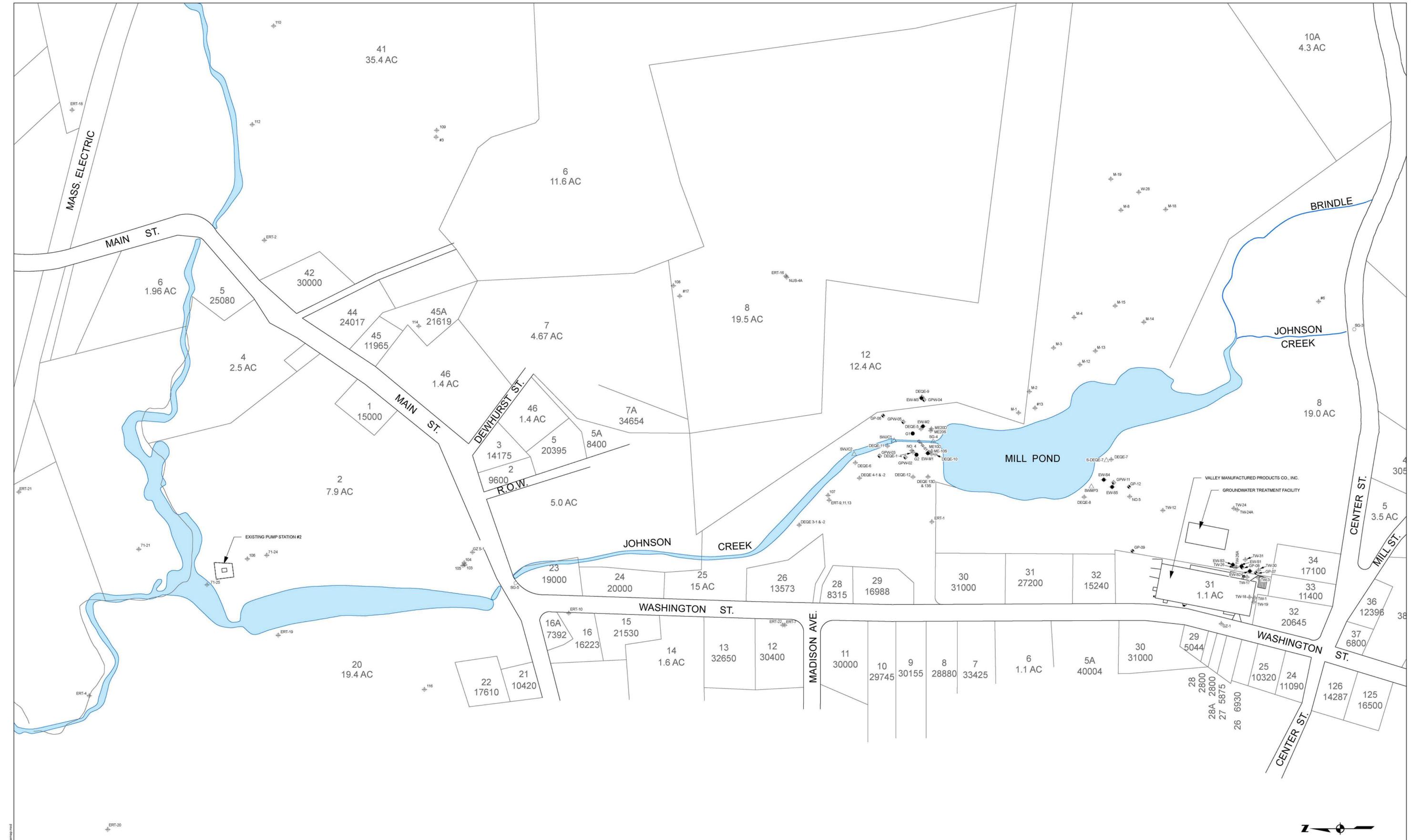
Source: MassGIS
Commonwealth of Massachusetts
Executive Office of Environmental Affairs

0 375 750 1,500 2,250 3,000
Feet

METCALF & EDDY | **AECOM**

Figure 2-1.
SITE LOCATION
GROVELAND WELLS NOS 1&2
SUPERFUND SITE
Groveland, Massachusetts





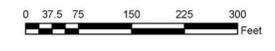
LEGEND

- EXISTING EXTRACTION WELL
- △ SURFACE WATER ELEVATION GAUGE
- ⊕ GROUNDWATER PROBE WELL
- ⊕ MONITORING WELL
- ⊕ GROUNDWATER PROBE LOCATION
- INACTIVE EXTRACTION WELL

NOTES:

1. BASE MAP WAS COMPILED FROM TOWN OF GROVELAND TAX MAPS. LOCATIONS OF PROPERTY LINES AND SURFACE WATER BOUNDARIES ARE APPROXIMATE. CHANGES THAT MAY HAVE OCCURRED SINCE 1994 ARE NOT INCLUDED.
2. EXTRACTION WELL EW-M2 IS CURRENTLY INACTIVE.

METCALF & EDDY | AECOM



SCALE: 1" = 120'

GROVELAND WELLS
SUPERFUND SITE
GROVELAND, MASSACHUSETTS

**FIGURE 2-2
SITE MAP**

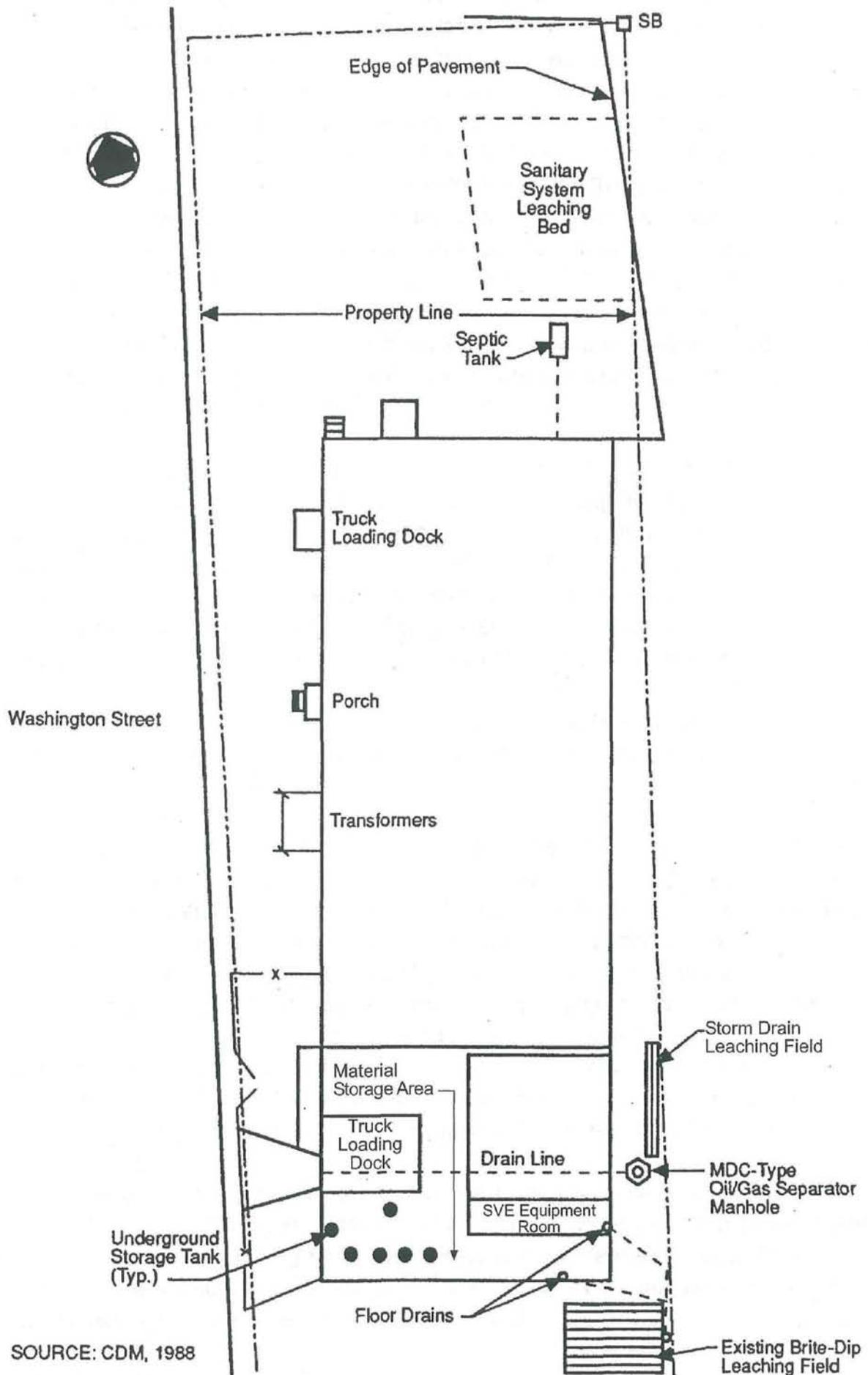
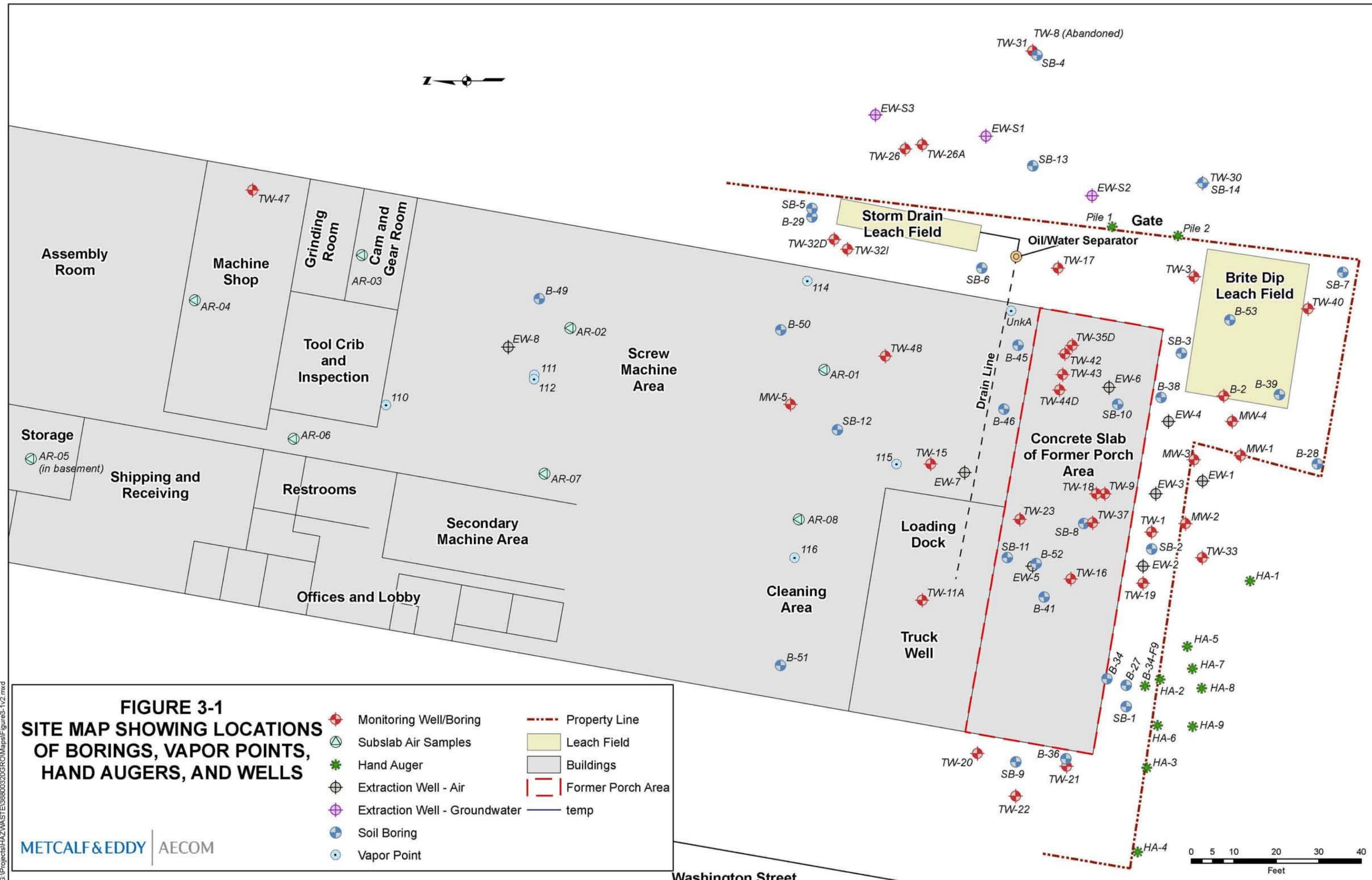


FIGURE 2-3. VALLEY PROPERTY, GROVELAND WELLS NOS. 1 & 2 SUPERFUND SITE, GROVELAND, MA



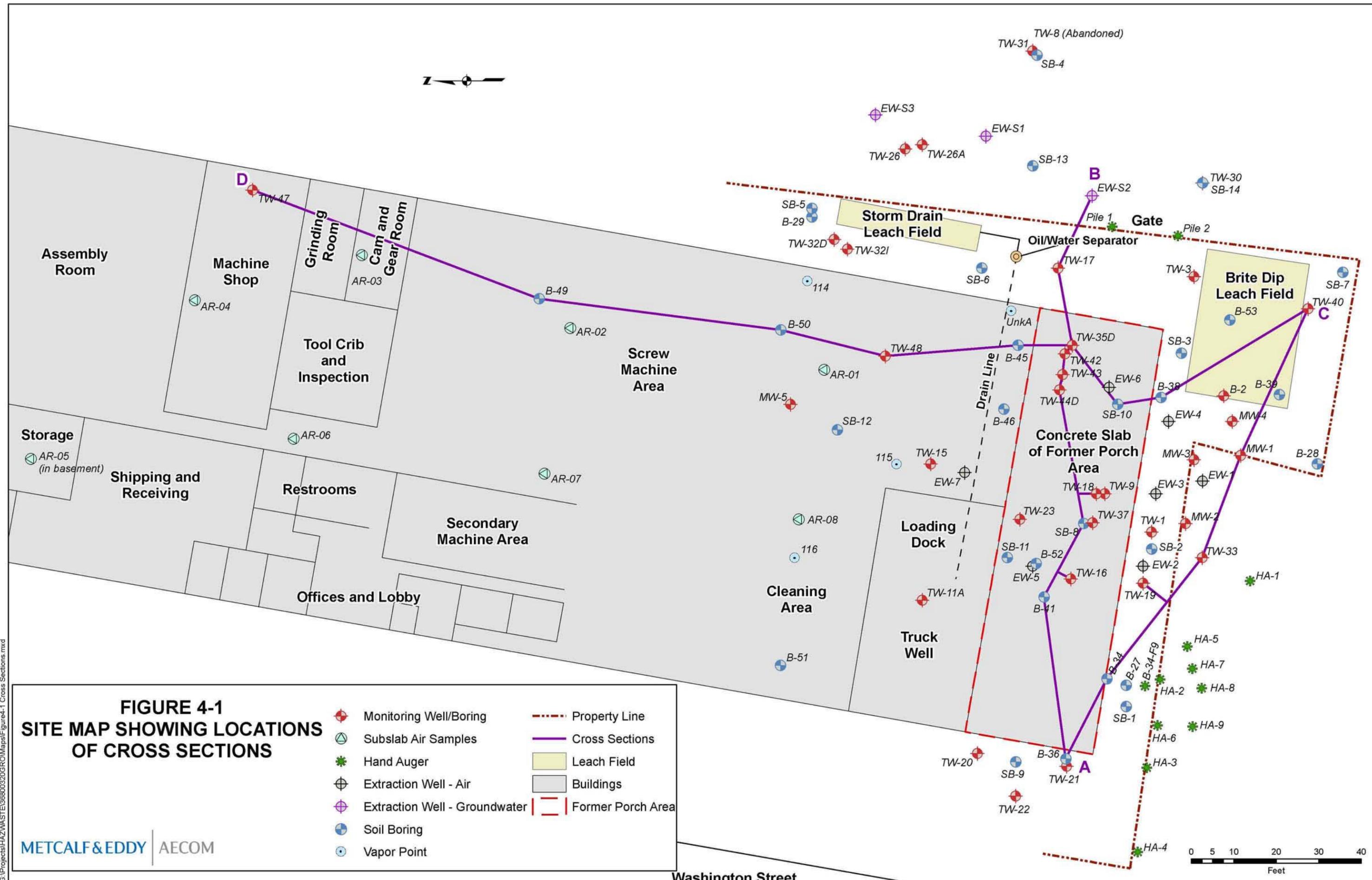
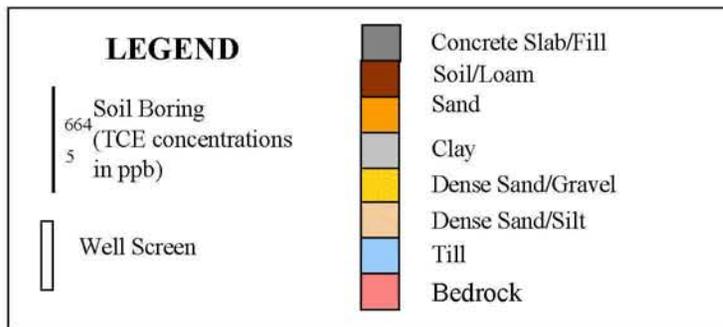
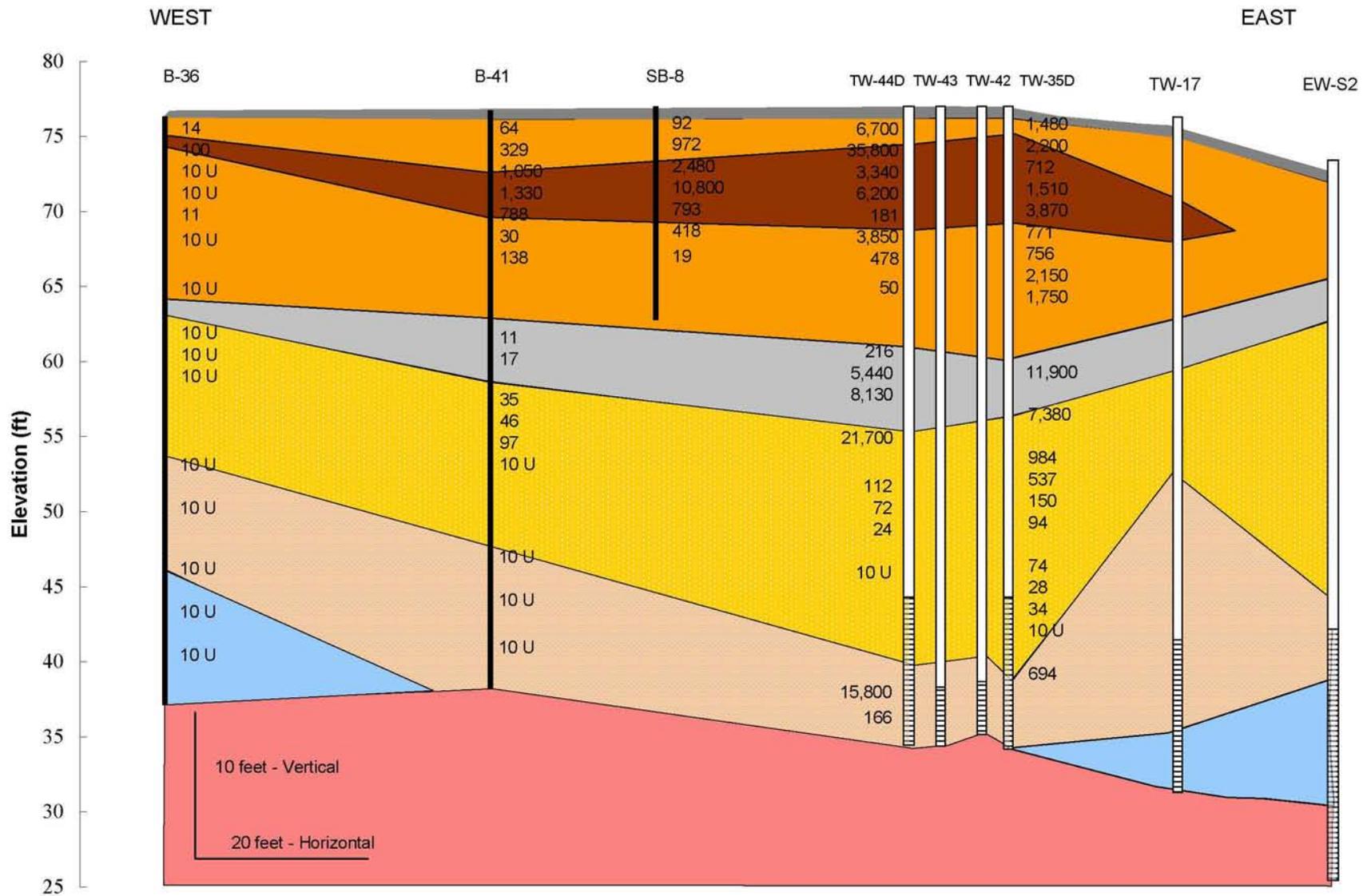


FIGURE 4-1
SITE MAP SHOWING LOCATIONS
OF CROSS SECTIONS

- | | | | |
|--|-------------------------------|--|-------------------|
| | Monitoring Well/Boring | | Property Line |
| | Subslab Air Samples | | Cross Sections |
| | Hand Auger | | Leach Field |
| | Extraction Well - Air | | Buildings |
| | Extraction Well - Groundwater | | Former Porch Area |
| | Soil Boring | | |
| | Vapor Point | | |

