EPA Region 1 RAC 2 Contract No. EP-S1-06-03

September 20, 2011
Nobis Project No. 80037

Via Electronic Submittal

U.S. Environmental Protection Agency, Region 1
Attention: Mr. Derrick Golden, Task Order Project Officer
5 Post Office Square, Suite 100
Boston, Massachusetts 02109-3919

Subject: Transmittal of the Final Remedial Action Report
Groveland Wells Numbers 1 and 2 Superfund Site – Operable Unit 2
Groveland, Massachusetts
Remedial Action
Task Order No. 0037-RA-RA-0132

Dear Mr. Golden:

Enclosed with this correspondence is the Final Remedial Action Report for the Operable Unit 2 Remedial Action at the Groveland Wells Numbers 1 and 2 Superfund Site. This RA Report was prepared in accordance with the May 2011 EPA guidance *Closeout Procedures for National Priorities List Sites*. The Final document incorporates revisions that address the comments you provided on the Draft Final Remedial Action Report.

Should you have any questions or comments, please contact me at (978) 703-6025, or dbaxter@nobisengineering.com. It has been a pleasure working with you on the Groveland Wells Site Task Orders and I hope we can work together again in the future.

Sincerely,

NOBIS ENGINEERING, INC.

Diane M. Baxter

Diane M. Baxter
Senior Project Manager

Enclosure

c: File 80037/MA

Remedial Action

Volume I – Text, Tables, and Figures

Groveland Wells Superfund Site – Operable Unit 2
Groveland, Massachusetts

Remedial Action
EPA Task Order No. 0037-RA-RA-0132

REMEDIAL ACTION CONTRACT
No. EP-S1-06-03

FOR

US Environmental Protection Agency
Region 1

BY

Nobis Engineering, Inc.

Nobis Project No. 80037

September 2011

U.S. Environmental Protection Agency

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Volume I – Text, Tables, and Figures

Groveland Wells Superfund Site – Operable Unit 2
Groveland, Massachusetts
Remedial Action
EPA Task Order No. 0037-RA-RA-0132

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Diane M. Baxter
Senior Project Manager

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APPENDICES

ACRONYMS

ACFM	Actual Cubic Feet per Minute
cis-1,2-DCE	cis-1,2-dichloroethene
digiPAM™	Digital Pressure Sensor
digiTAM™	Digital Temperature Sensor
EPA	United States Environmental Protection Agency
ERH	Electrical Resistance Heating
ESD	Explanation of Significant Differences
ET-DSP™	Electro-Thermal Dynamic Stripping Process
GAC	Granular Activated Carbon
gpm	Gallon per Minute
GRC	Groveland Resources Corporation
GWTF	Groundwater Treatment Facility
HP	Horsepower
inch wc	Inch Water Column
ISTT	In Situ Thermal Treatment
kWh	Kilowatt Hour
MCLs	Maximum Contaminant Levels
µg/Kg	Microgram per Kilogram
µg/L	Microgram per Liter
MassDEP	Massachusetts Department of Environmental Protection
MOM	Management of Migration
MPE	Multi-Phase Extraction
NAPL	Non-Aqueous Phase Liquid
O&M	Operation and Maintenance
OEME	Office of Environmental Measurement and Evaluation
OU	Operable Unit
PDS	Power Distribution Systems
PID	Photoionization Detector
ppbv	Part per Billion by Volume
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
RA Report	Remedial Action Report

ACRONYMS (cont.)

ROD	Record of Decision
SC	Source Control
SCFM	Standard Cubic Feet per Minute
SVE	Soil Vapor Extraction
TCE	Trichloroethene
TPV	Temperature Pressure Vacuum
USACE	United States Army Corps of Engineers
USTs	Underground Storage Tanks
VOCs	Volatile Organic Compounds
WCS	Water Circulation Systems

1.0 INTRODUCTION

Nobis Engineering, Inc. (Nobis) has prepared this Remedial Action Report (RA Report) for the Groveland Wells Superfund Site (Site) located in Groveland, Massachusetts (Figure 1-1). The RA Report documents the installation and operation of the remedial action for the Source Control Operable Unit (OU) 2, which was implemented by Nobis in 2009 and completed in 2011. The remedy implemented for OU2 consisted of Soil Vapor Extraction (SVE), enhanced by In Situ Thermal Treatment (ISTT); hereafter, the remedy is referred to as ISTT. The remedial action and this RA Report were completed by Nobis on behalf of the U.S. Environmental Protection Agency (EPA) under Contract No. EP-S1-06-03, Task Order No. 0037-RA-RA-0132.

1.1 Site Location and Description

The Site is located in Groveland, Massachusetts and consists of two Operable Units:

- Source Control, OU2 – the original release area and the immediately surrounding property; and

- Management of Migration, OU1 – an approximately 850-acre study area including the aquifer that recharges the Groveland Municipal Well Stations No. 1 and 2 that were impacted by Site contaminants (Figure 1-1).

Soil and groundwater at the Site are contaminated with volatile organic compounds (VOCs), primarily trichloroethene (TCE) and cis-1,2-dichloroethene (cis-1,2-DCE). OU2, the identified source area for the Site contaminants, is located at the former Valley Manufactured Products Company/Groveland Resources Corporation property at 64 Washington Street in Groveland, Massachusetts (hereafter described as the Valley Manufacturing property) (Figure 1-2). The OU1 remedial action Groundwater Treatment Facility (GWTF) is located on the adjacent property at 62 Washington Street in Groveland, Massachusetts (Figure 1-2). Portions of the OU1 GWTF infrastructure are located on the downgradient properties to the north.

1.2 Report Objective

The remedial action was performed consistent with the provisions of the following documents:

- OU2 Record of Decision (EPA, 1988);

- Explanation of Significant Differences (EPA, 1996a and EPA, 2007);

- Final Summary Report, Thermal Remediation Independent Government Cost Estimate and Scope of Work for Groveland Wells No. 1 & 2 Superfund Site, Groveland, Massachusetts [USACE, 2008];

- Statement of Work for Task Order 0037-RA-RA-0132 [EPA, 2008];

- Work Plan [Nobis, 2009a];

- Work Plan, Amendment No. 1 [Nobis, 2009c];

- Subcontract For Site Remediation Using In Situ Thermal Treatment [Nobis, TerraTherm, 2009];

- Final Design for In Situ Thermal Treatment [TerraTherm, 2010b]; and

- Closeout Procedures for National Priorities List Sites [EPA, 2011].

1.3 Report Organization

This report is organized as follows:

- Section 1, *Introduction*, provides a brief overview of the Site location and purpose of the report.

- Section 2, *Site Background*, presents a brief description of the Site history and previous remedial actions.

- Section 3, *Remedial Action Design*, presents the performance objectives and basis of the ISTT design.

- Section 4, *Construction Activities,* presents an overview of the various ISTT construction activities completed between April 2009 and August 2010.

- Section 5, *Construction Quality Control*, describes the construction oversight activities, pre-final and final inspections, and startup authorization.

- Section 6, *Operations and Maintenance Performance Monitoring,* provides a general description of ISTT monitoring systems, progress monitoring, and system optimizations conducted between August 2010 and February 2011. In addition, this section describes how performance criteria were modified and shutdown decisions were made, and ISTT system maintenance.