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**FIGURE 4-2. CROSS-SECTION A-B
TCE CONCENTRATIONS IN SOIL**

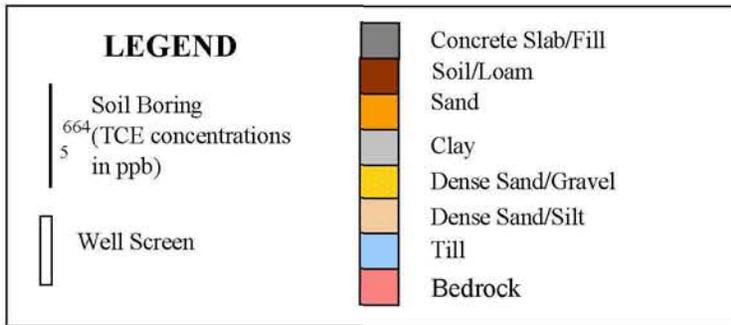
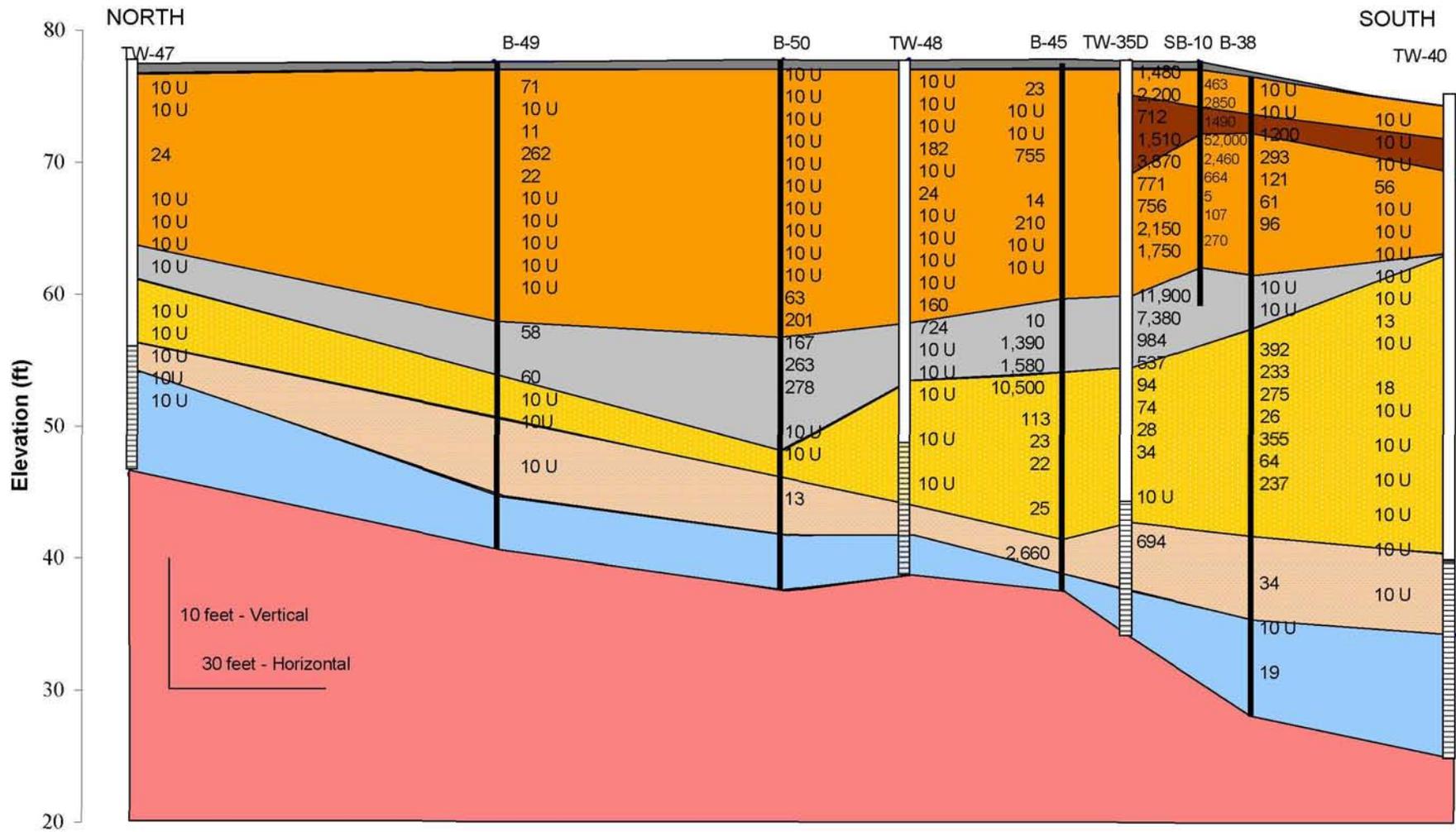
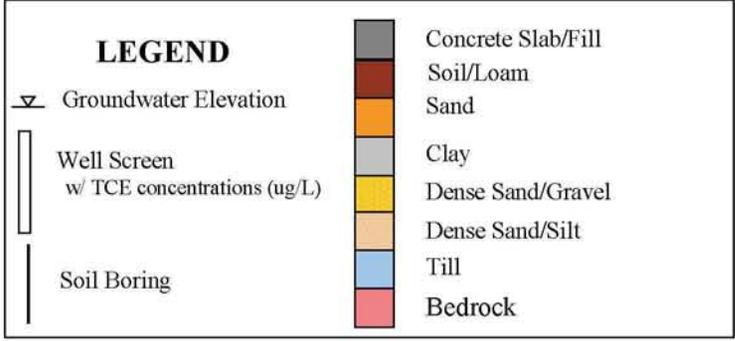
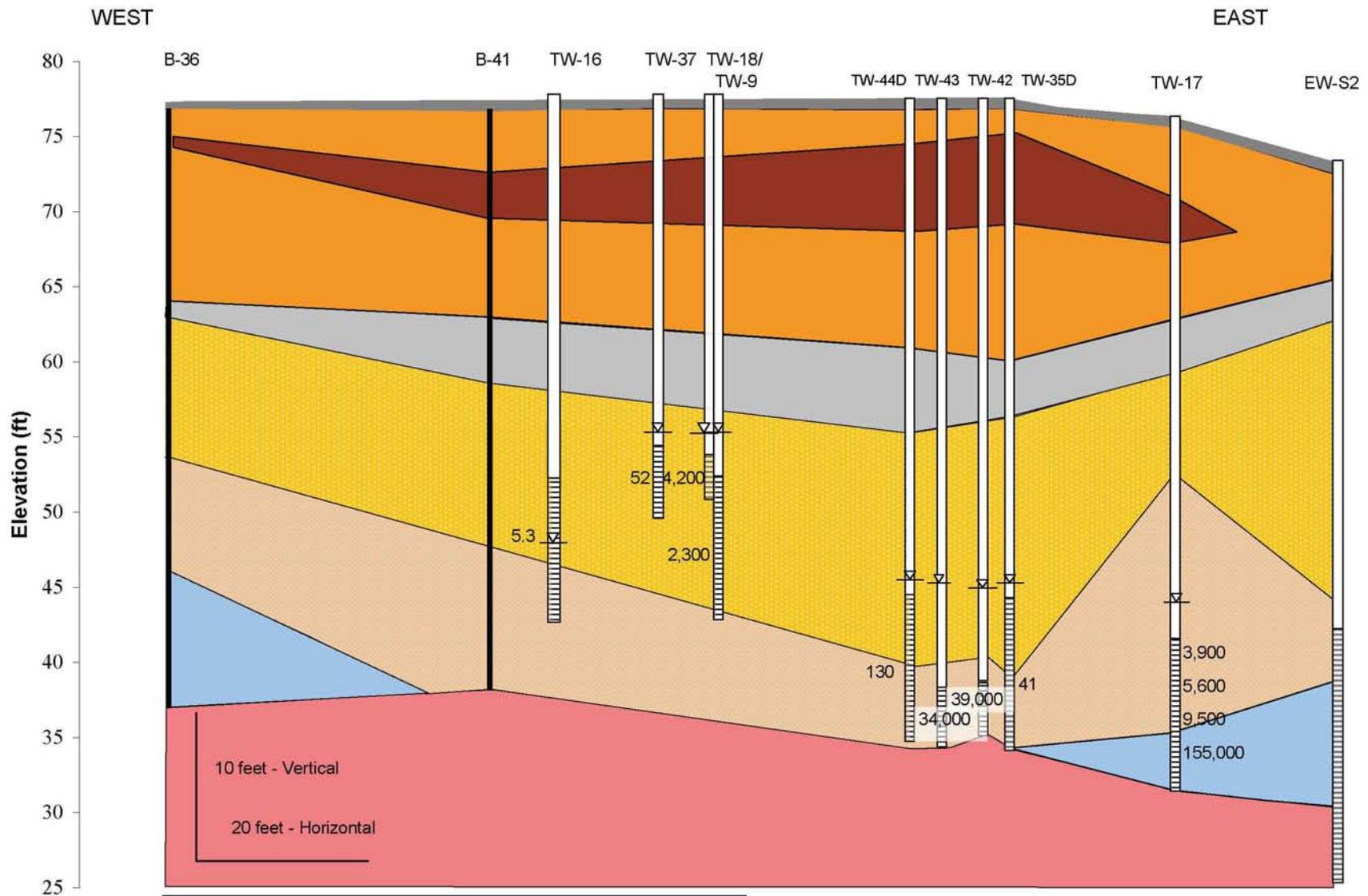
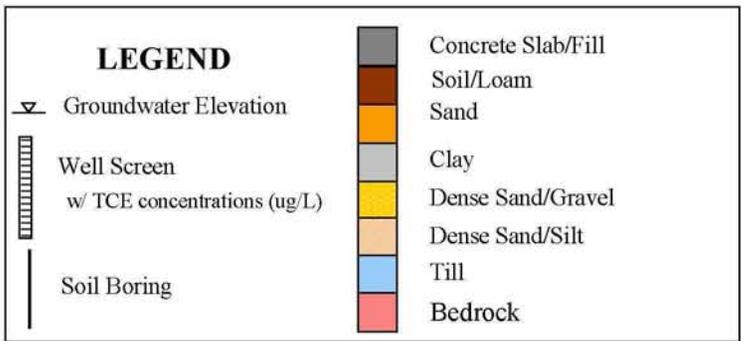
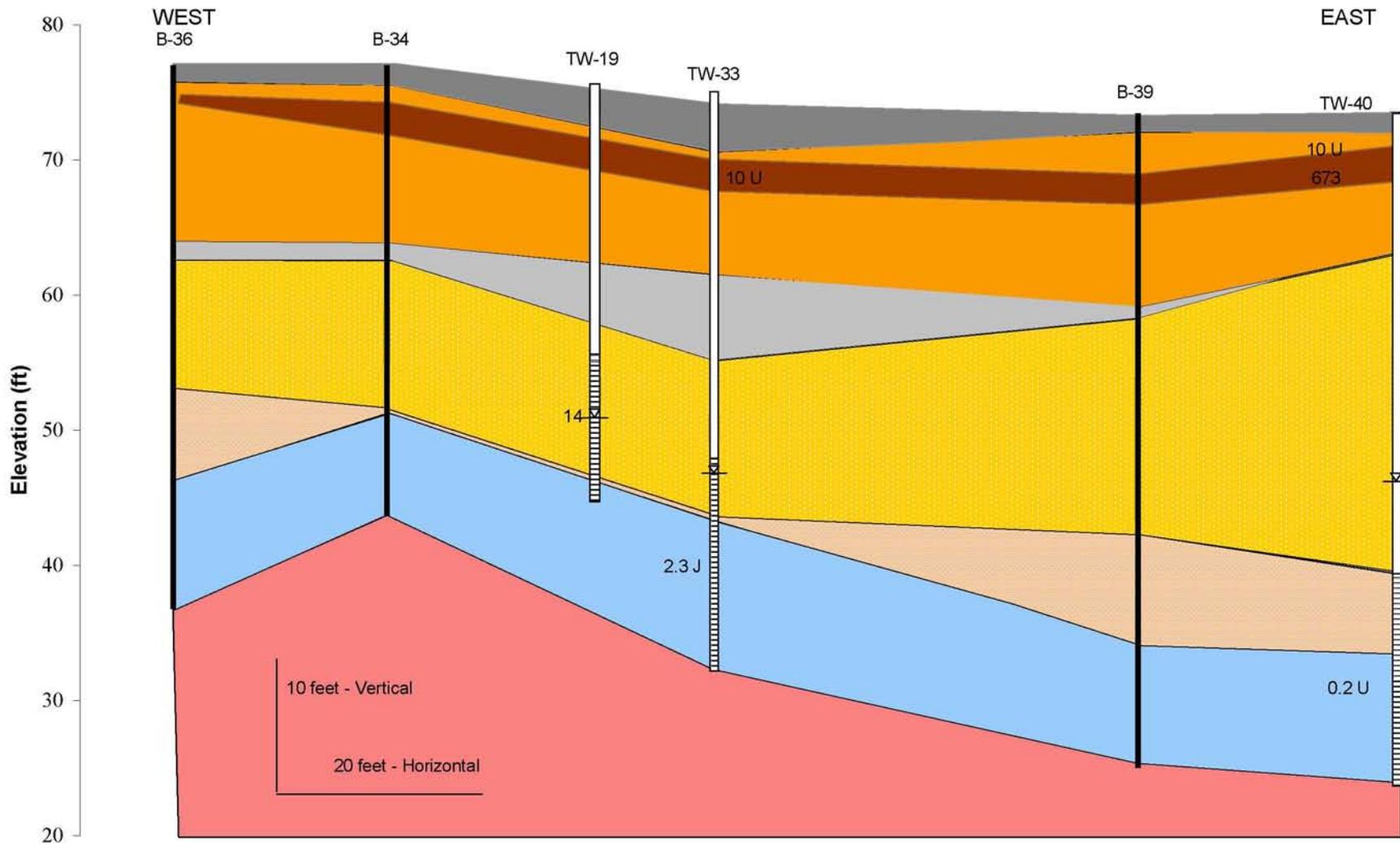


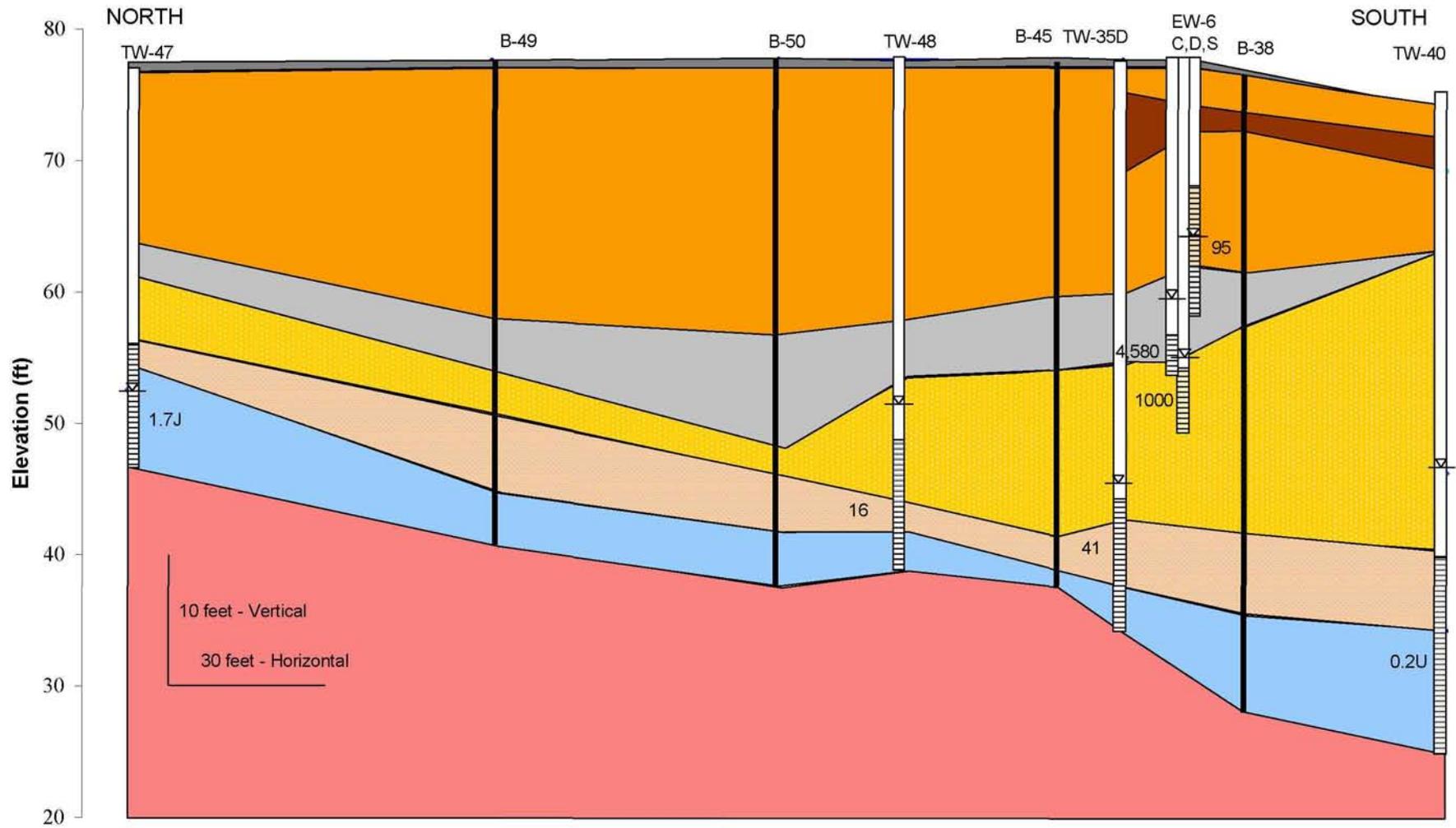
FIGURE 4-4. CROSS-SECTION D-C TCE CONCENTRATIONS IN SOIL



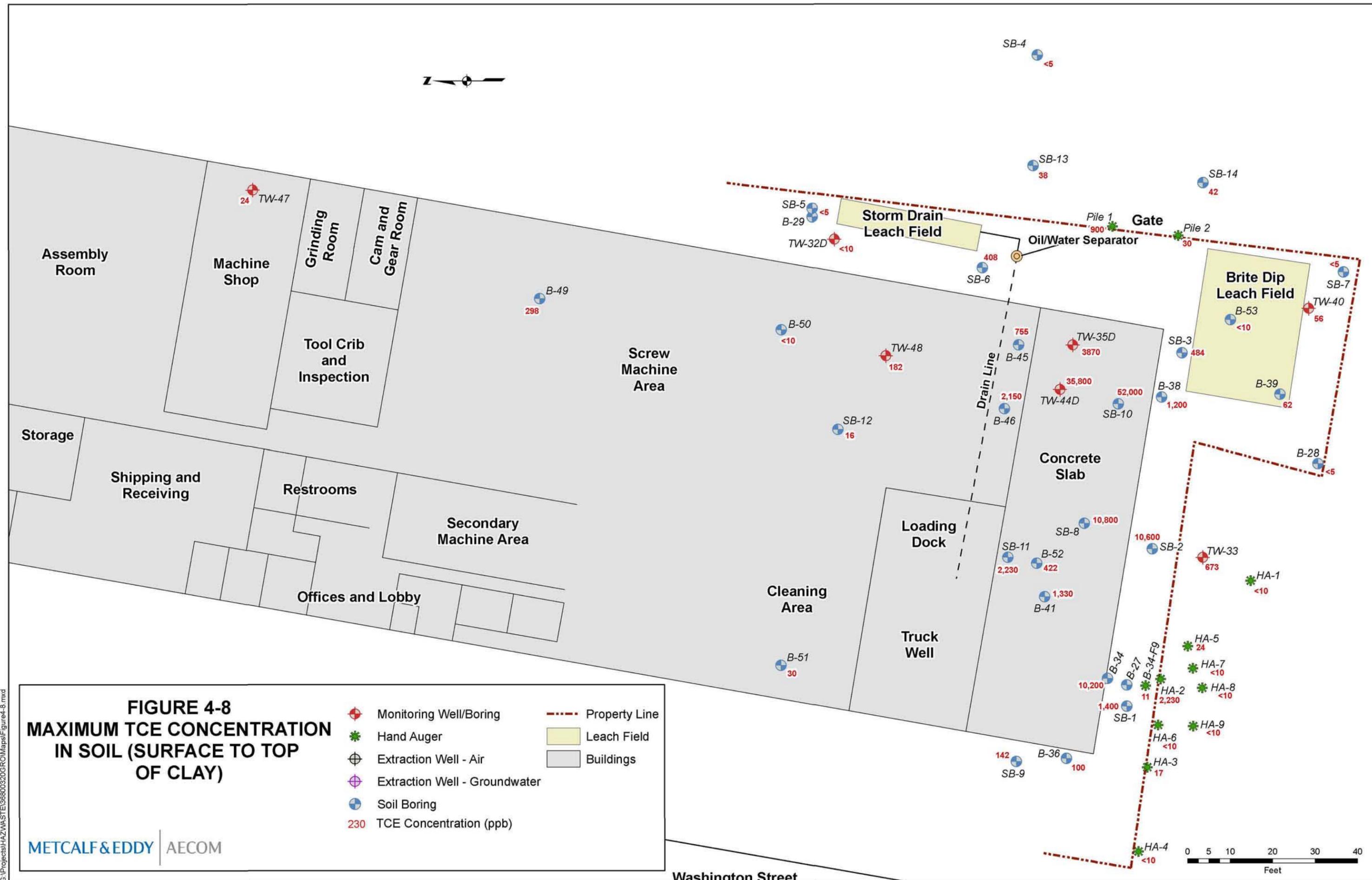
**FIGURE 4-5. CROSS-SECTION A-B
TCE CONCENTRATIONS IN GROUNDWATER**



**FIGURE 4-6. CROSS-SECTION A-C
TCE CONCENTRATIONS IN GROUNDWATER**



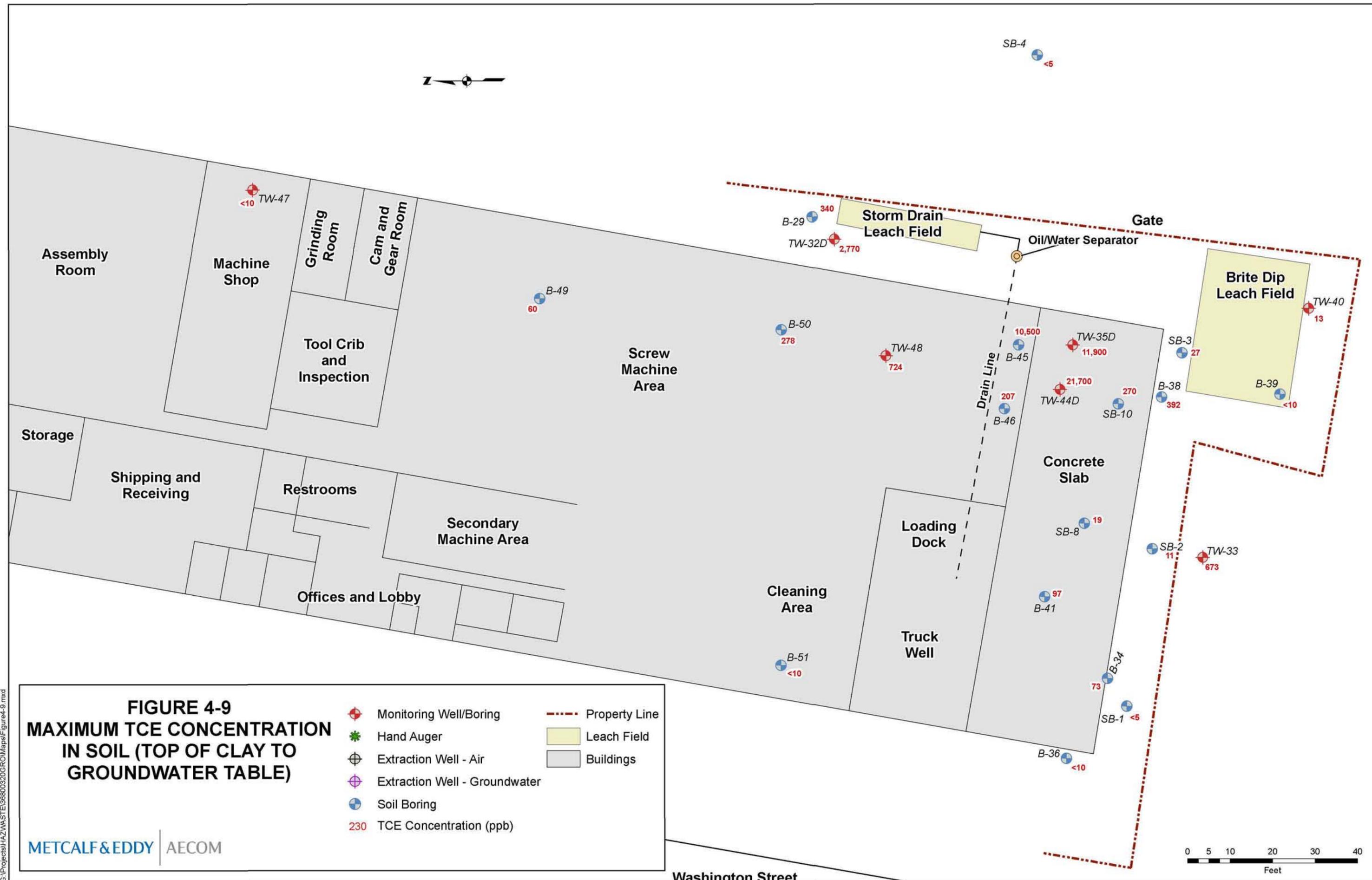
**FIGURE 4-7. CROSS-SECTION D-C
TCE CONCENTRATIONS IN GROUNDWATER**



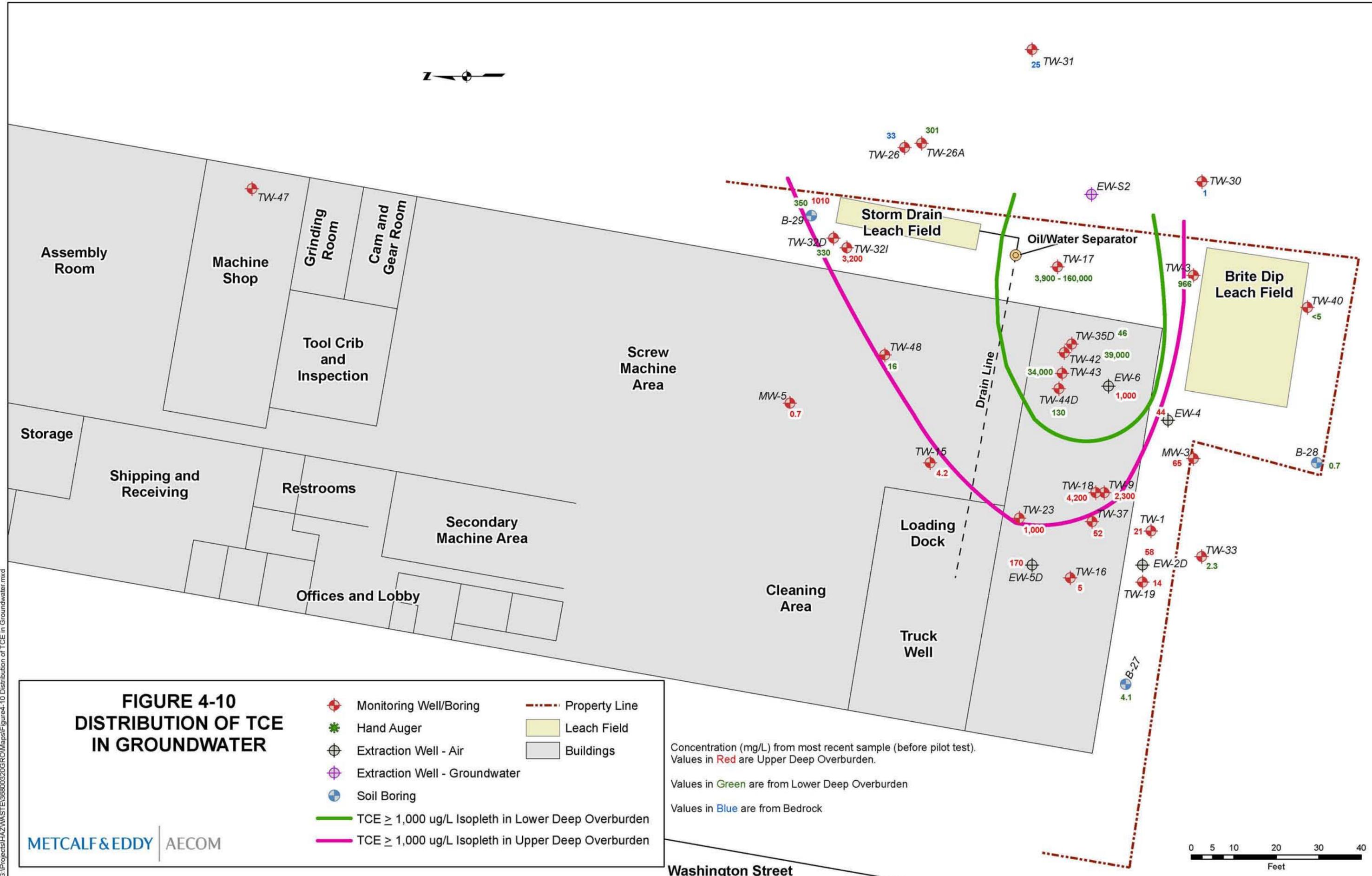
**FIGURE 4-8
MAXIMUM TCE CONCENTRATION
IN SOIL (SURFACE TO TOP
OF CLAY)**

- ⊕ Monitoring Well/Boring
- ⊕ Hand Auger
- ⊕ Extraction Well - Air
- ⊕ Extraction Well - Groundwater
- ⊕ Soil Boring
- 230 TCE Concentration (ppb)
- - - Property Line
- Leach Field
- Buildings

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**FIGURE 4-10
DISTRIBUTION OF TCE
IN GROUNDWATER**

- ◆ Monitoring Well/Boring
- ◆ Hand Auger
- ◆ Extraction Well - Air
- ◆ Extraction Well - Groundwater
- ◆ Soil Boring
- TCE ≥ 1,000 ug/L Isopleth in Lower Deep Overburden
- TCE ≥ 1,000 ug/L Isopleth in Upper Deep Overburden
- - - Property Line
- Leach Field
- Buildings

Concentration (mg/L) from most recent sample (before pilot test).
 Values in **Red** are Upper Deep Overburden.
 Values in **Green** are from Lower Deep Overburden
 Values in **Blue** are from Bedrock

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**FIGURE 4-11
GROUNDWATER CONTOUR MAP
LOWER DEEP OVERBURDEN
JULY 18-21, 2006**

+
 Monitoring Well/Boring
 Property Line

+
 Extraction Well - Air
 Groundwater Contours

+
 Extraction Well - Groundwater
 Leach Field
 Buildings

Numbers are elevation of water in well, in feet. Only elevations in boxes were used to draw contours.

G:\Projects\HAZ\WASTE\398800320\ROMaps\Figure4-11 Groundwater Contour Map.mxd

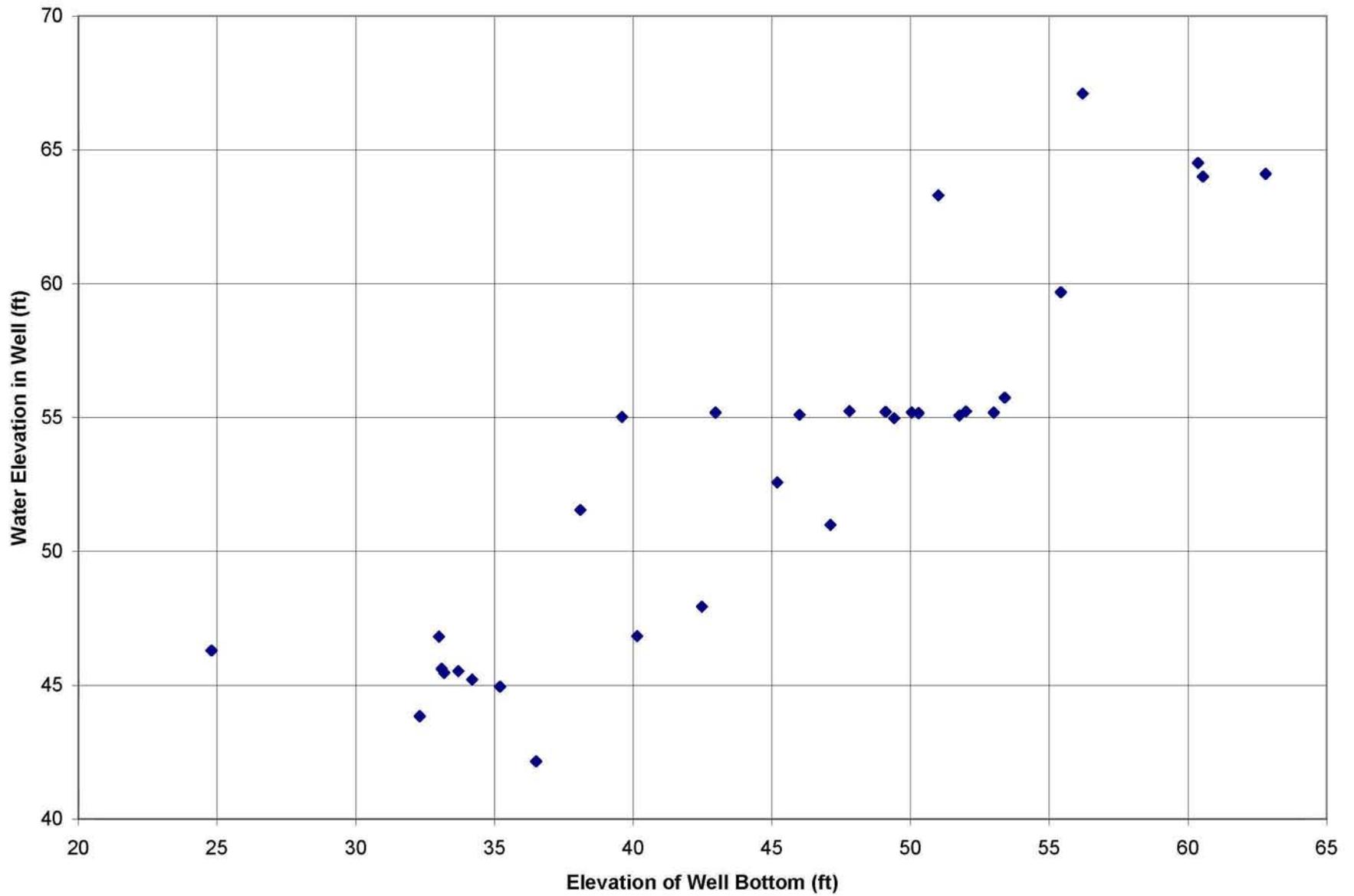
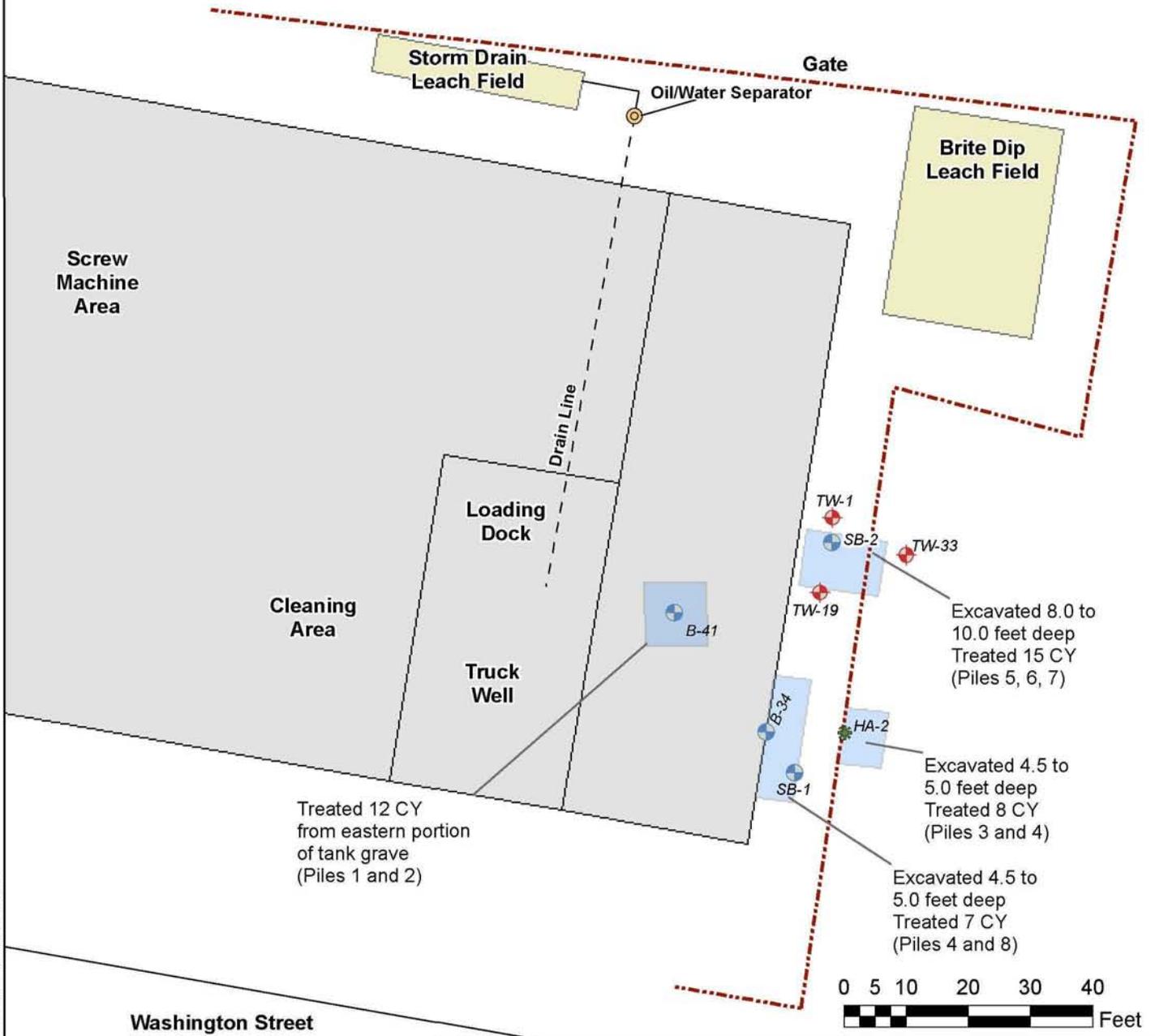


FIGURE 4-12. RELATIONSHIP BETWEEN WELL DEPTH AND PIEZOMETRIC HEAD



Eight piles of soil (5 CY each) treated in four roll-offs in the parking lot of the groundwater treatment plant.

Pile 1 and Pile 2 Dose = 6g/kg 180 lb KMnO ₄ per pile	Pile 3 and Pile 4 Dose = 3g/kg 90 lb KMnO ₄ per pile	Pile 5 and Pile 6 Dose = 5g/kg 150 lb KMnO ₄ per pile	Pile 7 and Pile 8 Dose = 2g/kg 60 lb KMnO ₄ per pile
--	---	--	---



**FIGURE 5-2
SUMMARY OF
PILOT TEST ACTIVITIES -
UNSATURATED SOIL**

- - - Property Line
- Leach Field
- Buildings
- Excavation Area
- ⊕ Monitoring Well/Boring
- ⊕ Soil Boring
- ✱ Hand Auger

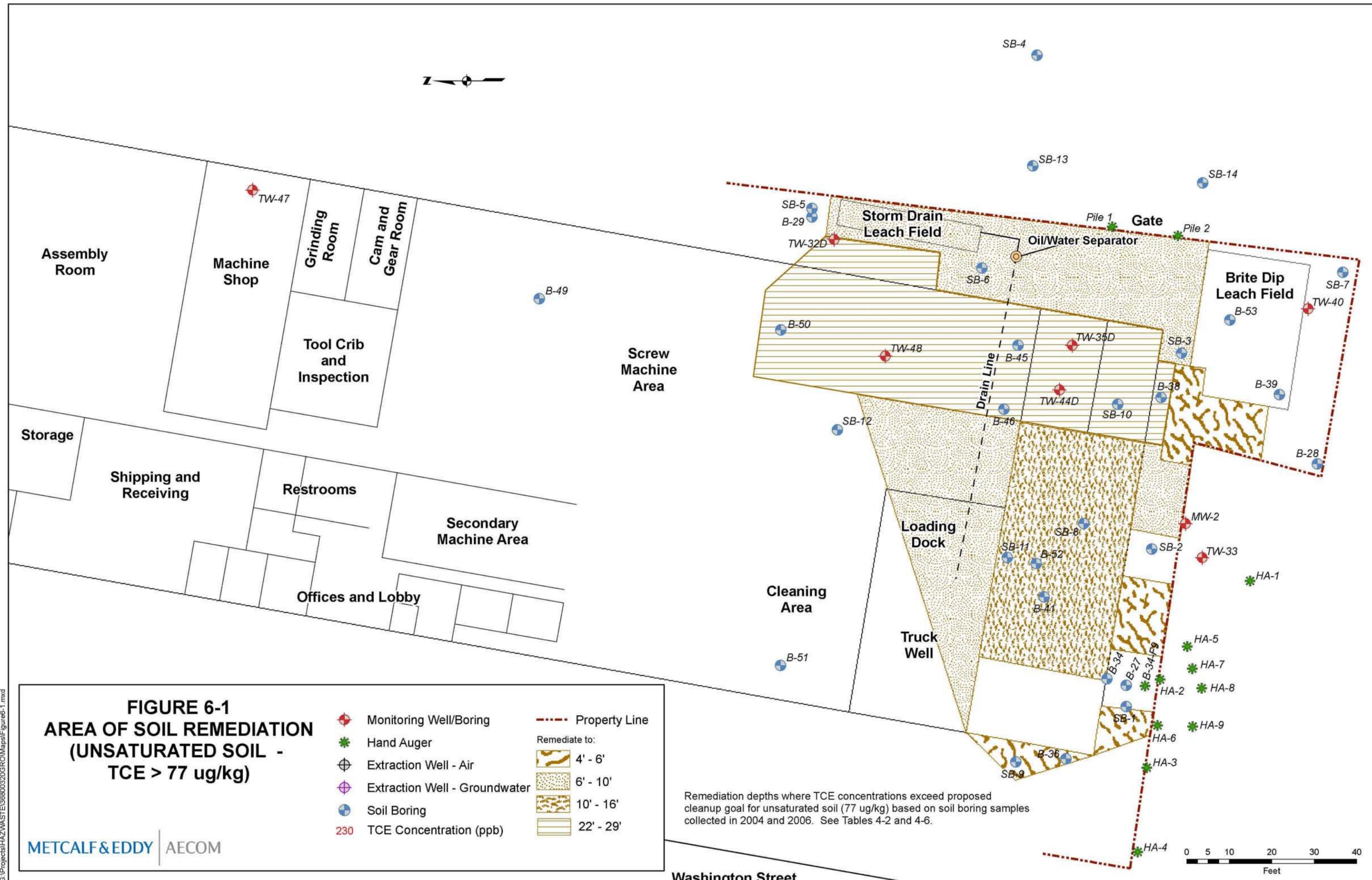


FIGURE 6-1
AREA OF SOIL REMEDIATION
(UNSATURATED SOIL -
TCE > 77 ug/kg)

- Monitoring Well/Boring
 - Hand Auger
 - Extraction Well - Air
 - Extraction Well - Groundwater
 - Soil Boring
 - 230** TCE Concentration (ppb)
 - Property Line
- Remediate to:
- 4' - 6'
 - 6' - 10'
 - 10' - 16'
 - 22' - 29'

Remediation depths where TCE concentrations exceed proposed cleanup goal for unsaturated soil (77 ug/kg) based on soil boring samples collected in 2004 and 2006. See Tables 4-2 and 4-6.

**Table 3-1
Field Sampling and Data Validation Summary
Groveland Wells Source Re-Evaluation**

Date	Event	Case / SDG	Analytical Program / Matrix / Analysis	Laboratory	No. Field Samples	MS/MSD	FDs	TB	PE	RB	Total Samples	Validation Tier	
July 2004	PID Survey	NA	Field Screening	NA	48	0	0	0	0	0	48	NA	All data are useable as field analytical results.
July / August 2004	Soil / Basin Sediment Field Screening	NA	OEME Mobile Lab / Soil / VOCs	OEME Mobile Lab	97	0	8	0	0	0	105	NA	All data are useable as field analytical results.
July / August 2004	Groundwater / Basin Aqueous Field Screening	NA	OEME Mobile Lab / Aqueous / VOCs	OEME Mobile Lab	33	0	2	0	0	0	35	NA	All data are useable as field analytical results.
October 2004	Passive Diffusion Bag Groundwater	NA	On-Site Sentex / Groundwater / VOCs	On-Site Sentex	23	0	1	1	0	0	25	NA	All data are useable as field analytical results.
July / August 2004	TOC in Groundwater	0244M / D05271	DAS / Groundwater / D-033.1 TOC	Southwest Research Institute, San Antonio, TX	6	1	1	0	0	0	8	NA	All data are useable as field analytical results.
May 2006	Sub-Slab Soil Gas	0274M / D07199	DAS / Soil Gas / D-152 VOCs	Air Toxics, Ltd. Folsom, CA	8	0	1	1	0	0	10	Tier II	All data are useable as qualified.
June / July 2006	Soil Field Screening (Standard and Indoor Drill Rigs)	NA	OEME Mobile Lab / Soil / VOCs	OEME Mobile Lab	297	0	15	8	0	9	329	NA	All data are useable as field analytical results.
June / July 2006	Groundwater / Aqueous Field Screening	NA	OEME Mobile Lab / Groundwater / VOCs	OEME Mobile Lab	23	0	0	6	0	0	29	NA	All data are useable as field analytical results.
June 2006	PCB Data	35396 / A2639	RAS / Soil / SOM01.1 PCBs	Datachem Laboratories, Inc. Salt Lake City, UT	1	1	1	0	1	1	5	Tier I	All data are useable for project objectives.
June 2006	Confirmation VOC soil and Residential HA-1 through HA-4	35396 / A2639	RAS / Soil / SOM01.1 PCBs	Datachem Laboratories, Inc., Salt Lake City, UT	10	1	1	3	1	0	16	Tier I	VOC samples were reported on a wet-weight basis. Results are lower than they would be if reported on a dry-weight basis.
June / July 2006	Residential Soil HA-5 through HA-9	35611 / A2924	RAS / Soil / SOM01.1 VOCs	Mitkem Corporation, Warwick, RI	13	1	1	1	1	1	17	Tier I	All data are useable for project objectives.
June / July 2006	TOC in Soil	0276M / D07231	OEME Fixed / Soil / USEPA Region I Standard Operating Procedure for the Determination of Total Organic Carbon EIA-MISTOC6.SOP	OEME Fixed Laboratory, Chelmsford, MA	19	1	1	0	0	0	21	Tier II	All are useable for project objectives as qualified.
July 2006	Pre-Injection Groundwater	35471 / A28D4	RAS / Groundwater / SOM01.1 VOCs	Mitkem Corporation, Warwick, RI	16	1	1	1	1	1	21	Tier I	If a Tier II validation were performed, some data may be qualified as estimated (J or UJ). There would be no rejected results if a Tier II validation were performed.
August 2006	Post-Injection Groundwater	35593 / A28F9	RAS / Groundwater / SOM01.1 VOCs	Mitkem Corporation, Warwick, RI	6	1	1	1	1	2	12	Tier I	If a Tier II validation were performed, some data may be qualified as estimated (J or UJ). In addition, if a Tier II validation were performed, results for acetone and 2-butanone in sample TW-42-Post would be rejected due to surrogate recovery issues.

**Table 3-2
Measurement Performance Criteria
Groveland Wells Source Re-Evaluation**

Event	Field Precision	Laboratory Precision	Field Accuracy	Laboratory Accuracy	Representativeness	Comparability	Sensitivity	Completeness
PID Survey: 2004	PID was calibrated with 100 ppm isobutylene. Initial and final calibrations were acceptable. No field duplicates collected due to nature of survey.	Not applicable. Not a laboratory analysis.	PID was calibrated with 100 ppm isobutylene. Initial and final calibrations were acceptable. No field duplicates collected due to nature of survey.	Not applicable. Not a laboratory analysis.	Seventeen extraction wells, sixteen monitoring points, and fifteen monitoring wells were screened using the PID. These points are located throughout the Source Area.	Due to the unique nature of the survey, there is no comparison to historical data. The PID survey results were consistent with soil and groundwater sample results collected during the 2004 M&E field investigation in that the highest PID readings generally corresponded to the highest concentrations of TCE in groundwater and soil.	Lowest detectable concentration (as ppm isobutylene) is 0.1 ppm.	Seventeen extraction wells, sixteen monitoring points, and fifteen monitoring wells were screened using the PID. These points are located throughout the Source Area. Data collection was 100% complete.
EPA Mobile Laboratory: 2004	Field duplicates were collected at a rate of 1 per 20 field samples. Field duplicate RPDs for groundwater (<30%) and soil (<50%) were met for all samples except SB-02-2.5. The RPDs for TCE, 1,1,1-TCA, and PCE in this sample were 84%, 100%, and 100%, respectively.	Results of replicate analyses were not reported by the EPA mobile laboratory.	Trip blanks were nondetect for VOCs. Samples were appropriately handled and preserved.	Laboratory QC samples, such as Laboratory Fortified Blanks, were not reported for the mobile laboratory.	A total of 105 soil samples, 33 groundwater samples, one aqueous sample from the MDC-type basin, and one sediment sample from the MDC-type basin were collected during field efforts. The majority of these samples were analyzed by the EPA mobile laboratory, providing areal and vertical coverage of the study area.	Data were reported in standard units, on a wet-weight basis.	Reporting Limits for the EPA mobile laboratory soil analyses were as follows: TCE (5 ppb), cis-1,2-DCE (3 ppb), and tetrachloroethene (2 ppb).	The fieldwork proposed was completed (100%). Data were obtained for all samples submitted.
EPA Fixed Laboratory: 2004	Selected samples were submitted to OEME fixed laboratory to confirm field results. Field duplicates were typically not submitted for these confirmation analyses.	The laboratory duplicate results for TOC and the MS/MSD met criteria.	Trip blanks were nondetect for VOCs. Samples were appropriately handled and preserved.	For the VOC analysis, the surrogates, MS/MSD, and LFB recoveries all met acceptance criteria.	Not applicable.	VOA data were reported in standard units, on a wet-weight basis. TOC data were reported on a dry-weight basis. TOC detection limits were elevated.	Detection limits were reported in the OEME data and were sufficiently low to meet project requirements.	The fieldwork proposed was completed (100%). Data were obtained for all samples submitted.
Sentex Unit: 2004	Field duplicates were collected at a rate of 1 per 20 field samples. The trip blank was nondetect for VOCs. Field duplicate RPDs for groundwater (<30%) were met.	Field duplicates were collected at a rate of 1 per 20 field samples. Field duplicate RPDs for groundwater (<30%) were met.	Trip blanks were nondetect for VOCs. Samples were appropriately handled and preserved.	Calibration check standards were analyzed throughout the analytical sequence. Recoveries were generally acceptable, within 70% -130%. Some recoveries were <70%, indicating a possible low bias.	Not applicable.	Data were reported in standard units.	Detection limits were not provided.	Of the seven wells selected for PDB installation, only six contained enough water to deploy the PDBs (86% deployment completion). All samples collected were analyzed and produced viable data (100% analysis completion).
DAS Laboratory (Southwest Research Institute): 2004	Field duplicates were collected at a rate of 1 per 20 field samples. An RPD of 107% was noted for the field duplicate, indicating poor field precision for this analysis.	Replicate analyses were performed on each sample until performance criteria were met.	Trip blanks are not applicable to this analysis. Samples were appropriately handled and preserved.	Recoveries for the MS, LCS, and LFB standards all met acceptance criteria. Recoveries for the instrument calibration check standards were acceptable.	Not applicable.	Data were reported in standard units.	The reported detection limit for TOC is 0.1 mg/L.	The fieldwork proposed was completed (100%). Data were obtained for all samples submitted.
EPA Mobile Laboratory: 2006	Field duplicates were collected at a rate of 1 per 20 field samples. Field duplicate RPDs for soil (<50%) were met for all samples except B-36-3.8 (TCE), TW-35D-2.5 (TCE, PCE, cis-1,2-DCE), and TW-44D-25.5 (TCE, TCA). Field duplicate RPDs for groundwater (<30%) were met.	Results of replicate analyses were not reported by the EPA mobile laboratory.	Trip blanks were nondetect for VOCs. Samples were appropriately handled and preserved.	Laboratory QC samples, such as Laboratory Fortified Blanks, were not reported for the mobile laboratory.	A total of 297 soil samples and 23 groundwater samples were collected. The majority of these samples were analyzed by the EPA mobile laboratory, providing areal and vertical coverage of the study area.	Data were reported in standard units, on a wet-weight basis.	Reporting Limits for the EPA mobile laboratory soil analyses were as follows: TCE (10 ppb), cis-1,2-DCE (20 ppb), PCE (10 ppb), and 1,1,1-TCA (10 ppb). Reporting Limits for the EPA mobile laboratory soil analyses were as follows: TCE (0.2 ppb), cis-1,2-DCE (0.5 ppb), PCE (0.2 ppb), and 1,1,1-TCA (0.5 ppb).	The fieldwork proposed was completed (100%). Data were obtained for all samples submitted.
EPA Fixed Laboratory: 2006	Selected samples were submitted to OEME fixed laboratory to confirm field results. Product samples (oily material) was also submitted for identification.	The laboratory followed its Standard Operating Procedure.	Trip blanks were nondetect for VOCs. Samples were appropriately handled and preserved.	The laboratory followed its Standard Operating Procedure.	Not applicable.	VOA data were reported in standard units, on a wet-weight basis.	Detection limits were reported in the OEME data and were sufficiently low to meet project requirements.	The fieldwork proposed was completed (100%). Data were obtained for all samples submitted.
DAS Laboratory (Air Toxics for D-152)	Field duplicates were collected at a rate of 1 per 20 field samples. Air RPDs (<50%) were met.	Replicate analyses were performed on each sample until performance criteria were met.	A Trip Blank / Equipment Blank was collected. Samples were appropriately handled and preserved.	The laboratory failed to analyze LFBs spiked with the entire list of target VOCs at concentrations equal to the required quantitation limits. No validation action was taken as a result of this LFB nonconformance since the initial calibration contained a low level standard at the quantitation limit.	Not applicable.	Data were reported in standard units.	Reporting limits identified in the DAS Specification were met.	The fieldwork proposed was completed (100%). Data were obtained for all samples submitted.
RAS Laboratories (Datachem for VOCs and PCBs in soil Mitkem for Pre-and Post-Injection Groundwater): 2006	Field duplicates were collected at a rate of 1 per 20 field samples. Groundwater RPDs (<30%) were met for pre-injection groundwater, with the exception of cis-1,2-DCE in TW-9 (31%). Groundwater RPDs (<30%) were met for post-injection groundwater. Soil RPDs (<50%) were met for soil PCBs and for soil VOCs with the exception of the VOCs cis-1,2-DCE (67%) and TCE (87%).	Replicate analyses were performed on each sample until performance criteria were met.	Trip blanks for VOC analysis were collected. Samples were appropriately handled and preserved.	The laboratory performed the RAS Scope of Work appropriately. PE samples were submitted to assess laboratory accuracy.	Not applicable.	Data were reported in standard units.	Reporting limits identified in the RAS Scope of Work were met.	The fieldwork proposed was completed (100%). Data were obtained for all samples submitted.