- Section 7, *Confirmation Sampling Activities*, presents the field methodologies and results of confirmation sampling events.

- Section 8, *Demobilization and Site Restoration*, presents a description of the ISTT system demobilization and Site restoration activities completed between February 2011 and September 2011.

- Section 9, *Conclusions and Recommendations*, presents the summary, conclusions and recommendations.

- Section 10, *Summary of Project Costs*, presents a summary of estimated and actual project costs.

- Section 11, *Contact Information*, provides contact information for applicable project personnel.

- Section 12, *References*, provides the project document references used throughout this report.

2.0 SITE BACKGROUND

The Valley Manufacturing property was used for metal and plastic parts manufacturing from 1963 until 2001. The original building, in which the Valley Manufactured Products Company (Valley Manufacturing) 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. 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).

Historical processes at the Site 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 and methylene chloride was used from 1979 to 1983. Solvosol and other solvents were also used with the vapor degreasing operations. In 1984, Valley Manufacturing discontinued the use of solvents and replaced them with detergent degreasers (RFW, 1988). Parts that required additional cleaning were 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 (Brite Dip leach field) (RFW, 1988). Based on historical records, several subsurface disposal systems, including an oil/water separator and leach field, were used on the property for the disposal of wastes associated with the parts cleaning operations. Locations of the Brite Dip leach field and oil/water separator and leach field are shown on Figure 1-2.

Six underground storage tanks (USTs) were reportedly installed in the southern portion of the Valley Manufacturing property around 1972 for storage of cutting oils, solvents, and mineral spirits (Figure 1-2). The USTs ranged from 700 gallons to 3,000 gallons. The 700-gallon UST reportedly contained TCE. Later, a porch structure was constructed extending off the south end of the Valley Manufacturing Building and over the UST area; this area, referred to as the Former Porch Area, was used for storage of oils and solvents in drums and small containers.

Cutting oils were reportedly 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. However, interviews with former employees indicate that waste oils were disposed of at the site and were used as a defoliant. In 1973, 500 gallons of TCE were reportedly released from a UST into the soil beneath the Former Porch Area. A total of 3,000 gallons of contaminants is estimated to have been discharged to the environment from several surface and subsurface sources and by routine operations practices over the period that the facility operated (RFW, 1988). Most of the releases appear to have occurred south of the Valley Manufacturing building, beneath the Former Porch Area. These releases migrated through the vadose zone to groundwater beneath the Valley Manufacturing property and eventually contaminated the aquifer that supplied the Town of Groveland's drinking water.

In June and October 1979, Groveland's drinking water supply wells No. 1 and 2, were determined to be impacted with TCE. As a result, the wells were taken off-line and the Town imposed water rationing. Later in 1979, the Town installed another drinking water well, Station No. 3, in a different aquifer. In 1982, EPA determined that the groundwater contamination at the Site constituted a threat to public health and to the environment. EPA placed the Site on the National Priorities List in December 1982.

In 1988, EPA issued a Source Control (SC) Record of Decision (ROD) for OU2 [EPA, 1988] requiring cleanup of the VOC contamination source area on the Valley Manufacturing property. The major components of the selected remedy for the Source Control Operable Unit included:

- Installation, operation, and maintenance of a SVE system to clean all areas of subsurface soil VOC contamination;
- Installation, operation, and maintenance of a groundwater recovery/re-circulation system;
- Installation, operation, and maintenance of a groundwater treatment system to treat contaminated groundwater from the recovery/re-circulation system; and
- Sealing or disconnection of all drains and lines to the Brite Dip subsurface disposal system.

In September 1991, EPA issued the Management of Migration (MOM) ROD for OU1 [EPA, 1991]. The MOM ROD required extraction and treatment of contaminated water from outside the source area and the downgradient plume. The MOM remedial actions were intended to supplement remedial actions required by the SC ROD.

In November 1996, EPA issued Explanation of Significant Differences (ESD) to both the Source Control (OU2) and MOM (OU1) RODs. The ESDs removed the requirement for a separate groundwater extraction and treatment system for the source area and mandated that the groundwater from the source area would be extracted and treated in the OU1 Groundwater Treatment Facility (GWTF) to be constructed downgradient of the Source Area [EPA, 1996b]. However, due to financial issues, Valley Manufacturing was not able to fulfill this obligation. Therefore, EPA made this Site a fund lead with access to federal funding. The OU1 GWTF was constructed beginning in 1999, and began operating in 2000 by treating groundwater extracted from wells located immediately downgradient of the source area and wells farther downgradient, north and south of Mill Pond (Figure 2-1). The OU1 GWTF remains in operation today (2011).

Pursuant to the OU2 ROD, Valley Manufacturing constructed and operated a Source Control SVE system from 1992 through 2002. In April of 2002, Valley Manufacturing ceased operating and maintaining the SVE system due to financial difficulties and terminated all business operations.

EPA performed a comprehensive source area investigation, UST removals, and chemical-oxidation treatment pilot studies between 2004 and 2006 that were documented in the Source Area Re-evaluation Report [M&E, 2006]. The Report concluded that the initial SVE remedial action had been largely ineffective, that significant source area contamination remained, and that chemical oxidation would not be a viable remedial alternative. Based on the results of the Source Area Re-evaluation, EPA concluded that the Source Control remedy should be modified to include ISTT along with SVE to address soil and groundwater contamination remaining on the Valley Manufacturing property within the source area.

In September 2007, EPA issued a second ESD for OU2. The ESD outlined the use of ISTT in conjunction with SVE for subsurface soil and overburden groundwater to increase the effectiveness of the Source Control remedy and thereby remove the continuing source of contamination and decrease the overall length of cleanup time for the Site (OU2 and OU1). The

2007 ESD also included revised soil clean up goals, which were re-calculated using Site-specific data and new EPA guidance (revised from 1988 ROD). Table 2-1 provides a summary of cleanup goals for soil and groundwater. The purpose of the new soil cleanup goals was to ensure that residual soil contamination will not have an adverse effect on groundwater or human health. The recalculated Site-specific soil clean up goals are protective of groundwater Maximum Contaminant Levels (MCLs), direct contact exposures (i.e., the incidental ingestion, dermal contact, and inhalation of dust released from the soil), and for the subsurface vapor intrusion pathway (i.e., the inhalation of contaminated air).

The remedies implemented at the Site (OU1 GWTF and OU2 ISTT) are considered protective in the short term because the contaminated groundwater at the site is not currently being used for public or private water supply purposes and contaminants remaining in subsurface soil in the Source Area are not accessible for human exposure. However, in order to ensure that the remedies remain protective until cleanup standards are achieved throughout the Site, institutional controls are needed to prevent contact with contaminated soil and groundwater in the source area and prevent potable use of groundwater within the contaminant plume. The final implementation of comprehensive institutional controls has not yet been realized. This activity is currently being completed by EPA, Massachusetts Department of Environmental Protection (MassDEP), the responsible party, and the Town of Groveland.

3.0 REMEDIAL ACTION DESIGN

The following sections describe the basis of design, final design, and performance objectives of the OU2 ISTT remedial action.