Table 4-1
Photoionization Detector Survey: Conducted July 23, 2004
Groveland Wells Source Re-Evaluation

Location	PID Reading (ppm isobutulene)	Depth to Water from MP	Depth to Bottom from MP	Distance of MP to Ground	Condition / Notes
EXTRACTION WELLS					
EW-1S	0.0	ND	11.0	1.6	PVC.
EW-1D	0.0	ND	24.1	1.2	PVC.
EW-2S	0.0	ND	11.5	0.8	PVC.
EW-2D	0.0	22.69	23.5	1.1	PVC.
EW-3S	0.0	ND	7.4	1.2	PVC.
EW-3D	0.0	ND	22.8	1.2	PVC.
EW-4S	0.0	ND	5.3	0.9	PVC.
EW-4D	0.0	23.12	23.7	2.1	PVC.
EW-5S	0.0	17.30	20.5	3.3	PVC.
EW-5D	0.0	22.93	24.2	-0.2	PVC.
EW-6S	0.0	14.70	18.5	1.3	PVC.
EW-6C	84.3	21.05	24.7	2.6	PVC.
EW-6D	58.3	24.18	28.3	1.1	PVC.
EW-7S	0.0	--	--	--	PVC. Sealed, no depth measurements taken.
EW-7D	0.0	--	--	--	PVC. Sealed, no depth measurements taken.
EW-8S	0.0	--	--	--	PVC. Sealed, no depth measurements taken.
EW-8D	0.0	--	--	--	PVC. Sealed, no depth measurements taken.
VAPOR POINTS					
Unknown A	0.0	ND	8.8	--	0.5-inch steel pipe, higher of the two pipes.
Unknown A	0.0	ND	4.5	--	0.5-inch steel pipe, lower of the two pipes.
110	0.0	ND	6.5	--	0.5-inch steel pipe.
111	0.0	ND	5.7	--	0.5-inch steel pipe.
112	0.0	ND	--	--	0.5-inch steel pipe. Bent pipe, no accurate depth measurement.
114	0.0	ND	1.6	--	0.5-inch steel pipe.
115	0.0	ND	5.6	--	0.5-inch steel pipe.
116	0.0	ND	2.0	--	0.5-inch steel pipe.
B2	0.0	ND	10.6	0.7	PVC.
MW-1S	0.0	ND	9.9	0.9	PVC.
MW-1D	0.0	ND	25.0	0.4	PVC.
MW-2S	0.0	ND	11.0	0.3	PVC.
MW-2D	0.0	ND	22.6	0.3	PVC.
MW-3	0.0	21.94	24.6	0.7	PVC.
MW-4S	0.0	ND	10.5	0.3	PVC.
MW-4D	0.0	ND	24.9	0.3	PVC.

**Table 4-1
Photoionization Detector Survey: Conducted July 23, 2004
Groveland Wells Source Re-Evaluation**

Location	PID Reading (ppm isobutulene)	Depth to Water from MP	Depth to Bottom from MP	Distance of MP to Ground	Condition / Notes
MONITORING WELLS					
TW-1	0.0	33.87	40.0	3.5	Steel outer case - locked. No cap on inner PVC case.
TW-3	0.0	33.95	44.3	3.0	Steel outer case - locked. No cap on inner PVC case.
MW-5D	0.0	13.65	27 +/-	-0.3	Oil on water level tape and bailer. Possible cutting oil, sweet smell.
MW-5S	0.0	Not Recorded	20.2	-0.1	Steel Road-Box, not locked. No inner PVC cap.
TW-9	2.3	23.00	34.5	-0.1	Steel Road-Box, not locked. No cap on PVC inner case.
TW-11A	--	--	--	--	Under water, not screened.
TW-15	0.0	26.74	31.7	-0.1	Steel Road-Box, not locked. No cap on inner PVC case.
TW-16	0.0	30.01	35.0	-0.1	Steel Road-Box, not locked. No cap on inner PVC case.
TW-17	0.0	37.14	46.7	2.6	Steel case - locked. No cap on inner PVC case.
TW-18	0.0	23.08	27.5	-0.1	Steel Road-Box, not locked. No inner PVC cap.
TW-19	0.0	27.78	31.0	1.4	No inner cap, outer cap not locked, but lockable. M&E locked after survey.
TW-20	0.0	ND	20.3	-0.2	Steel Road-Box, not locked. No inner PVC cap.
TW-21	0.0	ND	17.6	-0.1	Steel Road-Box, not locked. No inner PVC cap.
TW-22	0.0	ND	16.9	-0.1	Steel Road-Box, not locked. No inner PVC cap.
TW-23	0.0	23.24	28.3	-0.1	Steel Road-Box, not locked. No inner PVC cap.

ppm = parts per million
PVC = poly vinyl chloride
MP = Measuring Point

Table 4-2
USEPA Mobile Laboratory Field Analytical Results - July and August 2004
Groveland Wells Source Re-Evaluation

Location	Matrix	Analysis Date	Trichlorethene (ug/kg)	1,1,1-Trichlorethane (ug/kg)	Tetrachlorethene (ug/kg)	cis-1,2-Dichloroethene (ug/kg)	Comments
Basin-AQ	AQ	7/27/2004	2.7	0.1 U	0.1 U	3.0	Aqueous sample from MDC-type basin east of porch area.
Basin-Sediment	SO	7/28/2004	9	2 U	2		Sediment sample from MDC-type basin east of porch area.
Groundwater Samples							
EW-2D-PRE	AQ	7/27/2004	12	0.5 U	0.5 U	4.3	Collected before purging well.
EW-2D-POST	AQ	7/27/2004	13	0.5 U	0.5 U	4.3	Collected after purging well.
EW-4D-PRE	AQ	7/27/2004	61	2 U	10	43	Collected before purging well.
EW-4D-POST	AQ	7/27/2004	68	2 U	13	45	Collected after purging well.
EW-6S-PRE	AQ	7/27/2004	107	2 U	4.9	55	Collected before purging well.
EW-6S-POST	AQ	7/27/2004	82	2 U	4.4	50	Collected after purging well.
EW-6C-PRE	AQ	7/27/2004	15,100	200 U	136	3,960	Collected before purging well.
EW-6C-POST	AQ	7/27/2004	15,100	200 U	110	4,460	Collected after purging well.
EW-6D-PRE	AQ	7/27/2004	5100	200 U	200 U	2,000 U	Collected before purging well.
EW-6D-POST	AQ	7/27/2004	1680	200 U	200 U	2,000 U	Collected after purging well.
MW-3-PRE	AQ	7/27/2004	48	2 U	6.0	138	Collected before purging well.
MW-3-POST	AQ	7/27/2004	65	2 U	6.0	117	Collected after purging well.
MW-3-DL-POST	AQ	7/27/2004	64	2 U	7.1	121	Field Duplicate of MW-3-POST
MW5D-PRE	AQ	7/27/2004	16	1.5 U	1.5 U		Collected before purging well.
SB-02-GW	AQ	7/27/2004	111	0.7 U	0.9 U		Water sample collected from boring SB-2
SB-03-GW	AQ	7/27/2004	59	3.8	0.9 U		Water sample collected from boring SB-3
SB-06-GW	AQ	7/27/2004	26	41	16		Water sample collected from boring SB-6
TW-16-PRE	AQ	7/27/2004	7.1	2.0 U	2.0 U	15	Collected before purging well.
TW-16-POST	AQ	7/27/2004	8.1	2 U	2.0 U	15	Collected after purging well.
TW-18-PRE	AQ	7/30/2004	4,280	100 U	100 U	1,650	Collected before purging well.
TW-18-POST	AQ	7/30/2004	4,420	100 U	100 U	1,370	Collected after purging well.
TW-19-PRE	AQ	7/27/2004	22	0.5 U	0.5 U	3.4	Collected before purging well.
TW-19-POST	AQ	7/27/2004	19	0.5 U	0.5 U	3.4	Collected after purging well.
TW-23-PRE	AQ	7/30/2004	5,040	100 U	100 U	2,600	Collected before purging well.
TW-23-POST	AQ	7/30/2004	1,400	100 U	100 U	910	Collected after purging well.
TW-27-43	AQ	8/4/2004	4.1	0.1 U	0.2 U	1.0 U	Water sample collected from TW-27 (end of boring, 43')
TW-28-37	AQ	8/4/2004	0.7	0.3	0.1 U	1.0 U	Water sample collected from TW-28 (during boring advancement, 37')
TW-28-42.5	AQ	8/4/2004	2.1	0.3	0.8	1.0 U	Water sample collected from TW-28 (end of boring, 42.5')
TW-28-DL-37	AQ	8/4/2004	0.8	0.3	0.1 U	1.0 U	Field Duplicate of TW-28-37
TW-29-25	AQ	8/4/2004	1,010	2 U	2 U	580	Water sample collected from TW-29 (during boring advancement, 25')
TW-29-38	AQ	8/4/2004	350	2 U	2 U	215	Water sample collected from TW-29 (end of boring, 38')
TW-9 PRE	AQ	7/27/2004	455	15 U	8 U	286	Collected before purging well.
TW-9-DL-POST	AQ	7/27/2004	817	15 U	8 U	450	Field Duplicate of TW-9-Post
TW-9-POST	AQ	7/27/2004	870	15 U	8 U	461	Collected after purging well.
Soil Samples							
SB-01-4.0	SO	7/26/2004	1,400	20	3		Soil sample from SB-01, 4.0' bgs
SB-01-8.0	SO	7/26/2004	6	2 U	2 U		Soil sample from SB-001, 8.0' bgs
SB-01-10.6	SO	7/26/2004	5 U	2 U	3		Soil sample from SB-001, 10.6' bgs
SB-01-11.7	SO	7/26/2004	5 U	2 U	7		Soil sample from SB-01, 11.7' bgs
SB-01-15.5	SO	7/26/2004	5 U	2 U	4		Soil sample from SB-01, 15.5' bgs
SB-01-18.0	SO	7/26/2004	5 U	2 U	2 U		Soil sample from SB-01, 18.0' bgs
SB-02-2.5	SO	7/26/2004	296	24	12		Soil sample from SB-02, 2.5' bgs
SB-02D-2.5	SO	7/26/2004	120	8	4		Field Duplicate of SB-02-2.5
SB-02-6.3	SO	7/26/2004	10,600	25	14		Soil sample from SB-02, 6.3' bgs
SB-02-7.5	SO	7/26/2004	559	10 U	10 U		Soil sample from SB-02, 7.5' bgs
SB-02-11.7	SO	7/26/2004	217	10	11		Soil sample from SB-02, 11.7' bgs
SB-02-13.6	SO	7/26/2004	5	2 U	2 U		Soil sample from SB-02, 13.6' bgs
SB-02-15.8	SO	7/26/2004	11	2 U	2 U		Soil sample from SB-02, 15.8' bgs
SB-02-16.7	SO	7/26/2004	5 U	2 U	2 U		Soil sample from SB-02, 16.7' bgs

Table 4-2
USEPA Mobile Laboratory Field Analytical Results - July and August 2004
Groveland Wells Source Re-Evaluation

Location	Matrix	Analysis Date	Trichlorethene (ug/kg)	1,1,1- Trichlorethane (ug/kg)	Tetrachlorethene (ug/kg)	cis-1,2- Dichloroethene (ug/kg)	Comments
Soil Samples (continued)							
SB-03-2.6	SO	7/26/2004	484	10 U	16		Soil sample from SB-03, 2.6' bgs
SB-03-5.8	SO	7/26/2004	122	2 U	9		Soil sample from SB-03, 5.8' bgs
SB-03-9.5	SO	7/26/2004	122	2 U	48		Soil sample from SB-03, 9.5' bgs
SB-03-12.4	SO	7/26/2004	142	2 U	54		Soil sample from SB-03, 12.4' bgs
SB-03-14.7	SO	7/26/2004	27	2 U	59		Soil sample from SB-03, 14.7' bgs
SB-04-1.7	SO	7/26/2004	5 U	2 U	2 U		Soil sample from SB-04, 1.7' bgs
SB-04-5.1	SO	7/26/2004	5 U	2 U	2 U		Soil sample from SB-04, 5.1' bgs
SB-04-6.8	SO	7/26/2004	5 U	2 U	2 U		Soil sample from SB-04, 6.8' bgs
SB-04-9.5	SO	7/26/2004	5 U	2 U	2 U		Soil sample from SB-04, 9.5' bgs
SB-04-12.5	SO	7/26/2004	5 U	2 U	2 U		Soil sample from SB-04, 12.5' bgs
SB-04-14.7	SO	7/26/2004	5 U	2 U	2 U		Soil sample from SB-04, 14.7' bgs
SB-05-1.6	SO	7/27/2004	5 U	2 U	2 U		Soil sample from SB-05, 1.6' bgs
SB-05-5.0	SO	7/27/2004	5 U	2 U	14		Soil sample from SB-05, 5.0' bgs
SB-05-6.5	SO	7/27/2004	5 U	2 U	2 U		Soil sample from SB-05, 6.5' bgs
SB-05-7.8	SO	7/27/2004	5 U	2 U	2 U		Soil sample from SB-05, 7.8' bgs
SB-05-8.3	SO	7/27/2004	5 U	2 U	2 U		Soil sample from SB-05, 8.3' bgs
SB-05-10.5	SO	7/27/2004	5 U	2 U	2 U		Soil sample from SB-05, 12.7' bgs
SB-05-12.7	SO	7/27/2004	5 U	2 U	2 U		Soil sample from SB-06, 6.0' bgs
SB-06-6.0	SO	7/27/2004	408	9	55		Soil sample from SB-06, 6.0' bgs
SB-06-7.6	SO	7/27/2004	36	3 U	5		Soil sample from SB-06, 7.6' bgs
SB-06-9.0	SO	7/27/2004	13	3 U	3 U		Soil sample from SB-06, 9.0' bgs
SB-06-10.7	SO	7/27/2004	5 U	3 U	3 U		Soil sample from SB-06, 10.7' bgs
SB-06-11.1	SO	7/27/2004	66	4	97		Soil sample from SB-06, 11.1' bgs
SB-06-12.3	SO	7/27/2004	5 U	3	4		Soil sample from SB-06, 12.3' bgs
SB-06-13.2	SO	7/27/2004	21	14	3 U		Soil sample from SB-06, 13.21' bgs
SB-06-DL-13.2	SO	7/27/2004	27	15	2		Field Duplicate of SB-06-13.2
SB-07-4.0	SO	7/27/2004	5 U	3 U	2 U		Soil sample from SB-07, 4.0' bgs
SB-07-6.0	SO	7/27/2004	21	14	3 U		Soil sample from SB-07, 6.0' bgs
SB-07-8.0	SO	7/27/2004	5 U	3 U	2 U		Soil sample from SB-07, 8.0' bgs
SB-07-DL-8.0	SO	7/27/2004	5 U	3 U	2 U		Field Duplicate of SB-07-8.0
SB-07-10.6	SO	7/27/2004	5 U	3 U	2 U		Soil sample from SB-07, 10.6' bgs
SB-07-12.5	SO	7/27/2004	5 U	3 U	2 U		Soil sample from SB-07, 12.5' bgs
SB-07-14.8	SO	7/27/2004	5 U	3 U	2 U		Soil sample from SB-07, 14.8' bgs
SB-08-3.4	SO	7/27/2004	92	3 U	12		Soil sample from SB-08, 3.4' bgs
SB-08-4.9	SO	7/27/2004	972	3	112		Soil sample from SB-08, 4.9' bgs
SB-08-6.9	SO	7/27/2004	2,480	3	324		Soil sample from SB-08, 6.9' bgs
SB-08-DL-6.9	SO	7/27/2004	2,100	3	257		Field Duplicate of SB-08-6.9
SB-08-7.8	SO	8/4/2004	10,800	120 U	1,210		Soil sample from SB-08, 7.8' bgs
SB-08-9.0	SO	8/4/2004	203	3 U	31		Soil sample from SB-08, 9.0' bgs
SB-08-DL-9.0	SO	8/4/2004	202	3 U	27		Field Duplicate of SB-08-9.0
SB-08-9.5	SO	8/4/2004	793	30 U	36		Soil sample from SB-08, 9.5' bgs
SB-08-11.0	SO	8/4/2004	5 U	3 U	3 U		Soil sample from SB-08, 11.0' bgs
SB-08-13.0	SO	8/4/2004	5 U	3 U	3 U		Soil sample from SB-08, 13.0' bgs
SB-08-13.5	SO	8/4/2004	418	3 U	32		Soil sample from SB-08, 13.5' bgs
SB-08-14.3	SO	8/4/2004	11	3 U	1.8		Soil sample from SB-08, 14.3' bgs
SB-08-15.0	SO	8/4/2004	19	3 U	3 U		Soil sample from SB-08, 15.0' bgs
SB-09-3.7	SO	7/28/2004	142	2 U	2 U		Soil sample from SB-09, 3.7' bgs
SB-09-7.7	SO	7/28/2004	5 U	2 U	2 U		Soil sample from SB-09, 7.7' bgs
SB-09-8.8	SO	7/28/2004	5 U	2 U	2 U		Soil sample from SB-09, 8.8' bgs
SB-09-10.9	SO	7/28/2004	5 U	2 U	2 U		Soil sample from SB-09, 10.9' bgs
SB-09-12.7	SO	7/28/2004	5 U	2 U	2 U		Soil sample from SB-09, 12.3' bgs

Table 4-2
USEPA Mobile Laboratory Field Analytical Results - July and August 2004
Groveland Wells Source Re-Evaluation

Location	Matrix	Analysis Date	Trichlorethene (ug/kg)	1,1,1- Trichlorethane (ug/kg)	Tetrachlorethene (ug/kg)	cis-1,2- Dichloroethene (ug/kg)	Comments
Soil Samples (continued)							
SB-10-2.3	SO	7/28/2004	463	3 U	10		Soil sample from SB-10, 2.3' bgs
SB-10-3.8	SO	7/28/2004	2,850	20 U	85		Soil sample from SB-10, 3.8' bgs
SB-10-6.6	SO	7/28/2004	1,490	20 U	110		Soil sample from SB-10, 6.6' bgs
SB-10-7.7	SO	7/28/2004	52,000	200 U	560		Soil sample from SB-10, 7.7' bgs
SB-10-8.2	SO	8/4/2004	2,460	30 U	194		Soil sample from SB-10, 8.2' bgs
SB-10-11.0	SO	8/4/2004	664	30 U	296		Soil sample from SB-10, 11.0' bgs
SB-10-DL-11.0	SO	8/4/2004	584	30 U	225		Field Duplicate for SB-10-11.0
SB-10-12.7	SO	8/4/2004	5	4 U	48		Soil sample from SB-10, 12.7' bgs
SB-10-14.0	SO	8/4/2004	10	3 U	14		Soil sample from SB-10, 14.0' bgs
SB-10-15.0	SO	8/4/2004	107	3 U	3.0		Soil sample from SB-10, 15.0' bgs
SB-10-16.5	SO	8/4/2004	270	4.3	10		Soil sample from SB-10, 16.5' bgs
SB-11-2.2	SO	7/28/2004	505	3 U	3 U		Soil sample from SB-11, 2.2' bgs
SB-11-2.5	SO	7/28/2004	693	3 U	16		Soil sample from SB-11, 2.5' bgs
SB-11-5.0	SO	7/28/2004	369	3 U	8		Soil sample from SB-11, 5.0' bgs
SB-11-6.3	SO	7/28/2004	2,230	8	47		Soil sample from SB-11, 6.3' bgs
SB-11-9.0	SO	7/28/2004	5 U	3 U	3 U		Soil sample from SB-11, 9.0' bgs
SB-11-11.0	SO	7/28/2004	5 U	3 U	3 U		Soil sample from SB-11, 11.0' bgs
SB-11-12.5	SO	7/28/2004	5 U	3 U	3 U		Soil sample from SB-11, 12.5' bgs
SB-12-3.0	SO	7/28/2004	5 U	3 U	3 U		Soil sample from SB-12, 3.0' bgs
SB-12-DL-3.0	SO	7/28/2004	5 U	3 U	3 U		Field Duplicate of SB-12-3.0
SB-12-5.0	SO	7/28/2004	9	3 U	3 U		Soil sample from SB-12, 5.0' bgs
SB-12-7.0	SO	7/28/2004	5	3 U	3 U		Soil sample from SB-12, 7.0' bgs
SB-12-7.7	SO	7/28/2004	116	3 U	3 U		Soil sample from SB-12, 7.7' bgs
SB-12-11.0	SO	7/28/2004	5 U	3 U	3 U		Soil sample from SB-12, 11.0' bgs
SB-12-13.0	SO	7/28/2004	5 U	3 U	3 U		Soil sample from SB-12, 13.0' bgs
SB-12-15.0	SO	7/28/2004	5 U	3 U	3 U		Soil sample from SB-12, 15.0' bgs
SB-13-2.5	SO	8/4/2004	38	3 U	3 U		Soil sample from SB-13, 2.5' bgs
SB-13-7.0	SO	8/4/2004	14	3 U	32		Soil sample from SB-13, 7.0' bgs
SB-13-7.7	SO	8/4/2004	5 U	3 U	5.0		Soil sample from SB-13, 7.7' bgs
SB-14-3.7	SO	8/4/2004	42	3 U	20		Soil sample from SB-14, 3.7' bgs
SB-14-8.0	SO	8/4/2004	5 U	3 U	3 U		Soil sample from SB-14, 8.0' bgs
SB-14-9.7	SO	8/4/2004	14	3 U	19		Soil sample from SB-14, 8.0' bgs
SB-14-10.3	SO	8/4/2004	32	3 U	156		Soil sample from SB-14, 10.3' bgs
TW-28-9.2	SO	8/5/2004	5 U	3 U	3 U		Soil sample from boring TW-28, 9.2' bgs
TW-28-DL-9.2	SO	8/5/2004	5 U	3 U	3 U		Field Duplicate of TW-38-9.2
TW-28-11.7	SO	8/5/2004	5 U	3 U	3 U		Soil sample from boring TW-28, 11.7' bgs
TW-28-39	SO	8/5/2004	5 U	3 U	3 U		Soil sample from boring TW-28, 39' bgs
TW-29-17	SO	8/5/2004	340	3 U	3 U		Soil sample from boring TW-29, 17' bgs
TW-29-22	SO	8/5/2004	58	3 U	3 U		Soil sample from boring TW-29, 22' bgs

Note: cis-1,2-DCE was not reported by the OEME mobile laboratory for soil samples.

**Table 4-3
USEPA Fixed Laboratory Analytical Results - Soil Total Organic Carbon
Groveland Wells Source Re-Evaluation**

Location	Matrix	Analysis Date	SEQ_NUM	Analyte	SSDL_CHAR	Result (mg/kg)		Comments
TW-28-10.5	SO	8/11/2004	1	TOC		6,990	U	
TW-28.11.7	SO	8/11/2004	1	TOC		6,760	U	
TW-28-39	SO	8/11/2004	1	TOC		7,140	U	
TW-28-9.2	SO	8/11/2004	1	TOC		7,410	U	
TW-29-13	SO	8/11/2004	1	TOC		6,850	U	
TW-1029-13	SO	8/12/2004	1	TOC		6,580	U	Field Duplicate of TW-29-13
TW-29-21	SO	8/12/2004	1	TOC		7,190	U	

**Table 4-4
On-Site Sentex Gas Chromatograph Groundwater Analytical Results, and TOC in Groundwater Results - October 2004
Groveland Wells Source Re-Evaluation**

Sample Run	Field Sample ID	Date	Time	Type	Dilution Factor	Analyte Concentration					Comments
						t-1,2-DCE (µg/L)	c-1,2-DCE (µg/L)	1,1,1-TCA (µg/L)	TCE (µg/L)	PCE (µg/L)	
45	MW-5D	26-Oct-04	19:42	Sample	1.0	ND	3.3	ND	9.3	ND	Sample undiluted from 1L jar.
109	MW-5DA	28-Oct-04	15:59	Sample	2.0	ND	1.7	ND	5.4	ND	Sample from 4 VOA vials combined
110	MW-5DB	28-Oct-04	16:15	Sample	2.0	ND	1.8	ND	5.9	ND	Sample from 4 VOA vials combined
112	MW-5DC	28-Oct-04	16:33	Sample	2.0	ND	2.0	ND	6.2	ND	Sample from 4 VOA vials combined
113	MW-5DD	28-Oct-04	16:43	Sample	1.9	ND	2.3	ND	6.9	ND	Sample from 4 VOA vials combined
43	TW-15	26-Oct-04	19:01	Sample	1.0	ND	3.0	ND	20	0.11	Sample undiluted from 1L jar.
114	TW-15A	28-Oct-04	16:53	Sample	2.0	ND	1.3	ND	9.8	ND	Sample from 4 VOA vials combined
73	TW-17A	27-Oct-04	15:28	Sample	200	ND	460	ND	3,900	ND	
74	TW-17B	27-Oct-04	15:38	Sample	200	10	500	ND	5,600	ND	
93	TW-17C	28-Oct-04	11:15	Sample	5,000	ND	200	ND	89,000	ND	
94	TW-17C	28-Oct-04	11:27	Sample - Duplicate	5,000	ND	ND	ND	100,000	ND	
97	TW-17D	28-Oct-04	12:09	Sample	5,000	ND	ND	ND	150,000	ND	
98	TW-17D	28-Oct-04	12:24	Sample - Duplicate	5,000	ND	ND	ND	160,000	ND	
15	TW-23A	26-Oct-04	11:22	Sample	250	23	1,200	ND	5,700	10	
48	TW-23A	26-Oct-04	20:22	Sample	499	ND	1,100	ND	4,600	ND	
49	TW-23A	26-Oct-04	20:33	Sample - Duplicate	499	ND	930	ND	4,100	ND	
16	TW-23B	26-Oct-04	11:38	Sample	250	ND	990	ND	4,900	2.5	
50	TW-23B	26-Oct-04	20:53	Sample	499	ND	900	ND	4,200	ND	
17	TW-23-CS-B	26-Oct-04	11:58	Sample	250	ND	980	ND	4,900	2.5	
38	TW-30	26-Oct-04	17:10	Sample	1.0	ND	0.20	ND	1.1	0.99	Sample undiluted from 1L jar. Very small unknown at 141s
104	TW-30A	28-Oct-04	14:48	Sample	5.0	ND	ND	ND	0.30	0.05	Sample from 4 VOA vials combined
105	TW-30B	28-Oct-04	15:06	Sample	2.0	ND	ND	ND	0.08	0.06	Sample from 4 VOA vials combined
106	TW-30C	28-Oct-04	15:21	Sample	3.6	ND	ND	ND	ND	ND	Sample from 3 VOA vials combined
107	TW-30D	28-Oct-04	15:34	Sample	2.0	ND	ND	ND	ND	ND	Sample from 4 VOA vials combined
31	TW-31	26-Oct-04	15:28	Sample	1.0	ND	0.48	ND	25	0.09	Sample undiluted from 1L jar. Very small unknown at 142s
32	TW-31	26-Oct-04	15:42	Sample - Duplicate	1.0	ND	0.48	ND	25	0.08	Sample undiluted from 1L jar. Very small unknown at 142s
29	TW-31A	26-Oct-04	15:06	Sample	16	ND	ND	ND	10	1.3	
33	TW-31B	26-Oct-04	16:07	Sample	2.0	ND	0.24	ND	11	0.04	Sample from 4 VOA vials combined
34	TW-31C	26-Oct-04	16:17	Sample	2.0	ND	0.26	ND	14	ND	Sample from 4 VOA vials combined
35	TW-31D	26-Oct-04	16:27	Sample	2.0	ND	0.24	ND	13	ND	Sample from 4 VOA vials combined

TOC IN GROUNDWATER (DAS PROGRAM)

DAS Number	Sample Location	Result*	Unit	
D05271	TW-30	1.79	mg/L	
D05272	TW-30-CS	5.87	mg/L	Duplicate of TW-30
D05273	TW-31	1.37	mg/L	
D05274	TW-17	15.4	mg/L	
D05277	EW-6D	15.2	mg/L	
D05278	TW-18	18.5	mg/L	
D05279	TW-23	5.36	mg/L	

* Result is the average of the duplicate analyses.