3.1 Treatment System Description

The ISTT system implemented at the Site consisted of electrical resistance heating (ERH), soil vapor extraction, and liquid extraction systems. The ISTT system works as follows: electricity is applied to the subsurface electrodes in the ERH system; the electrical current passes through the soil, which heats the subsurface soil and groundwater; the heat volatilizes the contaminants trapped in the subsurface and creates soil vapors and steam within the treatment zone. Extraction wells are used to collect the soil vapor, steam, and liquids, preventing their migration to areas outside of the treatment zone. The soil vapor, steam, and liquids are processed and treated using vapor extraction and liquid extraction treatment systems prior to discharge to the environment.

3.2 Basis of Design

This section presents the basis for the selection of ISTT as the remedial approach and the basis of the design of the ISTT system. The basis for selection of the ISTT remedial approach was:

- Historical remedial actions and pilot tests in the source area (SVE system installed and operated by the PRPs and potassium permanganate pilot tests) had minimal effect on reducing the VOC contamination in the Source Area soil [M&E, 2006].

- The historical remedial actions and pilot tests were minimally effective due to the heterogeneity of the subsurface soils and the potential presence of Non-Aqueous Phase Liquid (NAPL) [M&E, 2006].

- Remediation of VOCs in soil and groundwater at the Site is limited by chemical sorption to and desorption from fine-grained soils.

- ISTT would heat up the soil thus causing the contaminants to volatilize and migrate under pressure. The contaminated vapors would be recovered with SVE [M&E, 2006].

- Heating the subsurface to temperatures around the boiling point of water can lead to significant changes in the thermodynamic conditions in the subsurface and can make NAPL, if present, more mobile and removable.

The basis of the design of the ISTT system is to heat the subsurface to create the following thermodynamic conditions that enhance contaminant removal:

- Adsorption coefficients are reduced moderately, leading to an increased rate of desorption of VOCs from the soil [Heron, et al., 1998].

- Henry's law constants are reduced, increasing the volatilization of VOCs from groundwater to soil vapor.

- The vapor pressure of NAPL increases with temperature. As the subsurface is heated from ambient temperature to temperatures in the range of 100°C, the vapor pressure of NAPL constituents will typically increase between 10 and 30-fold [Udell, 1996].

- Viscosity of NAPL is reduced by heating. The higher the initial viscosity, the greater the reduction. For TCE and other chlorinated solvents, the viscosity typically is reduced by about a factor of 2.

- NAPL-water interfacial tensions are cut in half, which can lead to improved recovery as a liquid. However, this change is very modest compared to the vaporization mechanism.

- Boiling of NAPL occurs at temperatures below the boiling point of water [DeVoe, et al., 1998]. At the Site, with TCE a potential predominant NAPL constituent, an estimated boiling point for the NAPL is between 70 and 80°C. Heating the subsurface to 70 to 80°C will make NAPL thermodynamically unstable, causing it to boil and convert to a vapor. Thus, once the temperature throughout the saturated portion of the target treatment zone has reached 80°C or higher, NAPL, if present, will no longer be able to exist and can be extracted as vapor and treated.

Performance objectives and metrics (Section 3.4) were developed to ensure these conditions were created in the subsurface.

Implementation of ISTT leads to the removal of VOCs as vapor (volatilized from soil and groundwater), as dissolved contaminants in extracted groundwater, and as NAPL phase if NAPL is present in the subsurface. To capture each mobilized phase, vapor and liquid extraction systems are needed to maintain hydraulic and pneumatic control, such that the mobilized phases travel towards the extraction wells and cannot migrate away from the treatment area.

3.3 Final Design

The Final ISTT Design for the Site was developed based on the Conceptual ISTT Design developed by the United States Army Corps of Engineers (USACE), Nobis, and EPA. The

Conceptual Design was initially developed by USACE in 2008 based on the 2006 Source Area Re-Evaluation prepared by Metcalf & Eddy [USACE, 2008]. The Conceptual Design was refined by Nobis [Nobis, 2009b], in collaboration with the EPA Remedial Project Manager and an ISTT expert from the EPA Office of Research and Development. The revised Conceptual Design was used as the basis for the detailed Statement of Objectives and Performance Metrics included in the solicitation of a remedial action contractor to complete the detailed design and implementation of ISTT at the Site. Nobis contracted TerraTherm, Inc. (TerraTherm) to design, construct, and operate an ISTT program to meet the remedial objectives and achieve the performance objectives and metrics described in the Conceptual Design.

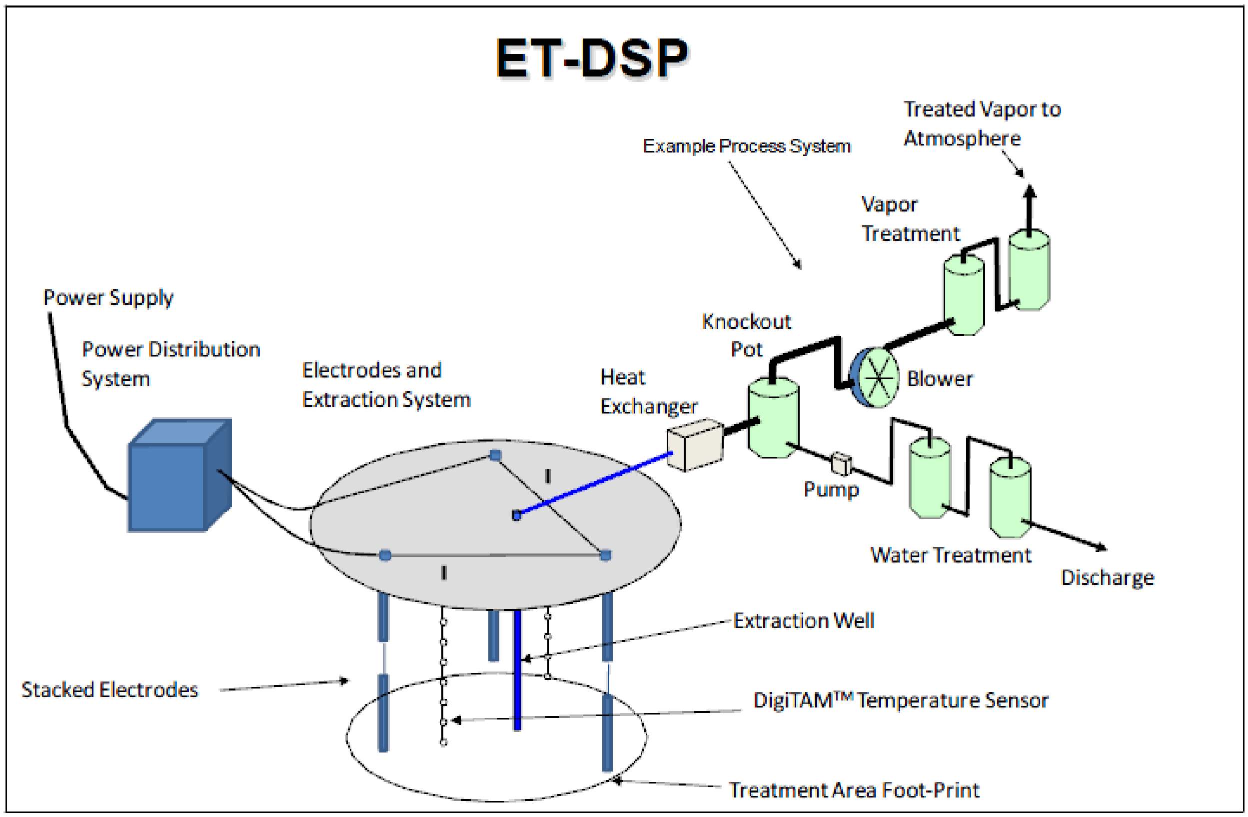
The lateral and vertical extent of the treatment zone was determined by the USACE based on the 2006 Source Area Re-Evaluation [M&E, 2006], and subsequently refined by Nobis based on the 2009 Baseline Investigation (Section 4.23, Appendix A) [Nobis, 2010c]. The ISTT treatment zone consists of four ISTT Areas of varying treatment depths encompassing the contamination located within the vadose and saturated zones (Figure 3-1). The total area of the treatment zone was approximately 14,830 square feet, with a total volume of 17,450 cubic yards (Table 3-1).

The treatment zone was divided into four contiguous ISTT Areas, as follows:

- ISTT Area A – vadose zone soil and overburden groundwater with a treatment depth of ground surface to the top of bedrock or approximately 45 ft bgs;
- ISTT Area B – vadose zone soil with a treatment depth of ground surface to 25 ft bgs;
- ISTT Area C – vadose zone soil with a treatment depth of ground surface to 10 ft bgs; and
- ISTT Area D – vadose zone soil with a treatment depth of ground surface to 10 ft bgs.

To treat the soil and groundwater at the Site, a design was developed for application of Electro-Thermal Dynamic Stripping Process (ET-DSP™) in the vadose and saturated zones at the Site. ET-DSP™ involves heating soil in the saturated and unsaturated zones by passing an electrical current between electrodes buried in the soil, with simultaneous circulation of water through the electrodes in order to transfer heat by convection. The coupling of electrical heating with heat transfer by convection enhances the efficiency and uniformity of the ISTT technology.

The ISTT system design included ET-DSP™ in combination with both soil vapor extraction and liquid extraction systems. The figure below shows a typical layout of an ET-DSP™ remediation process. Heating (ET-DSP™), vapor extraction (vacuum), liquid extraction (pumping), and water/saline injection systems were designed to be simultaneously applied to the soil and groundwater within the treatment zone using an array of electrodes and soil vapor and multiphase extraction wells. The ISTT system was designed to heat soil and groundwater temperatures to 90°C and 100°C, respectively (Section 3.4).



The major components of the ISTT system final design are identified below and described in greater detail in the following pages.

- ET-DSP™ electrodes installed in the subsurface deliver electrical current to the treatment areas;
- Temperature, pressure, and vacuum monitoring systems;

- Vapor extraction and liquid extraction systems (wells, manifolds, conveyance piping, and treatment process equipment) to maintain hydraulic and pneumatic control within treatment zones and treat extracted fluids;

- A transformer delivering power for the ET-DSP™ electrodes and soil vapor and liquid extraction systems;

- Power distribution systems with controls, switches, and meters controlling power distribution to ET-DSP™ electrodes;

- Water circulation units supplying water to the ET-DSP™ electrodes;

- Cables and water injection and return lines for ET-DSP™ electrodes;

- Vapor cover to prevent rainwater and snowmelt infiltration and to provide a surface seal for effective capture of vaporized contaminants by vacuum extraction; and

- Emergency power to maintain hydraulic and pneumatic control in the case of an unplanned power loss.

As part of the implementation of ISTT system, six different types of wells were designed and constructed within the ISTT Areas, as described below.

- 40 Standard Electrode Wells – 10 inch diameter soil boring with 1 to 3 electrodes (8-inch diameter, 10-feet long) installed in each boring, designed to supply electrical current to the subsurface. The number of electrodes in each boring is determined based on the required treatment depth in the area of electrode well.

- 24 Mini Electrode Wells – 6 ⅝ inch diameter soil boring with 1 to 3 electrodes (6-inch diameter, 8-feet long) installed in each boring inside the Valley Manufacturing building, to supply electrical current to the subsurface beneath the building. The number of electrodes in each boring is determined based on the required treatment depth in the area of electrode well. The smaller diameter borings were required because the height of the building interior restricted the size of the drilling equipment (and size of the boring).

- 29 Shallow Soil Vapor Extraction Wells – 2-inch steel casing with stainless steel screens designed to recover vapors from the unsaturated zone from 2 to 12 ft bgs via vacuum and to maintain pneumatic control.

- 15 Multi-Phase Extraction Wells – 4-inch diameter steel casing with stainless steel screen designed to extract fluids and vapors from the unsaturated and saturated zones from 25 to 45 ft bgs and to maintain pneumatic and hydraulic control.

- 16 Temperature Sensor Wells – 2-inch fiberglass blank casing with temperature sensors placed every 3 feet beginning at the ground surface to approximately 10 or 45 ft bgs, depending on the depth of the corresponding ISTT Area.

- 12 Temperature, Pressure, and Vacuum Sensor Wells – 2-inch fiberglass casing with slotted screen from approximately 4 to 45 ft bgs to monitor water pressure and vacuum for evaluation of hydraulic and pneumatic control. In addition, a 2-inch fiberglass blank casing was installed in the same borehole, with temperature sensors placed every 3 feet beginning at the ground surface to approximately 45 ft bgs, to monitor subsurface temperatures.

The ISTT vapor extraction and liquid extraction systems were designed to control the migration of VOCs from the ISTT Areas, treat recovered vapors before discharge to the atmosphere, and treat extracted liquids prior to discharge to the OU1 GWTF. The design for the vapor extraction system consisted of the following major components:

- Heat exchangers – to cool vapors extracted from the ISTT Areas;

- Cooling tower and chiller – used in conjunction with heat exchangers to cool vapors extracted from the ISTT Areas;

- Moisture knockout tanks – to remove entrained liquids from recovered vapor stream;

- Vacuum blowers – to create vacuum used to extract vapors from ISTT Areas and move recovered vapors through the vapor extraction system;

- Duct heater – to adjust the relative humidity of the recovered vapors for efficient treatment of effluent air and to minimize condensation in the Granular Activated Carbon (GAC) vessels; and

- GAC vessels – to treat the recovered vapors (removes VOCs) prior to discharge to the atmosphere.

The design for the liquid extraction system consisted of the following major components:

- Bag filters – to remove entrained sand and grit to protect downgradient process equipment;
- Heat exchanger – to cool liquids extracted from the ISTT Areas for efficient treatment in downgradient process equipment;
- Oil/Water Separator – to separate and remove NAPL from recovered liquids; and
- Transfer pump and conveyance – to move recovered liquids to the OU1 GWTF for treatment.

The ISTT final design [TerraTherm, 2010b] was reviewed and accepted by Nobis, on behalf of EPA, in February 2010.

3.4 Performance Objectives

The overall purpose of the ISTT system is to reduce contaminant concentrations in source area soils and overburden groundwater to below the cleanup goals specified in the 2007 ESD (Table 2-1) in order to protect human health and the environment and reduce the overall cleanup time for Site. The ISTT system performance objectives and metrics were developed with the goal of meeting this overall purpose. However, because of the uncertainty involved in any in situ treatment and the potential high cost of ISTT for achieving low cleanup concentrations (such as the specified Site groundwater cleanup goals of MCLs), an alternate performance endpoint was established by the project team that would allow ISTT to be terminated before attainment of the cleanup goals if the contaminant removal rate diminished to the point where continued operation of the ISTT system was not cost effective, i.e. the "point of diminishing returns."