Table 4.5
Sub-Slab Soil Gas Survey Results - 2006
Groveland Wells Source Re-Evaluation

Sample Identification DAS Number	AR-01 D07199	AR-02 (FD) D07200	AR-03 D07201	AR-04 D07202	AR-05 D07203
Volatile Organic Compounds (ppb/v)					
Freon 12	0.16 U	0.86 U	0.79 U	0.44	0.62
Chloromethane	0.24	0.86 U	0.79 U	0.16 U	0.18
Bromomethane	0.16 U	0.86 U	0.79 U	0.16 U	0.16 U
Chloroethane	2.0	16	0.79 U	0.16 U	0.16 U
Freon 11	0.31	0.86 U	0.79 U	0.29	1.2
Freon 113	0.16 U	0.86 U	0.79 U	0.16 U	0.16 U
1,1-Dichloroethene	0.16 U	0.86 U	0.79 U	0.16 U	0.16 U
Acetone	12	21	22	26	17
Carbon Disulfide	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
Methylene Chloride	0.32 U	1.7 U	1.6 U	0.32 U	0.32 U
Methyl tert-butyl ether	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
trans-1,2-Dichloroethene	2.5	4.3 U	4.0 U	0.80 U	0.79 U
1,1-Dichloroethane	0.16 U	0.86 U	0.79 U	0.16 U	0.16 U
2-Butanone (Methyl Ethyl Ketone)	2.6 J	4.3 UJ	4.0 UJ	3.7 J	2.6 J
cis-1,2-Dichloroethene	22	39	11	0.16 U	0.16 U
Tetrahydrofuran	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
Chloroform	46	39	9.3	0.80	0.17
1,1,1-Trichloroethane	0.29	0.86 U	0.79 U	0.16 U	0.21
Cyclohexane	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
Carbon Tetrachloride	0.16 U	0.86 U	0.79 U	0.16 U	0.16 U
1,2-Dichloropropane	0.16 U	0.86 U	0.79 U	0.16 U	0.16 U
Bromodichloromethane	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
cis-1,3-Dichloropropene	0.16 U	0.86 U	0.79 U	0.16 U	0.16 U
4-Methyl-2-pentanone	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
Toluene	0.50 U	1.0 U	0.79 U	0.25 U	0.56 U
trans-1,3-Dichloropropene	0.16 U	0.86 U	0.79 U	0.16 U	0.16 U
1,1,2-Trichloroethane	0.16 U	0.86 U	0.79 U	0.16 U	0.16 U
2-Hexanone	0.79 UJ	4.3 UJ	4.0 UJ	0.80 UJ	0.79 UJ
Dibromochloromethane	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
1,2-Dibromoethane (EDB)	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
Chlorobenzene	0.16 U	0.86 U	0.79 U	0.16 U	0.16 U
Ethyl Benzene	0.16 U	0.86 U	0.79 U	0.16 U	0.16 U
m,p-Xylene	0.27	0.86 U	0.79 U	0.16 U	0.16 U
o-Xylene	0.16 U	0.86 U	0.79 U	0.16 U	0.16 U
Styrene	0.16 U	0.86 U	0.79 U	0.16 U	0.16 U
Bromoform	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
Cumene	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
Propylbenzene	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
1,3-Dichlorobenzene	0.16 U	0.86 U	0.79 U	0.16 U	0.16 U
1,4-Dichlorobenzene	0.16 U	0.86 U	0.79 U	0.16 U	0.16 U
alpha-Chlorotoluene	0.16 U	0.86 U	0.79 U	0.16 U	0.16 UJ
1,2-Dichlorobenzene	0.16 U	0.86 U	0.79 U	0.16 U	0.16 U
1,2,4-Trichlorobenzene	0.79 UJ	4.3 UJ	4.0 UJ	0.80 UJ	0.79 UJ
Hexachlorobutadiene	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
p-Cymene	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
sec-Butylbenzene	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
Butylbenzene	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
tert-Butylbenzene	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
Methylcyclohexane	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
1,2-Dibromo-3-chloropropane	0.79 U	4.3 U	4.0 U	0.80 U	0.79 U
Vinyl Chloride	0.20 U	0.97 U	0.99 U	0.054 U	0.026 U
Benzene	0.99 U	4.9 U	4.9 U	0.31	0.47
1,2-Dichloroethane	0.40 U	1.9 U	2.0 U	0.11 U	0.053 U
Trichloroethene	190	1,100	850	63	27
1,4-Dioxane	2.0 U	9.7 U	9.9 U	0.54 U	0.26 U
Tetrachloroethene	9.8	15	8.4	5.5	48
1,1,2,2-Tetrachloroethane	0.40 U	1.9 U	2.0 U	0.11 U	0.053 U
1,3,5-Trimethylbenzene	0.40 U	1.9 U	2.0 U	0.11 U	0.053 U
1,2,4-Trimethylbenzene	0.40 U	1.9 U	2.0 U	0.11 U	0.053 U

DAS - Delivery of Analytical Services

FD - Field duplicate.

J - Quantitation is approximate due to limitations identified in the data validation review or because result is below sample quantitation limit.

U - Sample result was nondetect; value reported is the sample quantitation limit.

ppbv - Parts per billion by volume.

Table 4.5
Sub-Slab Soil Gas Survey Results - 2006
Groveland Wells Source Re-Evaluation

Analysis	AR-06 D07204	AR-07 D07205	AR-08 D07206	AR-09 (FD) D07207
Volatile Organic Compounds (ppb/v)				
Freon 12	0.46	0.58	0.24	0.91 U
Chloromethane	0.17 U	0.5	0.27	0.91 U
Bromomethane	0.17 U	1.1	0.16 U	0.91 U
Chloroethane	0.17 U	3.8	0.23	16
Freon 11	0.32	0.37 U	0.30	0.91 U
Freon 113	0.17 U	0.37 U	0.16 U	0.91 U
1,1-Dichloroethene	0.17 U	0.37 U	0.16 U	0.91 U
Acetone	14	20	15	22
Carbon Disulfide	0.86 U	9.5	0.79 U	4.6 U
Methylene Chloride	0.34 U	0.73 U	0.32 U	1.8 U
Methyl tert-butyl ether	0.86 U	1.8 U	0.79 U	4.6 U
trans-1,2-Dichloroethene	0.86 U	1.8 U	1.0	4.6 U
1,1-Dichloroethane	0.17 U	0.37 U	0.16 U	0.91 U
2-Butanone (Methyl Ethyl Ketone)	1.8 J	5.7 J	2.4 J	4.6 UJ
cis-1,2-Dichloroethene	0.48	41	10	41
Tetrahydrofuran	0.86 U	1.8 U	0.79 U	4.6 U
Chloroform	3.6	67	8.0	41
1,1,1-Trichloroethane	0.17 U	0.37 U	0.29	0.91 U
Cyclohexane	0.86 U	1.8 U	0.79 U	4.6 U
Carbon Tetrachloride	0.17 U	0.37 U	0.16 U	0.91 U
1,2-Dichloropropane	0.17 U	0.37 U	0.16 U	0.91 U
Bromodichloromethane	0.86 U	1.8 U	0.79 U	4.6 U
cis-1,3-Dichloropropene	0.17 U	0.37 U	0.16 U	0.91 U
4-Methyl-2-pentanone	0.86 U	1.8 U	0.79 U	4.6 U
Toluene	0.34 U	0.74 U	0.19 U	0.97 U
trans-1,3-Dichloropropene	0.17 U	0.37 U	0.16 U	0.91 U
1,1,2-Trichloroethane	0.17 U	0.37 U	0.16 U	0.91 U
2-Hexanone	0.86 UJ	1.8 UJ	0.79 UJ	4.6 UJ
Dibromochloromethane	0.86 U	1.8 U	0.79 U	4.6 U
1,2-Dibromoethane (EDB)	0.86 U	1.8 U	0.79 U	4.6 U
Chlorobenzene	0.17 U	0.37 U	0.16 U	0.91 U
Ethyl Benzene	0.17 U	0.37 U	0.16 U	0.91 U
m,p-Xylene	0.17 U	0.37 U	0.16 U	0.91 U
o-Xylene	0.17 U	0.37 U	0.16 U	0.91 U
Styrene	0.17 U	0.37 U	0.16 U	0.91 U
Bromoform	0.86 U	1.8 U	0.79 U	4.6 U
Cumene	0.86 U	1.8 U	0.79 U	4.6 U
Propylbenzene	0.86 U	1.8 U	0.79 U	4.6 U
1,3-Dichlorobenzene	0.17 U	0.37 U	0.16 U	0.91 U
1,4-Dichlorobenzene	1.2 J	0.57	0.16 U	0.94
alpha-Chlorotoluene	0.17 UJ	0.37 U	0.16 U	0.91 U
1,2-Dichlorobenzene	0.17 U	0.37 U	0.16 U	0.91 U
1,2,4-Trichlorobenzene	0.86 UJ	1.8 UJ	0.79 UJ	4.6 UJ
Hexachlorobutadiene	0.86 U	1.8 U	0.79 U	4.6 U
p-Cymene	0.86 U	1.8 U	0.79 U	4.6 U
sec-Butylbenzene	0.86 U	1.8 U	0.79 U	4.6 U
Butylbenzene	0.86 U	1.8 U	0.79 U	4.6 U
tert-Butylbenzene	0.86 U	1.8 U	0.79 U	4.6 U
Methylcyclohexane	0.86 U	1.8 U	0.79 U	4.6 U
1,2-Dibromo-3-chloropropane	0.86 U	1.8 U	0.79 U	4.6 U
Vinyl Chloride	0.14 U	0.30 U	0.10 U	0.62 U
Benzene	0.71 U	1.5 U	0.52 U	3.1 U
1,2-Dichloroethane	0.28 U	0.61 U	0.21 U	1.2 U
Trichloroethene	170	470	170	1,100
1,4-Dioxane	1.4 U	3.0 U	1.0 U	6.2 U
Tetrachloroethene	9.4	16	3.8	14
1,1,1,2-Tetrachloroethane	0.28 U	0.61 U	0.21 U	1.2 U
1,3,5-Trimethylbenzene	0.28 U	0.61 U	0.21 U	1.2 U
1,2,4-Trimethylbenzene	0.28 U	0.61 U	0.21 U	1.2 U

FD - Field duplicate.

J - Quantitation is approximate due to limitations identified in the data validation review or because result is below sample quantitation limit.

U - Sample result was nondetect; value reported is the sample quantitation limit.

ppb/v - Parts per billion by volume.

**Table 4-6
USEPA Mobile Laboratory Field Analytical Results – May and June 2006
Groveland Source Re-Evaluation**

Location	Matrix	Analysis Date	Trichlorethene (ug/kg)	1,1,1-Trichlorethane (ug/kg)	Perchlorethene (ug/kg)	cis-1,2-Dichloroethene (ug/kg)	Comments
TB-01	QC	5/30/2006	10 U	10 U	10 U	15 U	
TB-02	QC	5/31/2006	10 U	10 U	10 U	15 U	
TB-03	SO	6/2/2006	10 U	10 U	10 U	15 U	
TB-04	QC	6/5/2006	10 U	10 U	10 U	20 U	
TB-06	SO	6/7/2006	10 U	10 U	10 U	20 U	
TB-10	QC	6/12/2006	10 U	10 U	10 U	20 U	
TB-11	QC	6/12/2006	10 U	10 U	10 U	INTERFERENCE	
TB-12	QC	6/12/2006	10 U	10 U	10 U	20 U	
B-33-2.0	SO	6/12/2006	10 U	10 U	10 U	20 U	All B-33 samples from boring at monitoring well TW-33
B-33-3.1	SO	6/12/2006	673	10 U	10 U	40 U	
B-33-5.5	SO	6/12/2006	35	10 U	10 U	20 U	
B-33-6.4	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-33-8.5	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-33-10.5	SO	6/12/2006	27	10 U	10 U	20 U	
B-33-12.9	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-33-12.9-CS	SO	6/12/2006	10 U	10 U	10 U	20 U	Field Duplicate of B-33-12.9
B-33-16.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-33-17.8	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-33-17.8-CS	SO	6/12/2006	10 U	10 U	10 U	20 U	Field Duplicate of B-33-17.8
B-33-20.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-33-21.5	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-33-24.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-33-26.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-33-30.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-33-36.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-33-41.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-34-0.5	SO	6/1/2006	45	10 U	10 U	15 U	
B-34-2.5	SO	6/1/2006	10 U	10 U	10 U	15 U	
B-34-4.4	SO	6/1/2006	10,200	58	32	400 U	
B-34-4.4-CS	SO	6/1/2006	6,800	54	29	340 U	Field Duplicate of B-34-4.4
B-34-8.0	SO	6/1/2006	10 U	10 U	10 U	15 U	
B-34-10.0	SO	6/1/2006	10 U	10 U	10 U	15 U	
B-34-11.7	SO	6/1/2006	10 U	10 U	10 U	15 U	
B-34-13.1	SO	6/1/2006	73	10 U	10 U	15 U	
B-34-16.0	SO	6/1/2006	10 U	10 U	10 U	15 U	
B-34-17.9	SO	6/2/2006	10 U	10 U	10 U	15 U	
B-34-20.0	SO	6/2/2006	10 U	10 U	10 U	15 U	
B-34-21.9	SO	6/2/2006	10 U	10 U	10 U	15 U	
B-34-25.7	SO	6/2/2006	10 U	10 U	10 U	15 U	
B-34-30.9	SO	6/2/2006	10 U	10 U	10 U	15 U	
B-34-F9-0.9	SO	6/5/2006	10 U	10 U	10 U	20 U	
B-34-F9-2.0	SO	6/5/2006	10 U	10 U	10 U	20 U	
B-34-F9-4.5	SO	6/5/2006	11	10 U	10 U	20 U	
B-36-2.0	SO	6/8/2006	14	10 U	10 U	20 U	
B-36-3.8	SO	6/8/2006	100	10 U	10 U	20 U	
B-36-3.8-CS	SO	6/8/2006	32	10 U	10 U	20 U	Field Duplicate of B-36-3.8
B-36-6.0	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-36-8.0	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-36-9.0	SO	6/8/2006	11	10 U	10 U	20 U	
B-36-11.9	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-36-14.0	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-36-15.5	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-36-17.8	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-36-20.0	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-36-24.0	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-36-26.0	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-36-31.0	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-36-36.0	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-36-39.5	SO	6/8/2006	10 U	10 U	10 U	20 U	

**Table 4-6
USEPA Mobile Laboratory Field Analytical Results – May and June 2006
Groveland Source Re-Evaluation**

Location	Matrix	Analysis Date	Trichlorethene (ug/kg)	1,1,1- Trichlorethane (ug/kg)	Perchlroethene (ug/kg)	cis-1,2-Dichloroethene (ug/kg)	Comments
B-38-0.8	SO	6/9/2006	10 U	10 U	10 U	20 U	
B-38-3.8	SO	6/9/2006	10 U	10 U	10 U	20 U	
B-38-5.9	SO	6/9/2006	1200	10 U	99	100 U	
B-38-8.0	SO	6/9/2006	293	10 U	23	20 U	
B-38-8.0-CS	SO	6/9/2006	318	10 U	22	20 U	Field Duplicate of B-38-8.0
B-38-10.0	SO	6/9/2006	121	10 U	10 U	20 U	
B-38-10.8	SO	6/9/2006	61	10 U	10 U	20 U	
B-38-13.9	SO	6/9/2006	96	10 U	10 U	20 U	
B-38-15.8	SO	6/9/2006	10 U	10 U	10 U	20 U	
B-38-17.5	SO	6/9/2006	10 U	10 U	10 U	20 U	
B-38-20.0	SO	6/9/2006	392	10 U	10 U	124	
B-38-21.8	SO	6/9/2006	233	10 U	10 U	106	
B-38-24.0	SO	6/9/2006	275	10 U	10 U	46	
B-38-26.0	SO	6/9/2006	26	10 U	10 U	20 U	
B-38-28.0	SO	6/9/2006	355	10 U	10 U	94	
B-38-30.0	SO	6/9/2006	64	10 U	10 U	21	
B-38-32.0	SO	6/9/2006	237	10 U	10 U	203	
B-38-36.0	SO	6/9/2006	34	10 U	10 U	20 U	
B-38-40.5	SO	6/9/2006	10 U	10 U	10 U	20 U	
B-38-46.0	SO	6/9/2006	19	10 U	10 U	20 U	
B-39-2.0	SO	6/12/2006	10 U	10 U	10 U	64	
B-39-4.0	SO	6/12/2006	62	10 U	10 U	74	
B-39-6.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-39-8.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-39-10.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-39-11.9	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-39-13.9	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-39-16.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-39-18.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-39-20.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-39-22.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-39-24.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-39-26.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-39-31.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-39-35.9	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-39-40.9	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-39-46.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-40-2.0	SO	5/31/2006	10 U	10 U	10 U	15 U	All B-40 samples from boring at monitoring well TW-40
B-40-2.9	SO	5/31/2006	10 U	10 U	10 U	15 U	
B-40-4.6	SO	5/31/2006	10 U	10 U	10 U	15 U	
B-40-7.0	SO	5/31/2006	56	10 U	10 U	15 U	
B-40-9.0	SO	5/31/2006	10 U	10 U	10 U	15 U	
B-40-12.0	SO	5/31/2006	10 U	10 U	10 U	15 U	
B-40-14.0	SO	5/31/2006	10 U	10 U	10 U	15 U	
B-40-16.0	SO	5/31/2006	10 U	10 U	10 U	15 U	
B-40-18.0	SO	5/31/2006	10 U	10 U	10 U	15 U	
B-40-19.8	SO	5/31/2006	13	10 U	10 U	15 U	
B-40-22.0	SO	5/31/2006	10 U	10 U	10 U	15 U	
B-40-24.0	SO	5/31/2006	18	10 U	10 U	15 U	
B-40-26.0	SO	6/1/2006	10 U	10 U	10 U	15 U	
B-40-31.0	SO	6/1/2006	10 U	10 U	10 U	15 U	
B-40-35.8	SO	6/1/2006	10 U	10 U	10 U	15 U	
B-40-40.8	SO	6/1/2006	10 U	10 U	10 U	15 U	
B-40-45.5	SO	6/1/2006	10 U	10 U	10 U	15 U	
B-40-49.3	SO	6/1/2006	10 U	10 U	10 U	15 U	

**Table 4-6
USEPA Mobile Laboratory Field Analytical Results – May and June 2006
Groveland Source Re-Evaluation**

Location	Matrix	Analysis Date	Trichlorethene (ug/kg)	1,1,1-Trichlorethane (ug/kg)	Perchlorethene (ug/kg)	cis-1,2-Dichloroethene (ug/kg)	Comments
B-41-1.0	SO	6/2/2006	64	10 U	10 U	15 U	
B-41-4.0	SO	6/2/2006	329	10 U	10 U	20 U	
B-41-5.5	SO	6/2/2006	1,050	10 U	10 U	160	
B-41-7.8	SO	6/2/2006	1,330	10 U	17	75 U	
B-41-9.5	SO	6/2/2006	788	10 U	10 U	30 U	
B-41-11.9	SO	6/2/2006	30	10 U	10 U	20 U	
B-41-13.9	SO	6/2/2006	138	10 U	10 U	20 U	
B-41-16.0	SO	6/5/2006	11	10 U	10 U	20 U	
B-41-17.7	SO	6/5/2006	17	10 U	10 U	30 U	
B-41-19.0	SO	6/5/2006	35	10 U	10 U	20 U	
B-41-21.9	SO	6/5/2006	46	10 U	10 U	34	
B-41-24.0	SO	6/5/2006	97	10 U	10 U	20 U	
B-41-26.0	SO	6/5/2006	10 U	10 U	10 U	20 U	
B-41-31.0	SO	6/5/2006	10 U	10 U	10 U	20 U	
B-41-35.5	SO	6/5/2006	10 U	10 U	10 U	20 U	
B-41-35.5CS	SO	6/5/2006	10 U	10 U	10 U	20 U	Field Duplicate of B-41-35.5
B-41-39.0	SO	6/5/2006	10 U	10 U	10 U	20 U	
B-45-2.0	SO	5/30/2006	23	10 U	10 U	15 U	
B-45-5.0	SO	5/30/2006	10 U	10 U	10 U	15 U	
B-45-3.5	SO	5/30/2006	10 U	10 U	10 U	15 U	
B-45-8.0	SO	5/30/2006	755	10 U	35	58	
B-45-10.5	SO	6/1/2006	14	10 U	10 U	12	
B-45-12.0	SO	5/30/2006	210	10 U	10 U	15	
B-45-13.0	SO	5/30/2006	10 U	10 U	10 U	15 U	
B-45-16.0	SO	5/30/2006	10 U	10 U	10 U	15 U	
B-45-18.0	SO	5/30/2006	10	10 U	10 U	15 U	
B-45-19.7	SO	5/30/2006	1,390	40	11	2,000	
B-45-21.0	SO	5/30/2006	1,580	41	10 U	1,960	
B-45-23.5	SO	5/30/2006	10,500	95	51	3,400	
B-45-25.5	SO	5/31/2006	113	10 U	10 U	36	
B-45-27.5	SO	5/31/2006	23	10 U	10 U	52	
B-45-29.5	SO	5/31/2006	22	10 U	10 U	18	
B-45-31.5	SO	5/31/2006	25	10 U	10 U	32	
B-45-37.7	SO	5/31/2006	2,660	10 U	10 U	60 U	
B-46-1.9	SO	6/1/2006	48	10 U	10 U	15 U	
B-46-3.7	SO	6/1/2006	10 U	10 U	10 U	15 U	
B-46-5.7	SO	6/1/2006	2150	10 U	37	174	
B-46-7.9	SO	6/1/2006	176	10 U	10 U	28	
B-46-9.0	SO	6/1/2006	51	10 U	10 U	19	
B-46-13.8	SO	6/1/2006	10 U	10 U	10 U	15 U	
B-46-14.8	SO	6/1/2006	10 U	10 U	10 U	15 U	
B-46-17.5	SO	6/1/2006	10 U	10 U	10 U	17	
B-46-18.5	SO	6/1/2006	12	10 U	10 U	15 U	
B-46-21.3	SO	6/1/2006	207	10 U	10 U	140	
B-46-22.8	SO	6/1/2006	11	10 U	10 U	15 U	
B-46-24.8	SO	6/1/2006	10 U	10 U	10 U	15 U	
B-46-26.6	SO	6/1/2006	15	10 U	10 U	19	
B-46-28.2	SO	6/1/2006	10 U	10 U	10 U	15 U	
B-46-30.8	SO	6/1/2006	10 U	10 U	10 U	15 U	
B-46-34.4	SO	6/1/2006	10 U	10 U	10 U	15 U	
B-49-1.6	SO	6/2/2006	71	10 U	10 U	15 U	
B-49-3.3	SO	6/2/2006	10 U	10 U	10 U	15 U	
B-49-4.0	SO	6/2/2006	11	10 U	10 U	15 U	
B-49-6.7	SO	6/2/2006	262	10 U	10 U	15 U	
B-49-6.7CS	SO	6/2/2006	298	10 U	10 U	15 U	Field Duplicate of B-41-35.5
B-49-8.6	SO	6/2/2006	22	10 U	10 U	15 U	
B-49-11.0	SO	6/2/2006	10 U	10 U	10 U	15 U	
B-49-13.8	SO	6/2/2006	10 U	10 U	10 U	15 U	
B-49-14.4	SO	6/2/2006	10 U	10 U	10 U	15 U	
B-49-17.0	SO	6/2/2006	10 U	10 U	10 U	15 U	
B-49-19.5	SO	6/2/2006	10 U	10 U	10 U	15 U	
B-49-21.8	SO	6/5/2006	58	10 U	10 U	46	
B-49-23.7	SO	6/5/2006	60	10 U	10 U	43	
B-49-25.4	SO	6/6/2006	10 U	10 U	10 U	20 U	
B-49-27.4	SO	6/6/2006	10 U	10 U	10 U	20 U	
B-49-35.8	SO	6/8/2006	10 U	10 U	10 U	20 U	

**Table 4-6
USEPA Mobile Laboratory Field Analytical Results – May and June 2006
Groveland Source Re-Evaluation**

Location	Matrix	Analysis Date	Trichlorethene (ug/kg)	1,1,1-Trichlorethane (ug/kg)	Perchlorethene (ug/kg)	cis-1,2-Dichloroethene (ug/kg)	Comments
B-50-1.9	SO	6/6/2006	10 U	10 U	10 U	20 U	
B-50-3.9	SO	6/6/2006	10 U	10 U	10 U	20 U	
B-50-5.8	SO	6/6/2006	10 U	10 U	10 U	20 U	
B-50-7.8	SO	6/6/2006	10 U	10 U	10 U	20 U	
B-50-9.8	SO	6/6/2006	10 U	10 U	10 U	20 U	
B-50-11.8	SO	6/6/2006	10 U	10 U	10 U	20 U	
B-50-13.8	SO	6/6/2006	10 U	10 U	10 U	20 U	
B-50-13.8-CS	SO	6/6/2006	10 U	10 U	10 U	20 U	Field Duplicate of B-50-13.8
B-50-15.8	SO	6/6/2006	10 U	10 U	10 U	20 U	
B-50-17.8	SO	6/6/2006	10 U	10 U	10 U	20 U	
B-50-19.8	SO	6/6/2006	10 U	10 U	10 U	20 U	
B-50-21.8	SO	6/6/2006	63	10 U	10 U	28	
B-50-23.6	SO	6/6/2006	201	10 U	10 U	98	
B-50-25.6	SO	6/7/2006	167	10 U	10 U	93	
B-50-27.5	SO	6/7/2006	263	10 U	10 U	149	
B-50-29.0	SO	6/7/2006	278	10 U	10 U	155	
B-50-36.5	SO	6/7/2006	10 U	10 U	10 U	20 U	
B-50-38.9	SO	6/7/2006	10 U	10 U	10 U	20 U	
B-50-40.0	SO	6/7/2006	13	10 U	10 U	20 U	
B-50-40.0-CS	SO	6/7/2006	9	10 U	10 U	20 U	Field Duplicate of B-50-40.0
B-51-1.8	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-51-2.7	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-51-2.7-CS	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-51-5.9	SO	6/8/2006	30	10 U	10 U	20 U	
B-51-10.0	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-51-11.5	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-51-11.5-CS	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-51-14.0	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-51-16.3	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-51-18.3	SO	6/8/2006	10 U	10 U	10 U	20 U	
B-51-20.2	SO	6/9/2006	10 U	10 U	10 U	20 U	
B-51-22.3	SO	6/9/2006	10 U	10 U	10 U	20 U	
B-51-24.0	SO	6/9/2006	10 U	10 U	10 U	20 U	
B-51-26.0	SO	6/9/2006	10 U	10 U	10 U	20 U	
B-52-2.8	SO	6/5/2006	422	10 U	10 U	22	
B-53-2.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-53-4.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-53-6.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-53-8.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
B-53-9.5	SO	6/12/2006	10 U	10 U	10 U	20 U	
HA-1-1.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
HA-1-2.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
HA-1-4.5	SO	6/12/2006	10 U	10 U	10 U	20 U	
HA-2-1.0	SO	6/12/2006	58	10 U	10 U	20 U	
HA-2-2.0	SO	6/12/2006	2,230	10 U	10 U	45	
HA-2-4.3	SO	6/12/2006	68	10 U	10 U	21	
HA-3-1.0	SO	6/12/2006	17	10 U	10 U	20 U	
HA-3-2.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
HA-3-4.6	SO	6/12/2006	10 U	10 U	10 U	20 U	
HA-4-1.1	SO	6/12/2006	10 U	10 U	10 U	20 U	
HA-4-2.0	SO	6/12/2006	10 U	10 U	10 U	20 U	
HA-4-4.7	SO	6/12/2006	10 U	10 U	10 U	20 U	
Pile 1 Fence	SO	5/30/2006	900	10 U	665	237	
Pile 2 Fence	SO	5/30/2006	30	10 U	6	849	

**Table 4-6
USEPA Mobile Laboratory Field Analytical Results – May and June 2006
Groveland Source Re-Evaluation**

Location	Matrix	Analysis Date	Trichlorethene (ug/kg)	1,1,1-Trichlorethane (ug/kg)	Perchloroethene (ug/kg)	cis-1,2-Dichloroethene (ug/kg)	Comments
TW-32D-1.5	SO	5/30/2006	10 U	10 U	10 U	15 U	
TW-32D-3.8	SO	5/30/2006	10 U	10 U	10 U	15 U	
TW-32D-5.9	SO	5/30/2006	10 U	10 U	10 U	15 U	
TW-32D-7.9	SO	5/30/2006	10 U	10 U	10 U	15 U	
TW-32D-9.9	SO	5/30/2006	10 U	10 U	10 U	15 U	
TW-32D-11.8	SO	5/30/2006	10 U	10 U	10 U	15 U	
TW-32D-13.8	SO	5/30/2006	10 U	10 U	10 U	15 U	
TW-32D-15.7	SO	5/30/2006	10 U	10 U	10 U	15 U	
TW-32D-15.7CS	FD	5/30/2006	10 U	10 U	10 U	15 U	Field Duplicate of B-50-15.7
TW-32D-17.9	SO	5/30/2006	581	10 U	10 U	304	
TW-32D-18.8	SO	5/30/2006	1000	10 U	10 U	422	
TW-32D-21.9	SO	5/30/2006	1,240	10 U	10 U	522	
TW-32D-21.9CS	SO	5/30/2006	1,305	10 U	10 U	631	Field Duplicate of B-50-21.9
TW-32D-24.0	SO	5/30/2006	2,770	10 U	10 U	1,030	
TW-32D-25.9	SO	5/30/2006	31	10 U	10 U	22	
TW-32D-26.5	SO	5/30/2006	1,000	10 U	10 U	388	
TW-32D-29.0	SO	5/30/2006	31	10 U	10 U	16	
TW-32D-35.9	SO	5/31/2006	10 U	10 U	10 U	15 U	
TW-35D-2.0	SO	6/5/2006	1,480	10 U	820	140 U	
TW-35D-2.5	SO	6/5/2006	2,200	10 U	2,100	140 U	
TW-35D-2.5CS	SO	6/5/2006	2,100	10 U	1,800	140 U	Field Duplicate of TW-35D-2.5
TW-35D-5.5	SO	6/5/2006	712	10 U	166	60 U	
TW-35D-6.4	SO	6/5/2006	1,510	10 U	543	140 U	
TW-35D-9.0	SO	6/5/2006	3,870	10 U	279	280 U	
TW-35D-10.4	SO	6/5/2006	771	10 U	128	60 U	
TW-35D-13.8	SO	6/5/2006	756	10 U	147	60 U	
TW-35D-15.8	SO	6/5/2006	2,150	44	10 U	700	
TW-35D-17.0	SO	6/5/2006	1,750	28	10 U	435	
TW-35D-19.5	SO	6/6/2006	11,900	300 U	300 U	3,260	
TW-35D-21.9	SO	6/6/2006	7,380	300 U	300 U	2390	
TW-35D-23.8	SO	6/6/2006	984	42	158	132	
TW-35D-25.5	SO	6/6/2006	537	19	73	258	
TW-35D-25.5CS	SO	6/6/2006	150	10 U	12	78	Field Duplicate of TW-35D-25.5
TW-35D-27.9	SO	6/6/2006	94	10 U	10 U	150	
TW-35D-30.0	SO	6/6/2006	74	10 U	10 U	150	
TW-35D-32.0	SO	6/6/2006	28	10 U	10 U	20 U	
TW-35D-34.0	SO	6/6/2006	34	10 U	10 U	25 U	
TW-35D-36.0	SO	6/6/2006	10 U	10 U	10 U	20 U	
TW-35D-40.8	SO	6/6/2006	694	10 U	10 U	36	
TW-44D-1.6	SO	6/6/2006	6,700	10 U	593	200 U	
TW-44D-3.6	SO	6/7/2006	35,800	300 U	3,920	1200 U	
TW-44D-5.3	SO	6/7/2006	3,340	10 U	119	200 U	
TW-44D-7.7	SO	6/7/2006	6,200	10 U	100	600 U	
TW-44D-9.8	SO	6/7/2006	181	10 U	10 U	20 U	
TW-44D-10.4	SO	6/7/2006	3,850	10 U	302	100 U	
TW-44D-12.8	SO	6/7/2006	478	10 U	25	20 U	
TW-44D-15.9	SO	6/7/2006	50	10 U	120	25 U	
TW-44D-17.4	SO	6/7/2006	216	10 U	10 U	50	
TW-44D-19.9	SO	6/7/2006	5,440	26	10 U	1,860	
TW-44D-22.0	SO	6/7/2006	8,130	50	18	2,710	
TW-44D-23.5	SO	6/7/2006	21,700	32	10 U	600 U	
TW-44D-23.5-CS	SO	6/7/2006	11,000	12	10 U	600 U	Field Duplicate of TW-35D-23.5
TW-44D-26.0	SO	6/7/2006	112	10 U	10 U	36	
TW-44D-28.0	SO	6/7/2006	72	10 U	10 U	24	
TW-44D-30.0	SO	6/7/2006	24	10 U	10 U	20 U	
TW-44D-34.0	SO	6/7/2006	10 U	10 U	10 U	20 U	
TW-44D-40.5	SO	6/7/2006	15,800	300 U	300 U	600 U	
TW-44D-41.0	SO	6/7/2006	166	10 U	10 U	20 U	

**Table 4-6
USEPA Mobile Laboratory Field Analytical Results – May and June 2006
Groveland Source Re-Evaluation**

Location	Matrix	Analysis Date	Trichlorethene (ug/kg)	1,1,1- Trichlorethane (ug/kg)	Perchlorethene (ug/kg)	cis-1,2-Dichloroethene (ug/kg)	Comments
TW-47-1.9	SO	6/12/2006	10 U	10 U	10 U	20 U	
TW-47-3.9	SO	6/12/2006	10 U	10 U	10 U	20 U	
TW-47-7.8	SO	6/12/2006	24	10 U	10 U	20 U	
TW-47-11.9	SO	6/12/2006	10 U	10 U	10 U	20 U	
TW-47-13.9	SO	6/12/2006	10 U	10 U	10 U	20 U	
TW-47-15.8	SO	6/12/2006	10 U	10 U	10 U	20 U	
TW-47-17.8	SO	6/12/2006	10 U	10 U	10 U	20 U	
TW-47-21.7	SO	6/12/2006	10 U	10 U	10 U	20 U	
TW-47-23.5	SO	6/12/2006	10 U	10 U	10 U	20 U	
TW-47-25.8	SO	6/12/2006	10 U	10 U	10 U	20 U	
TW-45-27.8	SO	6/12/2006	10 U	10 U	10 U	20 U	
TW-47-29.8	SO	6/12/2006	10 U	10 U	10 U	20 U	
TW-48-1.9	SO	6/9/2006	10 U	10 U	10 U	20 U	
TW-48-3.9	SO	6/9/2006	10 U	10 U	10 U	20 U	
TW-48-5.8	SO	6/9/2006	10 U	10 U	10 U	20 U	
TW-48-7.1	SO	6/9/2006	182	10 U	32	33	
TW-48-9.9	SO	6/9/2006	10 U	10 U	10 U	20 U	
TW-48-11.8	SO	6/9/2006	24	10 U	10 U	20 U	
TW-48-12.8	SO	6/9/2006	10 U	10 U	10 U	20 U	
TW-48-13.8	SO	6/9/2006	10 U	10 U	10 U	20 U	
TW-48-15.8	SO	6/9/2006	10 U	10 U	10 U	20 U	
TW-48-19.8	SO	6/9/2006	10 U	10 U	10 U	20 U	
TW-48-20.25	SO	6/12/2006	160	10 U	10 U	79	
TW-48-23.3	SO	6/12/2006	724	10 U	10 U	297	
TW-48-25.5	SO	6/12/2006	10 U	10 U	10 U	20 U	
TW-48-27.8	SO	6/12/2006	10 U	10 U	10 U	20 U	
TW-48-29.5	SO	6/12/2006	10 U	10 U	10 U	20 U	
TW-48-36.9	SO	6/12/2006	10 U	10 U	10 U	20 U	
TW-48-38.2	SO	6/12/2006	10 U	10 U	10 U	20 U	

Table 4-6
USEPA Mobile Laboratory Field Analytical Results – May and June 2006
Groveland Source Re-Evaluation

Location	Matrix	Analysis Date	Trichlorethene (ug/L)	1,1,1-Trichlorethane (ug/L)	Carbon tetrachloride (ug/L)	cis-1,2-Dichloroethene (ug/L)	Comments
TB-01-GW	QC	5/31/2006	0.2 U	0.2 U	0.2 U	0.5 U	
TB-02 GW	QC	5/31/2006	0.2 U	0.2 U	0.2 U	0.5 U	
TB-03-GW	QC	6/6/2006	0.2 U	0.2 U	0.2 U	0.5 U	
TB-04-GW	QC	6/7/2006	0.2 U	0.2 U	0.2 U	0.5 U	
TB-06-GW	QC	6/9/2006	0.2 U	0.2 U	0.2 U	0.5 U	
TB-08-GW	QC	6/12/2006	0.2 U	0.2 U	0.2 U	0.5 U	
EB-01 (O)	EB	6/7/2006	0.2 U	0.2 U	0.2 U	0.5 U	
EB-01(I)	EB	6/7/2006	0.2 U	0.2 U	0.2 U	0.5 U	
EB-02 (O)	EB	6/9/2006	0.2 U	0.2 U	0.2 U	0.5 U	
EB-02 (I)	EB	6/9/2006	0.2 U	0.2 U	0.2 U	0.5 U	
EB-03 (HA)	EB	6/12/2006	0.2 U	0.2 U	0.2 U	0.5 U	
EB-03 (O)	EB	6/12/2006	0.2 U	0.2 U	0.2 U	0.5 U	
EB-03 (I)	EB	6/12/2006	0.2 U	0.2 U	0.2 U	0.5 U	
EB-04 (I)	EB	6/12/2006	0.2 U	0.2 U	0.2 U	0.5 U	
EB-04 (O)	EB	6/12/2006	0.2 U	0.2 U	0.2 U	0.5 U	
EW-2D	AQ	5/31/2006	58	0.4	0.2	51	
EW-4D	AQ	5/31/2006	44	0.2 U	7.0	27	
EW-6S	AQ	6/6/2006	95	6 U	6 U	81	
EW-6D	AQ	6/6/2006	1240	6 U	6 U	234	
EW-6C (pre)	AQ	6/6/2006	7100	42	70	2360	Collected before purging well
EW-6C	AQ	6/6/2006	4580	21	52	1310	Collected after purging well
MW-5S	AQ	6/6/2006	0.7	0.2 U	0.2 U	0.5 U	
MW-5D	AQ	6/7/2006	0.2 U	0.2 U	0.2 U	0.5 U	
TW-1	AQ	5/31/2006	21	0.2 U	0.2 U	5.3	
TW-1-C.S	AQ	5/31/2006	20	0.2 U	0.2 U	5.0	
TW-3	AQ	6/3/2006	966	6 U	6 U	398	
TW-9	AQ	5/31/2006	1210	12	10	401	
TW-15	AQ	5/31/2006	4.2	0.2 U	0.2	2.1	
TW-16	AQ	5/31/2006	5.3	0.2 U	0.2 U	0.5	
TW-18	AQ	5/31/2006	1770	18	22	683	
TW-19	AQ	5/31/2006	14	0.2 U	0.2 U	2.6	
TW-23	AQ	5/31/2006	1000	8.4	8.3	560	
TW-26	AQ	6/3/2006	33	0.2 U	0.2 U	11	
TW-26A	AQ	6/3/2006	301	1.3	0.6	108	
TW-32D	AQ	6/9/2006	11	0.2 U	0.2 U	6.7	
TW-35D-MI	AQ	6/6/2006	41	6 U	12	16 U	
TW-40	AQ	6/6/2006	0.2 U	0.2 U	0.2 U	0.5 U	
TW-44D	AQ	6/12/2006	73	6 U	6 U	14	

Table 4-7
Confirmation Soil Sample and Residential Soil Sample Analytical Results - 2006
Groveland Wells Source Re-Evaluation

Sample Identification CLP Number	TW-35DX-5.5 (1) A2643 (FD)	TW-35DX-5.5-CS (1) A2644 (FD)	B-50X-23.6 (1) A2645	B-49X-23.7 (1) A2647	TW-35DX-21.9 (1) A2648	B-50X-5.8 (1) A2649	TW-44DX-1.6 (1) A2650	TW-44DX-3.5-4.0 (1) A2651	B-50X-21.8 (1) A2652
Volatile Organic Compounds (ug/L)									
Dichlorodifluoromethane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Chloromethane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Vinyl chloride	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Bromomethane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Chloroethane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Trichlorofluoromethane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
1,1-Dichloroethene	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
1,1,2-Trichloro-1,2,2-trifluoroethane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Acetone	490 U	390 J	490 U	470 U	450 U	490 U	530 U	2,200 U	510 U
Carbon disulfide	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Methyl Acetate	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Methylene Chloride	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
trans-1,2-Dichloroethene	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Methyl tert-Butyl Ether	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
1,1-Dichloroethane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
cis-1,2-Dichloroethene	28 J	14 J	130 J	41 J	1,400	260 U	67 J	430 J	35 J
2-Butanone	490 U	470 U	490 U	470 U	450 U	490 U	530 U	2,200 U	510 U
Bromochloromethane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Chloroform	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
1,1,1-Trichloroethane	240 U	240 U	240 U	240 U	85 J	250 U	260 U	1,100 U	250 U
Cyclohexane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Carbon Tetrachloride	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Benzene	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
1,2-Dichloroethane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
1,4-Dioxane	4,900 U	4,700 U	4,900 U	4,700 U	4,500 U	4,900 U	5,300 U	22,000 U	5,100 U
Trichloroethene	3,300	1,300	260	86 J	5,800	250 U	6,200	34,000	95 J
Methylcyclohexane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
1,2-Dichloropropane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Bromodichloromethane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
cis-1,3-Dichloropropene	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
4-Methyl-2-Pentanone	490 U	470 U	490 U	470 U	450 U	490 U	530 U	2,200 U	510 U
Toluene	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
trans-1,3-Dichloropropene	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
1,1,2-Trichloroethane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Tetrachloroethene	840	560	240 U	240 U	130 J	250 U	720	4,100	250 U
2-Hexanone	490 U	470 U	490 U	470 U	450 U	490 U	530 U	2,200 U	510 U
Dibromochloromethane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
1,2-Dibromoethane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Chlorobenzene	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Ethylbenzene	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
o-Xylene	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
m-p-Xylene	240 U	240 U	240 U	240 U	230 U	250 U	260 U	100 J	250 U
Styrene	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Bromoform	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
Isopropylbenzene	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
1,1,2,2-Tetrachloroethane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
1,3-Dichlorobenzene	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
1,4-Dichlorobenzene	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
1,2-Dichlorobenzene	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
1,2-Dibromo-3-chloropropane	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
1,2,4-Trichlorobenzene	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U
1,2,3-Trichlorobenzene	240 U	240 U	240 U	240 U	230 U	250 U	260 U	1,100 U	250 U

B - Analyte was present in a blank sample.
CLP - Contract Laboratory Program.
FD - Field duplicate pair.
J - Quantitation is approximate due to limitations identified in the data validation review or because result is below sample quantitation limit.
U - Sample result was nondetect; value reported is the sample quantitation limit.
ug/L - Micrograms per liter, equivalent to parts per billion

(1) Sample is reported on a wet-weight or "as received" basis. The reported concentrations would be low compared to those reported on a dry-weight basis.

**Table 4-8
PCB Analytical Results - 2006
Groveland Wells Source Re-Evaluation**

Sample Identification CLP Number	B-52-3-5 A2639 (FD)	B-52-3-5CS A2640 (FD)
Polychlorinated Biphenyls (PCBs) ug/Kg		
Aroclor-1016	35 U	35 U
Aroclor-1221	35 U	35 U
Aroclor-1232	35 U	35 U
Aroclor-1242	35 U	35 U
Aroclor-1248	35 U	35 U
Aroclor-1254	35 U	35 U
Aroclor-1260	35 U	35 U
Aroclor-1262	35 U	35 U
Aroclor-1268	35 U	35 U

CLP - Contract Laboratory Program.

FD - Field duplicate pair.

U - Sample result was nondetect; value reported is the sample quantitation limit.

ug/Kg - Micrograms per kilogram.

**Table 4-9
Soil Total Organic Carbon With Depth - 2006
Groveland Wells Source Re-Evaluation**

Sample	TOC mg/kg	Site Location	Soil Description
0-8 Feet (Surface to Buried Soil Horizon)			
TW-35D-4-6	15400	Wooden Shed, Eastern Portion, Shallow	Sandy soil with some fine sand (dark brown/yellow)
B-36-2-4	414	SW Corner of Property, Just off Slab, Shallow	Fine sand with some organics, roots (light brown)
B-38-6-8	16200	Just South of Wooden Shed, East, Shallow	Sandy soil with fine sand (dark brown)
B-40-2-4	9860	SE Corner of Property, Topsoil/Fill	Medium to fine sand
TW-44D-4-6	6220	Wooden Shed, Eastern Portion, Shallow	Sandy soil with some fine sand (dark brown/yellow)
TW-48-5.8	343 ND	Inside Building, Shallow	Very fine sand and silt with trace coal fragments (dark brown)
B-49-6-8	19000	Inside Building, Shallow	Fine to very fine sand with some silt, roots and leaf litter
8-15 Feet (Below Soil Horizon to Top of Clay)			
TW-32D-12-14	743	East of Building	Fine to very fine sand with silt (light brown/gray)
B-41-10-12	886	Wooden Shed, Just East of USTs	Fine sand (striated orange and tan)
B-51-10.0	508	Inside Building, West Side, Shallow	Very fine and fine sand with trace silt (light brown)
Between Clay and Water Table			
B-36-17-18	498	SW Corner of Property, Immediately South of Slab, Below Clay	Medium sand with some gravel (light brown)
B-38-19.5-20.0	513	Just South of Wooden Shed, Below Clay	Fine to coarse sand with some gravel (orange/brown)
Below Water Table			
TW-32D-34-36	490	East of Building, Water Table	Fine sand with gravel (light brown/brown)
TW-35D-30-32	569	Wooden Shed, Eastern Portion Water Table	Medium sand with some small gravel (light brown)
B-40-29-31	814	SE Corner of Property, Water Table	Very fine sand (light brown/orange)
B-41-34-36	1010	Wooden Shed, Just East of USTs, Water Table	Silt with small gravel (gray)
TW-44D-32-34	417	Wooden Shed, Eastern Portion, Water Table	Fine sand with some coarse sand and gravel (brown/yellow)

Zone	Average TOC mg/kg
Site-wide	4346
Surface to Buried Soil Horizon	9634
Buried Soil Horizon to Top of Clay	712
Surface to Top of Clay	6957
Between Clay and Water Table	506
Unsaturated Overburden	5882
Saturated Overburden	660

Table 4-10
Summary of Analytical Results from UST Removal
Groveland Wells Source Re-Evaluation

Sample Name	MCP Reportable Concentrations		UST-1 BOTTOM	UST-1 WEST	UST-1 CONTENTS	UST-2 BOTTOM	UST-2 SOUTH	UST-2 CONTENTS
	S1	S2						
VOC (ug/kg)								
Trichloroethene	N/A	N/A	<220	<200	<190	<160	<140	<220
EPH (mg/kg)								
Unadjusted C5-C8 Aliphatics	100	500	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25
Unadjusted C9-C12 Aliphatics	1,000	2,500	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25
C5-C8 Aliphatic Hydrocarbons	100	500	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25
C9-C12 Aliphatic Hydrocarbons	1,000	2,500	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25
C9-C10 Aromatic Hydrocarbons	100	500	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
VPH (ug/kg)								
Total TPH	200,000	2,000,000	<3300	<3300	<3300	2,570,000	<3300	<3300
C9-C18 Aliphatic Hydrocarbons	1,000,000	250,000	<3300	<3300	<3300	520,000	<3300	<3300
C19-C36 Aliphatic Hydrocarbons	2,500,000	5,000,000	<3300	<3300	<3300	1,630,000	<3300	<3300
C11-C22 Aromatic Hydrocarbons	200,000	2,000,000	<3300	<3300	<3300	420,000	<3300	<3300

Notes:

Analyses performed by laboratory subcontracted by Charter Environmental.

Data has not been validated.