The ISTT performance objectives and associated metrics for achieving the performance endpoints were established to evaluate heating performance and efficiency and to demonstrate capture of the contaminated soil vapor and groundwater in the ISTT Areas during ISTT system operation [Nobis, 2009b]. The performance objectives and metrics defined to evaluate heating performance are summarized below. A complete listing of ISTT performance objectives and metrics is provided in Table 3-2.

- The minimum target temperature for the vadose zone is 90°C (194°F), where the vadose zone is assumed as 0 to 25 feet below ground surface (ft bgs); and
- The minimum target temperature for the saturated zone is the boiling point of water (approximately 100°C or 212°F), where the saturated zone is assumed as 25 to 45 ft bgs.

Performance metrics for meeting the target temperatures are further defined as:

- 85 percent of the temperature sensors within the vadose zone reach 90°C (194°F);
- 85 percent of the temperature sensors within the saturated zone reach the boiling point of water (approximately 100°C or 212°F); and
- 100 percent of the temperature sensors within both the vadose and saturated zones reach 60°C (140°F).

4.0 CONSTRUCTION ACTIVITIES

ISTT construction activities began in April 2009 and included community involvement activities that included preparing and mailing community updates. Other ISTT construction activities included: Site preparation; subsurface construction of the ISTT Areas, ISTT extraction systems, and the ET-DSP™ system; electrical installations; and startup testing. The following sections present the ISTT construction activities.

4.1 Community Involvement

In preparation for ISTT construction activities, Nobis assisted the EPA with the development of a Community Involvement Plan which documented the planned ISTT operations, described community involvement activities to keep the neighboring residents informed, and provided opportunities to be involved [Nobis, 2009d]. Nobis and EPA held several one-on-one meetings with neighboring residents in preparation for ISTT construction. ISTT operations, access issues, and health and safety concerns were discussed with the neighboring residents because several residential homes are located immediately adjacent to the treatment area.

4.2 Site Preparation

Site preparation activities began in April 2009 and included abandonment of polyvinyl chloride (PVC) monitoring wells, installation of stainless steel replacement wells, a baseline soil and groundwater investigation, and several ISTT construction preparation activities. These site preparation activities are described in the following sections.

4.2.1 Polyvinyl Chloride Monitoring Well Abandonment

In July 2009, twenty-three PVC groundwater monitoring wells and six PVC vapor extraction wells were abandoned within the ISTT Area (Figure 3-1). The wells were abandoned because the PVC well materials could not withstand the anticipated elevated temperatures of ISTT. The wells were abandoned using a high temperature compatible neat cement grout, composed of Type II Portland Cement, granular bentonite, and potable water mixed at a ratio of approximately one 94-lb. bag cement, 4 to 5 lbs (approximately 5 percent) bentonite, and 6 gallons of water. The grout mixture was injected into the bottom of the well by tremie method and filled upwards as the downhole tools were withdrawn to eliminate any void spaces. The grout mixture extended continuously the full depth of the well to the bottom of the protective casing. The protective casing and the top portion of the monitoring well riser were removed to approximately 2 ft bgs using over-drilling methods. Neat cement was used to fill the monitoring well void to the ground surface.

4.2.2 Replacement Wells Installation

In August 2009, ten overburden monitoring wells and two bedrock monitoring wells were installed within the ISTT Area to better define and understand the source area groundwater conditions. Drilling for the replacement wells was performed using sonic drilling techniques. The replacement monitoring wells were constructed of type 316 stainless steel to ensure that the monitoring wells would withstand the high temperatures and chemical conditions expected during ISTT operations. The wells were constructed using sand filter pack materials around the well screen and high-temperature compatible neat grout (described in Section 4.2.1) to seal the annular space above the screened interval.

The overburden monitoring wells were constructed using 2-inch diameter stainless steel with 10 foot long screens installed just above the top of bedrock. Monitoring well boring and construction logs are included in the Data Summary Report (Appendix A) and described in Table 4-1.

The bedrock monitoring wells were constructed using 4 inch diameter stainless steel with 20 foot long screens. The larger diameter well materials and long screens were used to allow the bedrock monitoring wells to later be converted to groundwater extraction wells, if needed. The location of the bedrock monitoring well screen in each well was selected based on the results of packer testing performed in the open borehole. Using an inflatable packer, the open borehole was segregated off in 10 foot intervals beginning just below the top of competent bedrock and continuing 30 to 50 feet. The segregated bedrock unit was pumped using a submersible pump to determine a sustainable flow rate. The monitoring well screen intervals were placed in the zones with the highest sustained flow rates. Sustained flow rates observed during packer testing did not exceed 1 gallon per minute (gpm).

4.2.3 Baseline Investigation

A soil and groundwater baseline investigation was completed and documented in the Baseline Investigation Data Summary Technical Memorandum (Memorandum) submitted to EPA on June 2, 2010 (included in the Data Summary Report, Appendix A). The purpose of the baseline investigation was to identify the VOC concentrations prior to treatment and to confirm the contaminant extent, particularly in Area D, for use in the ISTT design. The Memorandum summarized the field and laboratory data collected during the baseline investigation which included the following:

- Soil investigation in ISTT Area D – July 2009;
- Soil investigation during the installation of replacement monitoring wells – August 2009;
- Soil investigation during the ISTT system subsurface installation – March and April 2010;
- Groundwater investigation of historical groundwater monitoring wells – June and July 2009;

- Groundwater investigation of replacement groundwater monitoring wells – August 2009; and
- Ambient air monitoring – January 2010.

The baseline soil sample results were generally consistent with the results observed in the 2004 and 2006 Source Area Re-Evaluation investigation activities (Section 2.0). Figures 4-1 through 4-3 describe TCE concentrations with respect to the soil cleanup goal of 77 micrograms per kilograms (µg/kg) at the various depths. The highest contaminant concentrations and the highest frequency of contaminants occurring at levels exceeding soil cleanup goals were observed below the Former Porch Area (Figure 1-2). The highest TCE concentrations were detected in soil samples collected from E-43 from 4 to 5 feet bgs (20,000 µg/kg) and RW-05 from 3 to 4 feet bgs (11,000 µg/kg) (Figure 4-1). The complete data are presented and further summarized in the Data Summary Report (Appendix A).

As a result of the baseline soil investigation completed within ISTT Area D, the extent of ISTT Area D was expanded to ensure complete treatment of this area. These changes were documented in the ISTT Final Design [TerraTherm, 2010b]. The baseline soil data are used to evaluate the overall effectiveness of ISTT by comparison to confirmation soil samples (Section 7.0).

The baseline groundwater investigation results were generally consistent with the results observed in the 2004 and 2006 Source Area Re-Evaluation investigation activities. TCE and cis-1,2-DCE were the predominant contaminants detected above Site cleanup goals, with the highest contaminant concentrations in groundwater located beneath the Former Porch Area and the southern portion of the Valley Manufacturing Building. Figures 4-4 and 4-5 describe the baseline TCE and cis-1,2-DCE concentrations in groundwater, respectively, with respect to groundwater cleanup goals of 5 micrograms per liter (µg/L) for TCE and 70 µg/L for cis-1,2-DCE. The highest TCE concentrations detected in groundwater (11,000 µg/L to 96,000 µg/L) were from approximately the same area where the highest TCE concentrations in soil were detected (RW-03, RW-05, TW-42, and TW-43 – located within the Former Porch Area). The highest cis-1,2-DCE concentrations in groundwater were detected in the same area (maximum 1000 µg/L in TW-42).