UST-5 SW EAST/TOP sampled from soil treated in Ex-Situ test Piles 1 & 2

-Detected TCE concentration exceeds proposed **1000**
soil cleanup goal (77ug/kg)

-Concentration exceeds MCP S1 Reportable Conc. **1000**

Table 4-10
Summary of Analytical Results from UST Removal
Groveland Wells Source Re-Evaluation

Sample Name	MCP Reportable Concentrations		UST-3 BOTTOM	UST-3 CONENTS	UST-4 BOTTOM	UST-4 SOUTH	UST-4 CONTENTS	UST-5 SW - EAST/TOP	UST-5 - BOTTOM
	S1	S2							
VOC (ug/kg)									
Trichloroethene	N/A	N/A	<u>1800</u>	<190	<u>380</u>	<u>680</u>	<180	<210	<u>900</u>
EPH (mg/kg)									
Unadjusted C5-C8 Aliphatics	100	500	<1.25	<1.25	<1.25	<1.25	<1.25	2	<1.25
Unadjusted C9-C12 Aliphatics	1,000	2,500	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25
C5-C8 Aliphatic Hydrocarbons	100	500	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25
C9-C12 Aliphatic Hydrocarbons	1,000	2,500	<1.25	<1.25	<1.25	<1.25	<1.25	1.9	<1.25
C9-C10 Aromatic Hydrocarbons	100	500	<0.25	<0.25	<0.25	<0.25	<0.25	<1.25	2
VPH (ug/kg)									
Total TPH	200,000	2,000,000	<3300	<3300	240,000	3,600	<3300	110,000	1,240,000
C9-C18 Aliphatic Hydrocarbons	1,000,000	250,000	<3300	<3300	24,000	<3300	<3300	88,000	160,000
C19-C36 Aliphatic Hydrocarbons	2,500,000	5,000,000	<3300	<3300	170,000	<3300	<3300	<3300	900,000
C11-C22 Aromatic Hydrocarbons	200,000	2,000,000	<3300	<3300	40,000	<3300	<3300	22,000	180,000

Notes:

Analyses performed by laboratory subcontracted by Charter Environmental.

Data has not been validated.

UST-5 SW EAST/TOP sampled from soil treated in Ex-Situ test Piles 1 & 2

-Detected TCE concentration exceeds proposed 1000
soil cleanup goal (77ug/kg)

-Concentration exceeds MCP S1 Reportable Conc. **1000**

Table 4-10
Summary of Analytical Results from UST Removal
Groveland Wells Source Re-Evaluation

Sample Name	MCP Reportable Concentrations		UST-5 SOUTH	UST-5 EAST	UST 5 - CONTENTS	UST-6 NORTH	UST-6 EAST	UST-6 BOTTOM	UST-6 CONTENTS
	S1	S2							
VOC (ug/kg)									
Trichloroethene	N/A	N/A	<u>830</u>	<u>2700</u>	<300	<u>570</u>	<u>8000</u>	<u>2300</u>	<210
EPH (mg/kg)									
Unadjusted C5-C8 Aliphatics	100	500	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25
Unadjusted C9-C12 Aliphatics	1,000	2,500	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25
C5-C8 Aliphatic Hydrocarbons	100	500	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25
C9-C12 Aliphatic Hydrocarbons	1,000	2,500	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25	<1.25
C9-C10 Aromatic Hydrocarbons	100	500	1.7	2.2	<1.25	<0.25	<0.25	<0.25	<0.25
VPH (ug/kg)									
Total TPH	200,000	2,000,000	160,000	320,000	17,000	<3300	160,000	110,000	20,000
C9-C18 Aliphatic Hydrocarbons	1,000,000	250,000	19,000	8,300	<3300	<3300	6,800	7,200	<3300
C19-C36 Aliphatic Hydrocarbons	2,500,000	5,000,000	100,000	300,000	<3300	<3300	140,000	88,000	<3300
C11-C22 Aromatic Hydrocarbons	200,000	2,000,000	44,000	13,000	17,000	<3300	13,000	11,000	20,000

Notes:

Analyses performed by laboratory subcontracted by Charter Environmental.

Data has not been validated.

UST-5 SW EAST/TOP sampled from soil treated in Ex-Situ test Piles 1 & 2

-Detected TCE concentration exceeds proposed 1000
soil cleanup goal (77ug/kg)

-Concentration exceeds MCP S1 Reportable Conc. **1000**

**Table 4-11
Pre-Injection Groundwater Results - 2006
Groveland Wells Source Re-Evaluation**

Sample Identification CLP Number	RLs	TW-9-Pre A28D4	TW-18-Pre (FD) A28D5	TW-18CS-Pre (FD) A28E8	TW-32D-Pre A28D6	TW-32I-Pre A28D7	TW-33-Pre (FD) A28D8	TW-33CS-Pre (FD) A28F2	TW-43-Pre A28D9	TW-37-Pre A28E0
Volatle Organic Compounds (ug/L)										
Dichlorodifluoromethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
Chloromethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
Vinyl chloride	5.0	17	22	27	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
Bromomethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
Chloroethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
Trichlorofluoromethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
1,1-Dichloroethene	5.0	5.0 U	8.1	9.6	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
1,1,2-Trichloro-1,2,2-trifluoroethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
Acetone	10	10 U	10 U	10 U	10 U	10 U	35	28	50 U	29
Carbon disulfide	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
Methyl Acetate	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
Methylene Chloride	5.0	12 B	9.6 B	2.7 JB	18 B	12 B	3.2 JB	6.2 B	53 B	3.3 JB
trans-1,2-Dichloroethene	5.0	4.4 J	6.3	7.0	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
Methyl tert-Butyl Ether	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
1,1-Dichloroethane	5.0	5.4	9.2	10	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
cis-1,2-Dichloroethene	5.0	950 E	1,500 D	1,100 D	130 D	1,400 D	5.0 U	5.0 U	65	58
2-Butanone	10	10 U	10 U	10 U	10 U	10 U	10 U	10 U	50 U	10 U
Bromochloromethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
Chloroform	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
1,1,1-Trichloroethane	5.0	21	41	48	5.0 U	3.5 J	5.0 U	5.0 U	14 J	5.0 U
Cyclohexane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
Carbon Tetrachloride	5.0	2.7 J	6.1	7.2	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
Benzene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
1,2-Dichloroethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
1,4-Dioxane	100	100 U	100 U	100 U	100 U	100 U	100 U	100 U	500 U	100 U
Trichloroethene	5.0	2,300 E	4,200 D	3,300 D	330 D	3,200 D	2.3 J	3.3 J	34,000 D	52
Methylcyclohexane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
1,2-Dichloropropane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
Bromodichloromethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
cis-1,3-Dichloropropene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
4-Methyl-2-Pentanone	10	10 U	10 U	10 U	10 U	10 U	10 U	10 U	50 U	10 U
Toluene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.5	4.2 J	5.4	25 U	4.1 J
trans-1,3-Dichloropropene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
1,1,2-Trichloroethane	5.0	1.8 J	3.6 J	3.9 J	5.0 U	5.6	5.0 U	5.0 U	25 U	5.0 U
Tetrachloroethene	5.0	20	39	44	5.0 U	1.4 J	5.0 U	5.0 U	4.6 J	0.80 J
2-Hexanone	10	10 U	10 U	10 U	10 U	10 U	10 U	10 U	50 U	10 U
Dibromochloromethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
1,2-Dibromoethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
Chlorobenzene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
Ethylbenzene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	0.47 J	0.37 J	5.0 U	25 U	5.0 U
o-Xylene	5.0	5.0 U	5.0 U	1.2 J	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
m,p-Xylene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	1.2 J	0.92 J	1.2 J	25 U	0.92 J
Styrene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
Bromoform	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
Isopropylbenzene	5.0	5.0 U	1.4 J	1.4 J	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
1,1,2,2-Tetrachloroethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
1,3-Dichlorobenzene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
1,4-Dichlorobenzene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
1,2-Dichlorobenzene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
1,2-Dibromo-3-chloropropane	5.0	5.0 U	5.0 U	2.0 J	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
1,2,4-Trichlorobenzene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	25 U	5.0 U
1,2,3-Trichlorobenzene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	0.19 J	25 U	5.0 U

Notes: If a Tier II validation were performed, some results may be qualified as estimated (J or UJ).
There would be no rejected results if a Tier II validation were performed.

CLP - Contract Laboratory Program.

E - Quantitation is approximate, calibration range exceeded.

D - Reported from the diluted analysis

FD - Field duplicate.

TB - Trip blank.

J - Quantitation is approximate due to limitations identified in the data validation review or because result is below sample quantitation limit.

RLs - Reporting limits.

U - Sample result was nondetect; value reported is the sample quantitation limit.

ug/L - Micrograms per liter, equivalent to parts per billion

Table 4-12
Post-Injection Groundwater Results - 2006
Groveland Wells Source Re-Evaluation

Sample Identification CLP Number	RLs	TW-9-Post A28F9	TW-9CS-Post A28G7	TW-37-Post A28G0	TW-35D-Post A28G1	TW-42-Post A28G3	TW-43-Post A28G2	TW-44D-Post A28G5
Volatile Organic Compounds (ug/L)								
Dichlorodifluoromethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Chloromethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	730 E
Vinyl chloride	5.0	5.0 U	8.8	11	5.0 U	5.0 U	5.0 U	5.0 U
Bromomethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Chloroethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Trichlorofluoromethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
1,1-Dichloroethene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
1,1,2-Trichloro-1,2,2-trifluoroethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Acetone	10	78	85	10	10 U	10 U	10 U	10 U
Carbon disulfide	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Methyl Acetate	5.0	5.0 U	4.4 J	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Methylene Chloride	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
trans-1,2-Dichloroethene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	4.3 J	5.0 U
Methyl tert-Butyl Ether	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
1,1-Dichloroethane	5.0	5.0 U	5.0 U	5.0 U	2.2 J	5.0 U	5.0 U	5.0 U
cis-1,2-Dichloroethene	5.0	120	120	120	320 E	5.8	120	180
2-Butanone	10	10 U	23	10 U	10 U	10 U	10 U	10 U
Bromochloromethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Chloroform	5.0	5.0 U	5.0 U	5.0 U	5.0 U	2.5 J	5.0 U	5.0 U
1,1,1-Trichloroethane	5.0	4.8 J	4.1 J	5.0 U	20	26	16	8.8
Cyclohexane	5.0	4.8 U	4.8 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Carbon Tetrachloride	5.0	4.8 U	5.0 U	5.0 U	6.1	11	4.3 J	5.0 U
Benzene	5.0	4.8 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
1,2-Dichloroethane	5.0	4.8 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
1,4-Dioxane	100	100 U	100 U	100 U	100 U	100 U	100 U	100 U
Trichloroethene	5.0	39	37 B	130	32,000 DB	55 B	19,000 DB	9,800 DB
Methylcyclohexane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
1,2-Dichloropropane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Bromodichloromethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
cis-1,3-Dichloropropene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
4-Methyl-2-Pentanone	10	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Toluene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
trans-1,3-Dichloropropene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
1,1,2-Trichloroethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Tetrachloroethene	5.0	4.7 J	4.2 J	14	15	5.8	5.0 J	3.9 J
2-Hexanone	10	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibromochloromethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
1,2-Dibromoethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Chlorobenzene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Ethylbenzene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
m,p-Xylene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
o-Xylene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Styrene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Bromoform	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Isopropylbenzene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
1,1,2,2-Tetrachloroethane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
1,3-Dichlorobenzene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
1,4-Dichlorobenzene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
1,2-Dichlorobenzene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
1,2-Dibromo-3-chloropropane	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
1,2,4-Trichlorobenzene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
1,2,3-Trichlorobenzene	5.0	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U

Notes: If a Tier II validation were performed, some results may be qualified as estimated (J or UJ).
In addition, if a Tier II validation were performed, results for acetone and 2-butanone in sample TW-42-Post would be rejected due to surrogate recovery issues.

- B - Analyte was present in a blank.
- CLP - Contract Laboratory Program.
- D - Reported from diluted analysis.
- E - Quantitation is approximate, calibration range exceeded.
- FD - Field duplicate.
- J - Quantitation is approximate due to limitations identified in the data validation review or because result is below sample quantitation limit.
- RLs - Reporting limits.
- U - Sample result was nondetect; value reported is the sample quantitation limit.
- ug/L - Micrograms per liter, equivalent to parts per billion

Table 4-13
Groundwater Elevation Data
Groveland Wells Source Re-Evaluation

Well No.	Elevation of Water in Well on Date Shown, in Feet (NGVD 1929)							
	6/23/04	7/24/04	10/26/04	11/10/04 ⁽¹⁾	11/10/04 ⁽¹⁾	7/18/06	7/21/06	8/30/06
EW-S1	NM	NM	33.6	40.6	NM	NM	NM	NM
EW-S2	NM	NM	35.8	41.6	NM	NM	NM	NM
EW-S3	NM	NM	NM	40.5	NM	NM	NM	NM
TW1	46.28	45.79	46.05	45.95	45.97	46.83	NM	45.99
TW3	43.54	42.40	42.22	42.35	42.38	45.46	NM	43.14
TW9	54.47	53.27	NM	53.35	NM	55.18	NM	53.04
TW15	50.90	dry at 46.0	NM	dry at 46.0	dry at 46.0	55.10	54.88	dry at 46.0
TW16	47.47	46.96	NM	47.16	NM	47.93	47.85	dry at 65.2
TW17	41.87	40.49	40.35	42.06	41.01	43.84	NM	41.92
TW18	54.46	53.28	NM	53.35	NM	55.19	NM	well clogged
TW19	50.33	49.1	NM	50.7	50.76	50.99	NM	48.07
TW23	54.47	53.26	NM	53.32	NM	NM	54.97	53.00
TW26	NM	NM	37.44	40.33	38.72	NM	37.55	37.53
TW26A	NM	NM	39.27	41.13	40.35	NM	42.15	40.4
TW30	NM	NM	NM	41.26	40.87	NM	41.20	39.99
TW31	NM	NM	NM	40.36	39.36	NM	39.11	38.77
TW32D	NC	NC	NC	NC	NC	55.02	NM	52.56
TW32I	NC	NC	NC	NC	NC	55.24	NM	52.76
TW33	NC	NC	NC	NC	NC	46.81	NM	45.29
TW35D	NC	NC	NC	NC	NC	45.61	NM	43.28
TW37	NC	NC	NC	NC	NC	55.21	55.02	53.45
TW40	NC	NC	NC	NC	NC	46.29	NM	44.15
TW42	NC	NC	NC	NC	NC	44.94	NM	42.86
TW43	NC	NC	NC	NC	NC	45.21	NM	43.06
TW44D	NC	NC	NC	NC	NC	45.53	NM	43.26
TW47	NC	NC	NC	NC	NC	52.57	NM	51.22
TW48	NC	NC	NC	NC	NC	51.54	51.34	49.55
EW2D	55.59	55.06	NM	55.28	NM	NM	NM	Destroyed
EW4D	53.98	54.0	NM	55.57	NM	55.74	NM	Destroyed
EW-5D	54.5	NM	NM	NM	NM	55.23	NM	Destroyed
EW5S	UNK	NM	NM	63.67	NM	64.2	NM	Destroyed
EW6S	64.16	64.36	NM	64.19	64.21	64.51	NM	64.1
EW6C	59.07	58.54	NM	58.67	58.66	59.68	NM	Destroyed
EW6D	54.41	53.25	NM	53.34	53.34	55.16	NM	Destroyed
EW7D	NM	NM	NM	NM	NM	55.18	NM	53.8
EW8D	NM	NM	NM	NM	NM	64.1	NM	64.0
MW3	54.42	53.27	NM	53.33	NM	55.1	NM	NM
MW5D	63.8	oil	NM	NM	NM	NM	63.3	62.2
MW5S	NM	67.2	NM	NM	NM	NM	67.1	67.3

NOTES:

1. First set of water levels was measured after source area extraction wells had been off for almost 2 days;
second set was measured after wells were restarted and had run about 1 hour

NM = not measured

NC = not constructed yet

Table 4-14
Summary of Groundwater Slug Test Results
Groveland Wells Source Re-Evaluation

Well	Test 1 K ⁽¹⁾ (ft/d)	Test 2 K ⁽¹⁾ (ft/d)	Avg. K ⁽¹⁾ (ft/d)	Screened Interval ⁽²⁾
TW32D	3.8	3	3.4	30-38
TW32I	96	104	100	22-30
TW35D	34	32	33	34-44
TW37	3.4	3.4	3.4	23-28
TW42	3.8	3.4	3.6	39.5-42.5
TW43	4.8	4.6	4.7	39.5-43.5
TW44D	14.1	11.5	12.8	34-44
TW48	0.3	-	0.3	29-39
Geometric Mean			6.3	

1. Hydraulic conductivity
2. Numbers are depth intervals, in feet below ground surface

**Table 5-1
Groundwater Pilot Test Summary
Groveland Wells Source Re-Evaluation**

	TW-37			TW-9			TW-43			TW-42			TW-35D			TW-44D			
	Pre-	Post-1	Post-2	Pre-	Post-1	Post-2	Pre-	Post-1	Post-2	Pre-	Post-1	Post-2	Pre-	Post-1	Post-2	Pre-	Post-1	Post-2	
Concentration (ug/L)																			
Tetrachloroethene	0.80 J	14	NA	20	4.7 J	NA	4.8 J	5 J	NA	3.4 J	5.6	NA	5.0 U	320 E	NA	5.0 U	3.9 J	NA	
Trichloroethene	52	130	NA	2,300 E	39	NA	34,000 D	19,000 DB	NA	39,000 D	55 B	NA	46	32,000 DB	NA	130	9,800 DB	NA	
cis-1,2-Dichloroethene	58	120	NA	950 E	120	NA	65	120	NA	58	5.6	NA	9.1	15	NA	12	180	NA	
trans-1,2-Dichloroethene	5.0 U	5 U	NA	4.4 J	5 U	NA	25 U	4.3 J	NA	5.0 U	5 U	NA	5.0 U	5 U	NA	5.0 U	5 U	NA	
Vinyl chloride	5.0 U	11	NA	17	5 U	NA	25 U	5 U	NA	5.0 U	5 U	NA	5.0 U	5 U	NA	5.0 U	5 U	NA	
Methylene Chloride	3.3 JB	5 U	NA	12 B	5 U	NA	53 B	5 U	NA	30 B	5 U	NA	7.2 B	5 U	NA	4.1 JB	5 U	NA	
Dissolved Oxygen (mg/L)	0.52	0.77	3.51	0.54	0.87	0.75	8.01	7.48	11.50	8.19	6.36	9.97	8.69	7.63	9.20	7.12	8.07	10.63	
ORP (mV)	61.8	176.5	196.6	85.3	120	154	299.4	705.8	575.3	309.9	742.1	387.3	308.8	149.1	106.6	343	125.7	539.7	
pH	5.83	5.57	5.36	5.99	6.32	5.77	6.45	4.98	5.19	5.84	3.32	5.65	5.58	6.07	6.21	5.54	3.32	5.10	
Conductivity (umhos/cm)	512	336	326	349	775	479	862	943	1046	888	1423	1001	1063	905	755	708	927	778	
Well Headspace (ppm)	11.2	75	65	0.1	0.3	0.2	60.8	4.3	30.3	160	10.2	82.4	5.6	28.4	12.9	67.3	18.3	47	

Notes:

Pre-Injection samples collected on June 26 and 27, 2006.

Sodium Permanganate injection (10%) performed on July 24, 2006.

Post-Injection #1 samples collected on August 17, 2006.

Post-Injection #2 samples collected on September 20, 2006.

E - Quantitation is approximate, calibration range exceeded.

D - Reported from the diluted analysis

J - Quantitation is approximate due to limitations identified in the data validation review or because result is below sample quantitation limit.

U - Sample result was nondetect; value reported is the sample quantitation limit.

ug/L - Micrograms per liter, equivalent to parts per billion

NA - Laboratory results for Post-Injection #2 samples were not available for inclusion in report.

**Table 5-2
Ex-Situ Soil Pilot Test Summary of Analytical Data
Groveland Wells Source Re-Evaluation**

Pile (Dose)	Source	PSOD (High) g/kg	Pre- Treatment Sample	TCE Conc. ug/kg	Post- Treatment Sample	TCE Conc. ug/kg	MEK Conc. ug/kg
Pile 1 (6 g/kg)	East Wall of UST Grave	5.7	1A	5.1	1A	<180	<1100
			1B	3.4	1B	<160	<960
			1C	2.3	1C	<180	<1100
					1D	<140	<840
					1E	<150	1100
Pile 2 (6 g/kg)	East Wall of UST Grave	1.3	2A	<1.9	2A	<250	<1500
			2B	2.1	2B	<39	390
			2C	2.1	2C	<37	310
					2D	<37	360
					2E	<36	340
Pile 3 (3 g/kg)	106 Centre Street South of Fence	13.6	3A	35	3A	44	28
			3B	38	3B	120	100
			3C	35	3C	28	55
					3D	61	850
					3E	87	86
					3E-CS	62	72
Pile 4 (3 g/kg)	106 Centre Street South of Fence & near B-34	48.8	4A	<2.2	4A	33	72
			4B	<5	4B	4.4	27
			4C	3.9	4C	3.5	40
					4D	6.4	87
					4E	<3.8	54
Pile 5 (5 g/kg)	South of Slab near SB-2	64.4	5A	130	5A	89	170
			5B	13000	5B	82	130
			5C	220	5C	38	150
			5A-CS	190	5D	59	140
					5E	73	47
		5C-CS	63	180			
Pile 6 (5g/kg)	South of Slab near SB-2	63.3	6A	6000	6A	140	250
			6B	12000	6B	100	190
			6C	100	6C	73	60
					6D	150	78
					6E	170	190

**Table 5-2
Ex-Situ Soil Pilot Test Summary of Analytical Data
Groveland Wells Source Re-Evaluation**

File (Dose)	Source	PSOD (High) g/kg	Pre- Treatment Sample	TCE Conc. ug/kg	Post- Treatment Sample	TCE Conc. ug/kg	MEK Conc. ug/kg
Pile 7 (2g/kg)	South of Slab near SB-2	27.8	7A	26	7A	74	29
			7B	97	7B	210	41
			7C	140	7C	30	68
					7D	66	110
					7E	71	70
Pile 8 (2g/kg)	South of Slab near SB-2 & near B-34	22.4	8A	52	8A	40	190
			8B	48	8B	120	<21
			8C	67	8C	110	26
					8D	49	19
					8E	58	<22
Pile 9 (2 g/kg)	Drill Cuttings June 2006	4.7	9A	59	9A	<33	310
			9B	15	9B	<39	430
			9C	8.5	9C	3.4	130
					9D	<35	350
					9E	<3.4	140

Notes:

- Analyses performed by laboratory subcontracted by Charter Environmental. Data has not been validated.
- Methyl Ethyle Ketone (MEK) was not detected in any Pre-Treatment Sample.
- The soil cleanup goal for cis-1,2-DCE (401 ug/kg) was only exceeded in one sample (420 ug/kg, Pre-Treatment Pile 6).
See Section 6.2 for discussion of soil cleanup goals.
- The maximum cis-1,2-DCE detection in the Post-Treatment samples was 20 ug/kg (Pile 6).

Table 5-3
Ex-Situ Pilot Test Soil Source and Permanganate Dosage
Groveland Wells Source Re-Evaluation

Pile #	Nominal Permanganate Dose (g/kg)	KMnO4 Added (lb)	Soil Source
1	6	180	East Wall UST Tank Grave
2	6	180	East Wall UST Tank Grave
3	3	90	South of Fence at 106 Centre Street (HA-2)
4	3	90	Southwest of Slab (B-34, SB-1) and South of Fence at 106 Centre Street (HA-2)
5	5	150	South of Slab (SB-2, TW-33)
6	5	150	South of Slab (SB-2, TW-33)
7	2	60	South of Slab (SB-2, TW-33)
8	2	60	South of Slab (SB-2, TW-33) and Southwest of Slab (B-34, SB-1)
9	2	30	June 2006 Drill Cuttings

**Table 6-1
Contaminant Specific Proposed Cleanup Goals
Groveland Wells Source Re-Evaluation**

Contaminant	Groundwater Cleanup Goal ⁽¹⁾ (µg/L)	Proposed Soil Cleanup Goal ⁽²⁾ (µg/kg)	ROD Groundwater Cleanup Goal (µg/L)	ROD Soil Cleanup Goal (µg/kg)	MCP Method 1 GW-1 Standard (ug/L)	MCP Method 1 S-1 Soil & GW-1 Standard (ug/kg)
Trichloroethene	5	77	5	6.3	5	300
Vinyl chloride	2	11	2	1.14	2	600
Methylene chloride	5	22	5	0.44	5	100
Tetrachloroethene	5	56	5	18.2	5	1,000
1,1-Dichloroethene	7	45	7	4.6	7	3,000
trans-1,2-Dichloroethene	100	626	700	41.3	100	1,000
Toluene	1,000	22,753	2,000	6,000	1,000	30,000
1,1,1-Trichloroethane	200	1,388	200	302	200	30,000
cis-1,2-Dichloroethene	70	418	--	--	70	300

(1) MCL - Maximum Contaminant Level, Safe Drinking Water Act, 1996

(2) Based on migration to groundwater calculations intended to be protective of direct contact and inhalation risks. (See Appendix H)

Table 6-2
Alternative 1A Cost Estimate: Chemical Oxidation of unsaturated soils/In-situ Chemical Oxidation

Groveland Wells Source Re-Evaluation
Period of Performance: 5 years

Field Task 1 - Building Demolition/Soil Excavation	Number	Unit	Unit Cost	Total Cost
Subcontractor mobilization/demobilization	1	ls	\$10,000	\$10,000
Air monitoring (PID rental)	1	ls	\$5,000	\$5,000
Demolish Valley Building	1	ls	\$230,000	\$230,000
Excavate Soil >77 ppb + Chemical Oxidation (KMnO4, Labor)	4400	CY	\$150	\$660,000
Excavation Sheeting	3300	SF	\$20	\$66,000
Clean Fill Material	500	CY	\$25	\$12,500
Dispose of contaminated soils as listed waste	0	tons	\$225	\$0
SUBTOTAL				\$983,500
Field Task 2 - In-Situ Chemical Oxidation - installation	Number	Unit	Unit Cost	Total Cost
Install Injection Wells	50	EA	\$2,900	\$145,000
Procure and Assemble Injection Apparatus	1	ls	\$8,000	\$8,000
SUBTOTAL				\$153,000
TOTAL				\$1,136,500
Project Management/Oversight	6%	Tasks 1,2		\$68,190
Design (Construction)	12%	Tasks 1,2		\$136,380
Construction Management (Construction)	8%	Tasks 1,2		\$90,920
SUBTOTAL REMEDY IMPLEMENTATION				\$1,431,990
30% Contingency				\$429,597
TOTAL CAPITAL COST				\$1,861,587
Task 4 - Treatment O&M/Periodic Costs	Number	Unit	Unit Cost	Total Cost
<u>Year 1</u>				
Oxidant Injection Round 1	1	ls	\$155,000	\$155,000
Procurement/staging	1	ls	\$3,000	\$3,000
Performance Monitoring	1	ls	\$53,000	\$53,000
Project Management (6%)	1	ls	\$12,660	\$12,660
Contingency (30%)				<u>\$67,098</u>
Total Year 1				\$290,758
<u>Years 2 and 3</u>				
Oxidant Injection Round 2	1	ls	\$80,000	\$80,000
Procurement/staging	1	ls	\$3,000	\$3,000
Performance Monitoring	1	ls	\$53,000	\$53,000
Project Management (6%)	1	ls	\$8,160	\$8,160
Contingency (30%)				<u>\$43,248</u>
Total Year 2 and 3				\$187,408
<u>Year 4</u>				
Performance Monitoring	1	ls	\$53,000	\$53,000
Project Management (6%)	1	ls	\$3,180	\$3,180
Contingency (30%)				<u>\$16,854</u>
Total Year 4				\$73,034
<u>Year 5</u>				
Decommissioning	1	ls	\$57,000	\$57,000
Closeout Report	1	ls	\$15,000	\$15,000
Project Management (6%)	1	ls	\$4,320	\$4,320
Contingency (30%)				<u>\$22,896</u>
Total Year 5				\$99,216
Present Value:				
Capital Cost	\$1,861,587	\$1,861,587	1.00	\$1,861,587
O&M Year 1	\$290,758	\$290,758	0.93	\$270,405
O&M Years 2 and 3	\$374,816	\$187,408	1.70	\$318,594
O&M Year 4	\$73,034	\$73,034	0.76	\$55,506
O&M Year 5	\$99,216	\$99,216	0.71	<u>\$70,443</u>
TOTAL FOR ALTERNATIVE				\$2,576,535
	Number	Unit	Unit Cost	Total Cost
Additional GWTP Operation	15	YR	\$600,000	\$9,000,000
Present Value GWTP Operation (7%)				\$5,464,748
Additional MOM Monitoring	15	YR	\$50,000	\$750,000
Present Value MOM Monitoring (7%)				\$455,396
TOTAL PRESENT VALUE FOR ALTERNATIVE WITH GWTP				\$8,496,679

*assumes GWTP will operate during source remediation and for 10 yrs following remediation to remove residual groundwater contamination.