As a result of the baseline groundwater investigation, ISTT Area C was extended deeper within the interior of the Valley Manufacturing building. These changes were documented in the ISTT Final Design [TerraTherm, 2010b]. The baseline groundwater data are used (Section 7.0), in combination with data collected during and after the ISTT operation, to evaluate the progress and overall effectiveness of ISTT.

The purpose of baseline ambient air monitoring was to establish baseline conditions for comparison to ambient air monitoring events conducted during ISTT operations.

4.2.4 ISTT Construction Preparation

In preparation for ISTT system construction and operation, the following ISTT construction preparation activities were completed:

- Subsurface geophysical survey;
- Topographic survey;
- Fencing modifications;
- Installation of sedimentation and erosion controls;
- Clearing and grubbing;
- Tree removal;
- Site grading;
- Truck well modifications;
- Mold abatement; and
- Decommissioning of Source Area extraction wells.

These site preparation activities are described in the following paragraphs.

Subsurface Geophysical Survey

A subsurface geophysical survey was conducted in order to identify any subsurface utilities located within the ISTT Areas. The geophysical survey provided data on subsurface conditions and metal materials present and was used in planning for the Replacement Well installations, ISTT system design, and ISTT Areas subsurface installations.

Location and Topographic Survey

A location survey was performed at the Site to include all significant features, such as, groundwater monitoring wells (old monitoring wells prior to abandonment and new replacement wells following installation), existing management of migration extraction wells, buildings, fence lines and gates, utilities, waterways, swales, trees and shrub lines, foundation edges, and pavement edges. The location survey was performed at 62 and 64 Washington Street. In addition, a topographic survey was performed in the planned ISTT Areas. The purpose of the topographic survey was to provide an accurate base map for ISTT system design, including the design of any required grading or fill. The survey was also used as a starting point for the as-built plans.

Fencing Modifications

The existing fence line and gates were modified as described on Figure 4-6 and shown in construction photographs (Appendix B). The existing fence and gates adjacent to Washington Street were replaced. The new fence consists of both metal and wood fence posts. Non-electrically-conductive materials (wood) were used for fence posts installed within 25 feet of the ISTT Areas to ensure that the fence would not become electrically charged. Additionally, the chain link fence fabric was hung so that there was a minimum of 3 inches of clearance between the ground and the fence fabric, to eliminate the possibility of arcing of electrical current.

A section of existing chain-link fence within the ISTT Areas, along the border of the GWTF property, was temporarily removed and preserved during the ISTT construction and operations. This fence was replaced during Site restoration activities (Section 8.0). In addition, the wooden stockade fence located at the northern portion of the 106 Center Street residential property was removed in preparation for ISTT construction and operation because the fence and property line are within the limits of the ISTT Areas. A temporary construction fence was installed approximately 10 to 20 feet farther south, outside of the ISTT Areas boundary. The temporary fence was consisted of chain link fence set on wooden posts. On the exterior of the temporary construction fence, the wood stockade panels were used to provide an aesthetically pleasing temporary fence for the resident located at 106 Center Street. New vinyl and wood replacement fences were installed during Site restoration along the 106 Center Street border with the Valley Manufacturing property (Section 8.0).

Sedimentation and Erosion Controls

Sediment and erosion controls were installed at select locations within the ISTT Areas. Photographs of the sediment and erosion controls are provided in Appendix B. The controls, which consisted of straw bales and silt fences, were designed to capture and treat any stormwater runoff from the Site. The controls were installed at locations described on Figure 4-6. Sediment and erosion controls were removed during the Site restoration activities (Section 8.0).

Clearing and Grubbing and Tree Removal

In preparation for ISTT construction and operation activities, the ISTT Areas were cleared and grubbed of any small trees, shrubs, roots, brush, organic matter, debris, and miscellaneous structures (Appendix B). Further, three large (24 to 30 inch diameter) White Pine trees were removed prior to ISTT construction activities (Appendix B). These trees were cut flush to the ground surface leaving the trunk and roots in place. Six deciduous trees (6 to 8 inch diameter) within the ISTT well field were not removed [Nobis, 2009e] at the request of the neighboring resident at 106 Center Street. ISTT construction activities in the vicinity of the deciduous trees were modified in an attempt to preserve the deciduous trees. No adverse effects to these trees were observed during ISTT operations (heating). In April 2011, buds and new growth were observed on all six of the deciduous trees that were kept in place and the trees appeared to remain healthy through the Site restoration period.

Site Grading

Select areas within the ISTT Areas were filled and graded to prevent flooding and to promote the draining of stormwater runoff to the existing drainage swale during the ISTT construction and operation (Figure C102 in Appendix C). Historically, stormwater ponding has occurred along the southern boundary of the Site, including the neighboring residential properties located at 106 and 108 Center Street (Figure 1-2). Fill and grading activities prevented stormwater ponding at these locations during ISTT system construction and operations (Section 5.1).

Truck Well Modifications

In preparation for the drilling operations (ISTT Areas subsurface installations, Section 4.3) in the Valley Manufacturing building, the truck well area was filled. The fill provided a platform for drilling and prevented flooding of the area. The exterior portion of the truck well was also filled and a sump and gravel filter were installed to collect any stormwater which flowed to the truck well from Washington Street. A description of the grading activities is included on Figure C102 of Appendix C. In addition, photographs are included in Appendix B.

Mold Abatement

In preparation for drilling operations inside the Valley Manufacturing building during the ISTT Areas subsurface installations, a limited mold abatement was completed. Mold abatement activities included the removal of old ceiling tiles and other moldy materials, installation of a containment wall, and heating and drying of the containment area. Photographs of the mold abatement activities are included in Appendix B. Due to the extent and health hazards related to the mold, personal protective equipment (coveralls and respirators) was needed inside the building during ISTT construction and operation activities.

Decommissioning of Source Area Groundwater Extraction Wells

The OU1 Extraction Wells (EW-S1, EW-S2, and EW-S3) located within the ISTT Areas were decommissioned in April 2010 to prepare for ISTT construction and operation activities. The decommissioning of OU1 Extraction Wells consisted of removing extraction pumps and disconnecting and removing electrical supply and data communication lines and conduit. These lines powered and controlled the groundwater extraction pumps in the OU1 Extraction Wells. The conduit was cut off at a location approximately 25 feet outside of the ISTT. Temporary, above-ground power was installed to OU1 Extraction Well EW-S1, the most productive of the three wells, so that source area extraction could continue as long as possible. The operation of OU1 Extraction Well EW-S1 continued during ISTT construction until it was shut off and the pump was removed in July 2010 in preparation for ISTT startup activities.

4.3 ISTT Areas Wellfield Installations

ISTT Area wellfield installations included both subsurface installations (wells and electrodes) and the mechanical construction of the above-ground components of the wellfield (well heads and piping).

Subsurface installations in the ISTT Areas began in March 2010 and concluded in April 2010. Subsurface installations included the following:

- 64 electrode wells (40 standard and 24 mini electrodes),
- 143 electrodes (1 to 3 per electrode well),
- 29 shallow soil vapor extraction (shallow SVE) wells,
- 15 multi-phase extraction (MPE) wells,
- 16 temperature sensor wells,
- 12 temperature, pressure, and vacuum (TPV) sensor wells, and
- Concrete vapor cover.

Following the completion of the above-mentioned installations, the mechanical construction in the wellfield commenced in April 2010 and concluded in May 2010. Mechanical construction included the following:

- SVE, MPE, and sensor well heads, and
- Extraction conveyance lines and manifolds.

Wellfield installation activities were monitored by the Resident Engineer (Section 5.1) and progress was tracked in the weekly Construction Status Reports (Appendix D) distributed to the project team. The installation activities are described below.

The electrodes, shallow SVE wells, MPE wells, and sensor wells were installed using mini-sonic drill rigs, as shown in the construction photographs (Appendix B). The layout of electrodes was based on the results of the Numerical Simulation Study performed for the Final Design [TerraTherm, 2010b]. The 64 electrode well locations consisted of 40 standard, 8-inch diameter, electrode wells located outside the Valley Manufacturing building and 24 mini, 6-inch diameter, electrode wells located inside the building. The electrodes were spaced approximately 19.7 feet on center outside the Valley Manufacturing building and 16.4 feet on center inside the Valley Manufacturing building. The closer spacing for electrodes inside the Valley Manufacturing building was necessary because low clearance (overhead obstructions) inside the building required the use of a smaller drill rig and installation of smaller diameter electrodes (6-inch diameter electrode).

In total, 143 electrodes were installed within the ISTT Areas, with 1 to 3 electrodes installed in each electrode well, depending on the depth of the treatment zone. Electrode wells located within ISTT Area A (treatment depth 45 feet) contained three electrodes per boring, wells within ISTT Area B (treatment depth 25 feet) generally contained two electrodes per boring, and wells within ISTT Areas C and D (treatment depth 10 feet) generally contained a single electrode per boring. The electrode layout and number of electrodes installed at each location are identified on Figure C103 of the Construction As-Builts (Appendix C). Electrode wells were installed consistent with the construction details shown on Figure C104 of Appendix C.

Shallow SVE and MPE wells were located in and around the ISTT Area to collect volatilized and dissolved contaminants and ensure hydraulic and pneumatic containment of contaminants within the treatment area. At 15 locations, within ISTT Area A, the shallow SVE wells were co-located with the MPE wells (Figure C103 of Appendix C). The shallow SVE wells located in ISTT Areas A, C, and D were screened from 2 to 12 ft bgs. Shallow SVE wells located in ISTT Area B were screened from 2 to 22 ft bgs. The MPE wells, all located in Area A, were screened from 25 to 45 ft bgs and contained bottom-loading pneumatic pumps for groundwater and NAPL recovery (Figure C107 of Appendix C). MPE well heads were completed with a saddle which allowed for the extraction of deep soil vapor from the exposed screen at each MPE location (Figure C108 of Appendix C).

Temperature sensor wells were installed at 16 locations in ISTT Areas A, C, and D and around the perimeter of the ISTT Areas (Figure C103 of Appendix C). Temperature sensor wells were installed equidistant between electrode pairs or in the center of electrode triangles, which ensured uniform temperature monitoring in the ISTT Areas. At each temperature sensor well location, a digiTAM™ (digital temperature sensor) was installed in a sealed subsurface drop tube. A digiTAM™ is a string of digital temperature sensors installed at a vertical spacing interval of approximately 3 feet from just below the ground surface to the bottom of the treatment zone where the sensor is located. Temperature sensor wells were installed consistent with the construction details shown on Figure C105 of Appendix C. The monitoring of subsurface temperatures within the ISTT Areas is discussed in greater detail in Section 6.1.1.

TPV wells were installed at 12 locations in ISTT Areas A, C, and D and around the perimeter of the ISTT Areas (Figure C103 of Appendix C). TPV wells included a temperature sensor well, as described above, and a co-located pressure/vacuum sensor well used to monitor pressure (or water level changes). At each pressure/vacuum sensor well location, a digiPAM™ (digital pressure sensor) was installed in a slotted drop tube. A digiPAM™ is a digital pressure sensor that records changes in pressure related to water level fluctuations. The slots in the drop tube allowed for the digiPAM™ to be in constant communication with the groundwater in the surrounding formation. A vacuum monitoring point was installed at the surface of the slotted drop tube, allowing for the manual collection of vacuum readings from the TPV wells. TPV wells were installed consistent with the construction details shown on Figure C105 of Appendix C.

Well construction materials were selected based on the electrical properties, Site geology, target temperatures, and potential degradation products that may be generated during heating. Because the Site is contaminated with chlorinated VOCs, such as TCE, which can hydrolyze and generate small amounts of hydrochloric acid, well materials were selected for proper corrosion resistance. The following well construction materials were used:

- Electrodes – pre-fabricated, proprietary steel electrodes;
- Shallow SVE and MPE wells – stainless steel screens and thick-walled steel casings; and
- Temperature and TPV sensor wells – fiberglass.

Following the installation of the ISTT wells (electrodes, shallow SVE, MPE, temperature sensor, and TPV wells), the concrete vapor cover was installed. An approximately 3-inch thick concrete cover was applied to the ISTT Areas to minimize precipitation infiltration and to enhance pneumatic and hydraulic control. Some areas within the ISTT Areas were already covered with concrete (interior of Valley Manufacturing building and part of the Former Porch Area) and did not require the installation of the vapor cover.

After the vapor cover was allowed to set, well heads were constructed at each of the extraction (shallow SVE and MPE) and sensor (temperature and TPV) wells, consistent with the well completion details shown in Figures C108 and C106 of Appendix C, respectively. In addition, construction of vapor and liquid extraction conveyance lines and associated manifolds were completed (Appendix B). Selection of the construction materials for well heads and conveyance lines followed a similar rationale to that used for selection of well construction materials. The following materials were used to construct the well heads and conveyance:

- Shallow SVE and MPE well heads – carbon steel and Kynar®;
- Vapor extraction conveyance lines – reinforced fiberglass; and
- Liquid extraction conveyance lines – carbon steel.

A Kynar® nipple was installed at each of the extraction well heads to electrically isolate the two grounding systems (ISTT extraction system and ET-DSP™ system) that converged at the extraction well heads.

4.4 ISTT Extraction and Treatment Systems

Vapor and liquid extraction and treatment systems were designed and constructed at the Site for use during ISTT operations. The following sections describe the construction of the ISTT extraction systems.

4.4.1 Vapor Extraction and Treatment System

Construction of the vapor extraction and treatment system began with the receipt of major process equipment in June 2010 and continued into July 2010. Following delivery, the process equipment was set in the designated locations and the mechanical connections were built between the vapor process equipment as described in the Construction As-Builts (Figures M-101, P-101, and P-102 of Appendix C).