Table 6-3
Alternative 1B Cost Estimate: Excavation and Disposal / In-situ Chemical Oxidation
Groveland Wells Source Re-Evaluation
Period of Performance: 5 years

Field Task 1 - Building Demolition/Soil Excavation	Number	Unit	Unit Cost	Total Cost
Subcontractor mobilization/demobilization	1	ls	\$10,000	\$10,000
Air monitoring (PID rental)	1	ls	\$5,000	\$5,000
Demolish Valley Building	1	ls	\$230,000	\$230,000
Excavate soil TCE>77ppb	4400	CY	\$10	\$44,000
Excavation Sheeting	3300	SF	\$20	\$66,000
Backfill	4840	CY	\$25	\$121,000
Dispose of contaminated soils a listed waste	7260	tons	\$225	\$1,633,500
SUBTOTAL				\$2,109,500
Field Task 2 - In-Situ Chemical Oxidation - installation	Number	Unit	Unit Cost	Total Cost
Install Injection Wells	50	EA	\$2,900	\$145,000
Procure and Assemble Injection Apparatus	1	ls	\$8,000	\$8,000
SUBTOTAL				\$153,000
TOTAL				\$2,262,500
Project Management/Oversight	6%	Tasks 1,2		\$135,750
Design (Construction)	12%	Tasks 1,2		\$271,500
Construction Management (Construction)	8%	Tasks 1,2		\$181,000
SUBTOTAL REMEDY IMPLEMENTATION				\$2,850,750
30% Contingency				\$855,225
TOTAL CAPITAL COST				\$3,705,975
Task 4 - Treatment O&M/Periodic Costs	Number	Unit	Unit Cost	Total Cost
Year 1				
Oxidant Injection Round 1	1	ls	\$155,000	\$155,000
Procurement/staging	1	ls	\$3,000	\$3,000
Performance Monitoring	1	ls	\$53,000	\$53,000
Project Management (6%)	1	ls	\$12,660	\$12,660
Contingency (30%)				<u>\$67,098</u>
Total Year 1				\$290,758
Years 2 and 3				
Oxidant Injection Round 2	1	ls	\$80,000	\$80,000
Procurement/staging	1	ls	\$3,000	\$3,000
Performance Monitoring	1	ls	\$53,000	\$53,000
Project Management (6%)	1	ls	\$8,160	\$8,160
Contingency (30%)				<u>\$43,248</u>
Total Year 2 and 3				\$187,408
Year 4				
Performance Monitoring	1	ls	\$53,000	\$53,000
Project Management (6%)	1	ls	\$3,180	\$3,180
Contingency (30%)				<u>\$16,854</u>
Total Year 4				\$73,034
Year 5				
Decommissioning	1	ls	\$57,000	\$57,000
Closeout Report	1	ls	\$15,000	\$15,000
Project Management (6%)	1	ls	\$4,320	\$4,320
Contingency (30%)				<u>\$22,896</u>
Total Year 5				\$99,216
Present Value:	Total	Cost per	Discount	Present
	Cost	Year	Factor (7%)	Value
Capital Cost	\$3,705,975	\$3,705,975	1.00	\$3,705,975
O&M Year 1	\$290,758	\$290,758	0.93	\$270,405
O&M Years 2 and 3	\$374,816	\$187,408	1.70	\$318,594
O&M Year 4	\$73,034	\$73,034	0.76	\$55,506
O&M Year 5	\$99,216	\$99,216	0.71	\$70,443
TOTAL FOR ALTERNATIVE				\$4,420,923
Additional GWTP Operation	15	YR	\$600,000	\$9,000,000
Present Value GWTP Operation (7%)				\$5,464,748
Additional MOM Monitoring	15	YR	\$50,000	\$750,000
Present Value MOM Monitoring (7%)				\$455,396
TOTAL PRESENT VALUE FOR ALTERNATIVE WITH GWTP				\$10,341,067

*assumes GWTP will operate during source remediation and for 10 yrs following remediation to remove residual groundwater contamination.

Table 6-4
Alternative 2 Cost Estimate: Chemical Oxidation of unsaturated soils / Enhanced Biodegradation
Groveland Wells Source Re-Evaluation
Period of Performance: 7 years

Field Task 1 - Treatability Testing	Number	Unit	Unit Cost	Total Cost
Install test wells - collect soil & GW Samples	1	ls	\$17,400	\$17,400
Laboratory Testing & Field Testing	1	ls	\$15,400	\$15,400
Data Evaluation & Reporting	1	ls	\$5,000	\$5,000
SUBTOTAL				\$37,800
Field Task 2 - Building Demolition/Soil Excavation	Number	Unit	Unit Cost	Total Cost
Subcontractor mobilization/demobilization	1	ls	\$10,000	\$10,000
Air monitoring (PID rental)	1	ls	\$5,000	\$5,000
Demolish Valley Building	1	ls	\$230,000	\$230,000
Excavate Soil >77 ppb + Chemical Oxidation (KMnO4, Labor)	4400	CY	\$150	\$660,000
Excavation Sheeting	3300	SF	\$20	\$66,000
Backfill Material	500	CY	\$25	\$12,500
Dispose of contaminated soils as listed waste	0	tons	\$225	\$0
SUBTOTAL				\$983,500
Field Task 3 - In-Situ Reductive Dechlorination - installation	Number	Unit	Unit Cost	Total Cost
Install Injection Wells	50	EA	\$2,900	\$145,000
Procure and Assemble Injection Apparatus	1	ls	\$8,000	\$8,000
SUBTOTAL				\$153,000
TOTAL				\$1,021,300
Project Management/Oversight	6%	Tasks 1,2,3		\$61,278
Design (Construction)	12%	Tasks 2,3		\$136,380
Construction Management (Construction)	8%	Tasks 2,3		\$90,920
SUBTOTAL REMEDY IMPLEMENTATION				\$1,309,878
30% Contingency				\$392,963
TOTAL CAPITAL COST				\$1,702,841
Field Task 4 - Treatment O&M/Periodic Costs	Number	Unit	Unit Cost	Total Cost
<u>Year 1</u>				
Electron donor/inoculant Injection Round 1	1	ls	\$70,000	\$70,000
Procurement/staging	1	ls	\$3,000	\$3,000
Performance Monitoring	1	ls	\$56,000	\$56,000
Project Management (6%)	1	ls	\$7,740	\$7,740
Contingency (30%)				<u>\$41,022</u>
Total Year 1				\$177,762
<u>Years 2 and 3</u>				
Electron donor/inoculant Injection Rounds 2 and 3	1	ls	\$105,000	\$105,000
Procurement/staging	1	ls	\$3,000	\$3,000
Performance Monitoring	1	ls	\$56,000	\$56,000
Project Management (6%)	1	ls	\$9,840	\$9,840
Contingency (30%)				<u>\$52,152</u>
Total per year				\$225,992
<u>Years 4, 5 and 6</u>				
Performance Monitoring	1	ls	\$56,000	\$56,000
Project Management (6%)	1	ls	\$3,360	\$3,360
Contingency (30%)				<u>\$17,808</u>
Total per Year				\$77,168
<u>Year 7</u>				
Decommissioning	1	ls	\$57,000	\$57,000
Closeout Report	1	ls	\$15,000	\$15,000
Project Management (6%)	1	ls	\$4,320	\$4,320
Contingency (30%)				<u>\$22,896.0</u>
Total Year 7				\$99,216
Present Value:				
Capital Cost	\$1,702,841	\$1,702,841	1.00	\$1,702,841
O&M Year 1	\$177,762	\$177,762	0.93	\$165,319
O&M Years 2 and 3	\$451,984	\$225,992	1.70	\$384,186
O&M Years 4, 5, 6	\$231,504	\$77,168	2.14	\$165,140
O&M Year 7	\$99,216	\$99,216	0.62	\$61,514
TOTAL FOR ALTERNATIVE				\$2,479,000
Additional GWTP Operation	17	YR	\$600,000	\$10,200,000
Present Value GWTP Operation (7%)				\$5,857,934
Additional MOM Monitoring	17	YR	\$50,000	\$850,000
Present Value MOM Monitoring (7%)				\$488,161
TOTAL PRESENT VALUE FOR ALTERNATIVE WITH GWTP				\$8,336,934

*assumes GWTP will operate during source remediation and for 10 yrs following remediation to remove residual groundwater contamination.

Table 6-5
Alternative 3 Cost Estimate: In-situ Gaseous Chemical Oxidation/
In-situ Chemical Oxidation
Groveland Wells Source Re-Evaluation
Period of Performance:5 years

Field Task 1 - Treatability Testing (Ozone)	Number	Unit	Unit Cost	Total Cost
Install test wells - collect soil & GW Samples	1	ls	\$17,000	\$17,000
Laboratory Testing & Field Testing	1	ls	\$19,000	\$19,000
Data Evaluation & Reporting	1	ls	\$10,000	\$10,000
Field Oversight/Review	1	ls	\$4,000	\$4,000
SUBTOTAL				\$50,000
Field Task 2 - Demolition	Number	Unit	Unit Cost	Total Cost
Subcontractor mobilization/demobilization	0	ls	\$10,000	\$0
Air monitoring	0	ls	\$5,000	\$0
Demolish Building	0	ls	\$230,000	\$0
SUBTOTAL				\$0
Field Task 3 - Vadose Zone Ozone Injection System	Number	Unit	Unit Cost	Total Cost
Install Injection Points (25 points)	25	ea	\$2,000	\$50,000
Procure and Assemble Ozone Generator/Injection Apparatus	1	ls	\$122,000	\$122,000
SUBTOTAL				\$172,000
Field Task 4 - In-Situ Chemical Oxidation - Groundwater				
Install Injection Wells	50	EA	\$2,900	\$145,000
Procure and Assemble Injection Apparatus	1	ls	\$8,000	\$8,000
SUBTOTAL				\$153,000
TOTAL				\$375,000
Project Management/Oversight	6%	Tasks 1,2,3,4		\$22,500
Design (Construction)	12%	Tasks 2,3,4		\$39,000
Construction Management (Construction)	8%	Tasks 2,3,4		\$26,000
SUBTOTAL REMEDY IMPLEMENTATION				\$462,500
30% Contingency				\$138,750
TOTAL CAPITAL COST				\$601,250
Field Task 5 - Treatment O&M/Periodic Costs	Number	Unit	Unit Cost	Total Cost
Year 1				
Oxidant Injection Round 1	1	ls	\$155,000	\$155,000
Procurement/staging	1	ls	\$3,000	\$3,000
Ozone generation & assoc maintenance	1	ls	\$12,000	\$12,000
Performance Monitoring	1	ls	\$68,000	\$68,000
Project Management (6%)	1	ls	\$14,280	\$14,280
Contingency (30%)				\$75,684.0
Total Year 1				\$327,964
Years 2 and 3				
Oxidant Injection Round 2	1	ls	\$80,000	\$80,000
Procurement/staging	1	ls	\$3,000	\$3,000
Ozone generation & assoc maintenance	1	ls	\$6,000	\$6,000
Performance Monitoring	1	ls	\$60,000	\$60,000
Project Management (6%)	1	ls	\$8,940	\$8,940
Contingency (30%)				\$47,382
Total per Year				\$205,322
Year 4				
Performance Monitoring	1	ls	\$53,000	\$53,000
Project Management (6%)	1	ls	\$3,180	\$3,180
Contingency (30%)				\$16,854.0
Total Year 4				\$73,034
Year 5				
Decommissioning	1	ls	\$57,000	\$57,000
Closeout Report	1	ls	\$15,000	\$15,000
Project Management (6%)	1	ls	\$4,320	\$4,320
Contingency (30%)				\$22,896.0
Total Year 5				\$94,896
Present Value:				
Capital Cost	\$601,250	\$601,250	1.00	\$601,250
O&M Year 1	\$327,964	\$327,964	0.93	\$305,007
O&M Years 2 and 3	\$410,644	\$205,322	1.70	\$349,047
O&M Year 4	\$73,034	\$73,034	0.76	\$55,506
O&M Year 5	\$94,896	\$94,896	0.71	\$67,376
TOTAL FOR ALTERNATIVE				\$1,378,186
	Number	Unit	Unit Cost	Total Cost
Additional GWTP Operation	15	YR	\$600,000	\$9,000,000
Present Value GWTP Operation (7%)				\$5,464,748
Additional MOM Monitoring	15	YR	\$50,000	\$750,000
Present Value MOM Monitoring (7%)				\$455,396
TOTAL PRESENT VALUE FOR ALTERNATIVE WITH GWTP				\$6,842,934
*assumes GWTP will operate during source remediation and for 10 yrs following remediation to remove residual groundwater contamination.				

Table 6-6
Alternative 4 Cost Estimate: In-situ Thermal Treatment
Groveland Wells Source Re-Evaluation
Period of Performance (1 year)

Field Task 1 - Demolition	Number	Unit	Unit Cost	Total Cost
Subcontractor mobilization/demobilization	0	ls	\$10,000	\$0
Air monitoring (PID rental)	0	ls	\$5,000	\$0
Demolish Building	0	ls	\$230,000	\$0
SUBTOTAL				\$0
Field Task 2 - In-Situ Thermal Treatment System Installation	Number	Unit	Unit Cost	Total Cost
Subcontractor mobilization/demobilization	1	ls	\$250,000	\$250,000
Subsurface Utility Survey	1	ls	\$5,000	\$5,000
Electric Resistive Heating - Source Area	10100	CY	\$75	\$757,500
Electric Resistive Heating - Downgradient (includes drilling, electric, carbon usage, disposal)	2000	CY	\$10	\$20,000
MCL Guarantee	30%			\$309,750
SUBTOTAL				\$1,342,250
TOTAL				\$1,342,250
Project Management/Oversight	6%	Tasks 1,2		\$80,535
Design (Construction)	12%	Tasks 1,2		\$161,070
Construction Management (Construction)	8%	Tasks 1,2		\$107,380
SUBTOTAL REMEDY IMPLEMENTATION				\$1,691,235
30% Contingency				\$507,371
TOTAL CAPITAL COST				\$2,198,606
Field Task 3 - System O&M	Number	Unit	Unit Cost	Total Cost
Remediation System Operation (30% ERH Costs)	1	ea	\$308,250	\$308,250
Other O&M costs	1	ea	\$23,000	\$23,000
Groundwater Monitoring and Reporting	1	ls	\$100,000	\$100,000
Confirmatory Sampling (drilling, sampling, analytical)/Report	1	ea	\$65,000	\$65,000
Project Management (6%)	1	ls	\$51,075	\$51,075
Contingency (30%)				\$164,198
SUBTOTAL				\$711,523
Present Value:				
Capital Cost			Total Cost	Present Value
			\$2,198,606	\$2,198,606
			O&M Year 1	\$661,716
TOTAL FOR ALTERNATIVE				\$2,860,321
			Cost per Year	
			\$711,523	
			Discount Factor (7%)	
			1.00	
			0.93	
				\$2,860,321
			Number	Total Cost
Additional GWTP Operation	11	YR	\$600,000	\$6,600,000
Present Value GWTP Operation (7%)				\$4,499,205
Additional MOM Monitoring	11	YR	\$50,000	\$550,000
Present Value MOM Monitoring (7%)				\$374,934
TOTAL PRESENT VALUE FOR ALTERNATIVE WITH GWTP				\$7,359,526

*assumes GWTP will operate during source remediation and for 10 yrs following remediation to remove residual groundwater contamination.

**Table 6-7
Summary of Costs For Remediation Alternatives (Cost in Millions)
Groveland Wells Source Re-Evaluation**

Alternative #	1A	1B	2	3	4	
	No Further Action	Permanganate Treatment of Unsaturated Soil	Excavation & Disposal of Unsaturated Soil	Permanganate Treatment of Unsaturated Soil	In-situ Ozone Treatment of Unsaturated Soil	Electric Resistance Heating
	Continue MOM - GWTF Operation	In-situ Chemical Oxidation of Saturated Soil	In-situ Chemical Oxidation of Saturated Soil	Enhanced Biodegradation of Saturated Soils	In-situ Chemical Oxidation of Saturated Soil	of Unsaturated and Saturated Soils
Capital Cost - Remediation ¹	\$0	\$1.9	\$3.7	\$1.7	\$0.6	\$2.2
Total Present Value - Remediation	\$0	\$2.6	\$4.4	\$2.5	\$1.4	\$2.9
Period of Performance - Remediation	0 years	5 years	5 years	7 years	5 years	1 year
Period of Performance - GWTF Operation	100 years	15 years	15 years	17 years	15 years	11 years
Additional GWTF Operation Cost	\$60.0	\$9.0	\$9.0	\$10.2	\$9.0	\$6.6
Additional MOM Monitoring Cost	\$5.0	\$0.8	\$0.8	\$0.9	\$0.8	\$0.6
Total Present Value - GWTF Operation	\$8.6	\$5.5	\$5.5	\$5.9	\$5.5	\$4.5
Total Present Value - MOM Monitoring	\$0.7	\$0.5	\$0.5	\$0.5	\$0.5	\$0.4
Total Cost² -						
Remediation + GWTF + MOM	\$65.0	\$12.3	\$14.2	\$13.5	\$11.1	\$10.0
Total Present Value -						
Remediation + GWTF + MOM	\$9.3	\$8.5	\$10.3	\$8.8	\$7.3	\$7.7

Notes:

1. Remediation capital costs for Alternatives 3 and 4 do not include demolition of the Valley Manufacturing Building. An additional capital cost of \$0.4 million would be associated with demolition of the building
2. Total Cost is the sum of Total Present Value of Remediation and additional GWTF and Operation and MOM monitoring costs.

**Table 6-8
Abbreviated Comparative Analysis of Remedial Alternatives
Groveland Wells Source Re-Evaluation**

	Alternative #1A Excavation/Oxidation and Chemical Oxidation	Alternative #1B Excavation/Disposal and Chemical Oxidation	Alternative 2 Excavation/Oxidation and Enhanced Biodegradation	Alternative 3 In-Situ Gaseous Oxidation/Chemical Oxidation	Alternative #4 In-Situ Thermal Treatment
<p>Overall Protection of Human Health & the Environment</p> <p>Comments:</p>	<p>■</p> <p>Removes constituents in unsaturated zone; reduces mass in saturated zone and accelerates remediation of source area groundwater; Protective Solution</p>	<p>■</p> <p>Removes constituents in unsaturated zone; reduces mass in saturated zone and accelerates remediation of source area groundwater; Protective Solution</p>	<p>■</p> <p>Removes constituents in unsaturated zone; reduces mass in saturated zone and accelerates remediation of source area groundwater; Protective Solution</p>	<p>■</p> <p>Reduces mass in both vadose and saturated zones. Will accelerate remediation of source area groundwater. Protective solution.</p>	<p>■</p> <p>Reduces mass in both vadose and saturated zones. Will accelerate remediation of source area groundwater. Protective solution.</p>
<p>Compliance with ARARs</p> <p>Comments:</p>	■	■	■	■	■
<p>Long-Term Effectiveness and Permanence</p> <p>Comments:</p>	<p>■</p> <p>Contaminants will be permanently removed from vadose zone soils and destroyed in-situ in saturated zone.</p>	<p>■</p> <p>Contaminants will be permanently removed from vadose zone soils and destroyed in-situ in saturated zone.</p>	<p>■</p> <p>Contaminants will be permanently removed from vadose zone soils and destroyed in-situ in saturated zone.</p>	<p>■</p> <p>Contaminant concentration will be permanently reduced in vadose and saturated zones and treated onsite.</p>	<p>■</p> <p>Contaminant concentration will be permanently reduced in vadose and saturated zones and treated onsite.</p>
<p>Reduction of Toxicity, Mobility, and Volume through Treatment</p> <p>Comments:</p>	<p>■</p> <p>COCs will be effectively removed from the vadose and saturated zones; toxicity, mobility and volume will all be significantly reduced. Degree of removal will depend on amount of soil excavated and successful oxidant delivery. The presence of DNAPL presents potential for rebound and residual contamination to remain.</p>	<p>■</p> <p>COCs will be effectively removed from the vadose and saturated zones; toxicity, mobility and volume will all be significantly reduced. Degree of removal will depend on amount of soil excavated. The presence of DNAPL presents potential for rebound and residual contamination to remain. However, contaminants in vadose zone soil will not be treated (mass reduction).</p>	<p>■</p> <p>COCs will be effectively removed from the vadose and saturated zones; toxicity, mobility and volume will all be significantly reduced. Degree of removal will depend on amount of soil excavated and successful delivery of electron donor and/or microbe inoculants. The presence of DNAPL presents potential for rebound and residual contamination to remain.</p>	<p>■</p> <p>COCs will be effectively removed from the vadose and saturated zones; toxicity, mobility and volume will all be significantly reduced. Degree of removal will depend on successful oxidant delivery. The presence of DNAPL presents potential for rebound and residual contamination to remain.</p>	<p>■</p> <p>COCs will be effectively removed from the vadose and saturated zones; toxicity, mobility and volume will all be significantly reduced. Mobility will increase as a result of treatment, however it is anticipated that COCs will be captured by the treatment system. Degree of removal will depend on duration of operation. This technology is effective in removing DNAPL.</p>
<p>Short-Term Effectiveness</p> <p>Comments:</p>	<p>■</p> <p>Demolition has minor risks. Site workers may contact impacted media; minimal risk to workers handling chemical oxidants. Excavation and treatment of unsaturated soils to be completed within three months and chemical oxidation in approx. 3 years</p>	<p>■</p> <p>Demolition has minor risks. Site workers may contact impacted media; minimal risk to workers handling chemical oxidants; short-term risk to community due to truck traffic during excavation; excavation to be completed within one month, chem oxidation in approx. 3 years</p>	<p>■</p> <p>Demolition has minor risks; Site workers may contact impacted media; short-term risk to community due to truck traffic during excavation; Excavation and treatment of unsaturated soils to be completed within three months, and enhanced biodegradation by reductive dechlorination in approx. 3 years</p>	<p>■</p> <p>Site workers may contact impacted media; minimal risk to workers handling chemical oxidants; chemical oxidation to be completed in approx 3 years. No demolition is required.</p>	<p>■</p> <p>Site workers may contact impacted media; minimal risk to workers operating heating systems. Thermal treatment to be completed within one year. No demolition is required. Possible inhalation risk if gas extraction wells do not function properly.</p>
<p>Implementability</p> <p>Comments:</p>	■	■	■	■	■
<p>State Acceptance</p> <p>Comments:</p>	■	■	■	■	■
<p>Community Acceptance</p> <p>Comments:</p>	<p>■</p> <p>High truck traffic during excavation and demolition may be of concern to local residents</p>	<p>■</p> <p>High truck traffic during excavation and demolition may be of concern to local residents</p>	<p>■</p> <p>High truck traffic during excavation and demolition may be of concern to local residents</p>	<p>■</p> <p>Least impact to local residents. Community is expected to accept this alternative.</p>	<p>■</p> <p>Community may have concerns about use of heat or electricity in subsurface.</p>
<p>Cost</p>	Refer to Table 6-7 for a comparison of Alternative costs				