The vapor extraction and treatment system was constructed so that vapors extracted from the ISTT Areas were first introduced to heat exchangers to reduce the moisture content. A cooling tower provided the cooling water to the heat exchanger. After the vapor stream was initially cooled by the heat exchanger, the vapor stream was drawn through the first moisture knockout tank to remove condensate and entrained liquid droplets and then through the vacuum blower system. The vacuum blowers provided the force to pull vapors from the wellfield into and through the various vapor extraction system process equipment skids.

The vacuum system consisted of two rotary lobe positive displacement, vacuum blowers, powered by a 40 horsepower (HP) motor designed to handle the expected peak flow and vacuum conditions of 1,287 actual cubic feet per minute (ACFM) at 85 inch water column (inch wc), with a discharge pressure of 15 inch wc. The blowers were automatically controlled by a variable frequency drive that modulated the speed of the blowers to maintain the desired flow and vacuum. The vacuum blowers were configured in duplex fashion so that the second blower would be immediately available in the event of a problem with the primary blower.

Following the vacuum blowers, the vapor stream passed through the second heat exchanger, the chiller, and the second moisture knockout tank to further reduce the temperature and the amount of condensate and entrained liquid in the vapor stream. The vapor stream was then heated and dried by the duct heater to adjust the relative humidity to below 50 percent and minimize condensate formation in the GAC vessel. The vapor stream passed through two GAC vessels prior to discharge to ambient air through the stack.

4.4.2 Liquid Extraction and Treatment System

Construction of the liquid extraction and treatment system began in June 2010 with delivery of the major process equipment. Mechanical construction of the system continued into July 2010.

The liquid extraction and treatment system was designed to provide pre-treatment of all liquids generated during ISTT operations before discharge to the OU1 GWTF for final treatment. The objective of the pre-treatment was to reduce the temperature and remove particulate matter and any NAPL from the liquid stream to minimize potential for fouling or other interference with the GWTF operations. The water extracted from the ISTT Areas was filtered through a pair of bag filters to remove any particulate matter, and then processed through a heat exchanger to reduce the liquid temperature. The process water, as well as condensed liquid from the vapor extraction system's moisture knock out tanks, was allowed to flow into an oil/water separator to separate and collect any NAPL. Following the oil/water separator, ISTT process water was transferred to the OU1 GWTF for final treatment. Any separated NAPL was collected and stored for later disposal.

The liquid extraction system was integrated with the OU1 GWTF using a discrete interlock signal from the GWTF to the liquid extraction system. When a high level alarm occurred in the OU1 GWTF influent tank (where ISTT process water was received), a signal was transmitted to the ISTT extraction control system to prevent the transfer of ISTT process water to the OU1 GWTF.

4.5 ET-DSP™ System

In June 2010, mechanical construction of the Electro-Thermal Dynamic Stripping Process (ET-DSP™) system began with the installation of power, data communication, and water injection and return conveyance systems. Construction continued with the installation of power cables and water injection and water return hoses to each of the electrode wells. In addition, digiTAMs and digiPAMs (Section 4.3), and data communication cables were installed at each of the applicable sensor wells.

Construction of the ET-DSP™ system continued into July of 2010 with the delivery of the pre-fabricated, proprietary Power Distribution Systems (PDS) and Water Circulation Systems (WCS). Electrode power cables and water injection hoses were connected to the PDS and WCS units, respectively. Electrode water return hoses were tied into the liquid extraction system conveyance for treatment by the liquid extraction and treatment system and OU1 GWTF.

4.6 Electrical Installations

In July 2010, concurrent with the mechanical construction of the ISTT extraction and treatment systems and ET-DSP™ systems, a transformer and associated power distribution equipment were installed (Figure E101 of Appendix C). The 2,000 kilovolt-ampere, 13.8 kV-480Y/277 transformer was outdoor-rated and served as the main interface between the utility grid and the ET-DSP™ system. The main power distribution equipment consisted of two 480V, 3-phase, and 3-wire distribution panels, which powered the PDS units and other downstream distribution panels for the ISTT extraction and treatment systems' process equipment (Figure E101 of Appendix C).

On July 15, 2010, power to the Site was installed by Groveland Electric Light Department. An emergency generator was also installed for use in the event of a disruption to electrical service. The emergency generator provided power to operate the ISTT extraction systems (in order to maintain pneumatic and hydraulic control) during a power loss or failure.

Local emergency shut off devices were installed at each of the various ISTT extraction systems' process equipment and PDS units. In addition, two main emergency shut off devices were installed at the Site, which shut off power to the ISTT extraction and ET-DSP™ systems.

4.7 ISTT Startup Testing

Once the mechanical construction and electrical installations were completed, the equipment was tested and verified for proper operation prior to system startup. The ISTT startup testing consisted of the following activities:

- Test all major conveyance systems;
- Leak-check vapor and liquid extraction lines;
- Inspect all electrode and grounding system connections;
- Check all motors for proper rotation;
- Verify and calibrate all instrument signals;
- Verify all analog and discrete signals and alarm interlock signals to/from the ISTT extraction control system;
- Verify proper operation of emergency shut off devices;
- Verify contract-required noise limits;
- Configure all valves to the proper pre-start positions;
- Verify operation of all digiTAMs™ and digiPAMs™;
- Pressure test and leak-check the WCS;
- Verify data logging capabilities and electronic data transmission to web-based monitoring system;
- Collect background temperature, pressure, and water level data; and
- Perform ET-DSP™ acceptance testing (step and touch potential testing).

To confirm that the ISTT extraction system was integrated with the OU1 GWTF, verification of proper interlock interface and appropriate alarm actions between the two programmable logic control systems was completed.

ET-DSP™ acceptance testing was completed throughout the Site and along the Site perimeter, as well as at neighboring residential properties. ET-DSP™ performance testing included completion of step and touch potential surveys throughout the Site, along the Site perimeter, and on neighboring residential properties, as well as monitoring of baseline and startup testing voltage levels on neighboring properties. No issues were noted at the 106 and 108 Center Street properties. The few identified issues on the Site were corrected prior to startup.

Additional details of the findings of the Startup Testing and corrective actions performed are provided in Section 5.2.

Noise levels at surrounding properties were also measured and found to be in compliance with contract requirements.

4.8 Chronology of Remedial Action Events

The following table summarizes the chronology of events related to the OU2 Remedial Action.

DATE	EVENT
December 1982	Groveland Wells Site placed on the National Priorities List.
September 1988	Source Control (OU2) ROD for the Valley Manufacturing/GRC property signed.
March 1992	EPA issues Administrative Order to Valley Manufacturing and GRC to remediate soil and groundwater at the Source Control Operable Unit.
May 1992	EPA issues Administrative Order to Valley Manufacturing and GRC to remediate regional groundwater VOC plume that had migrated downgradient of the Valley Manufacturing/GRC property (Management of Migration Operable Unit).
June 1992	Valley Manufacturing and GRC informs EPA that they cannot comply with the Administrative Order to remediate the Management of Migration Operable Unit.
August 1992	• EPA issues a Notice of Failure to Comply with Valley Manufacturing and GRC, for failure to initiate work to remediate the Management of Migration Operable Unit. • EPA approves the SVE and groundwater treatment system design for the Valley Manufacturing/GRC property, submitted by Lally Associates for Valley Manufacturing and GRC.
October 1992	Valley Manufacturing and GRC informs EPA that they cannot continue to comply with the Administrative Order for remediation of the Source Control OU.
November 1992	EPA issues a Notice of Failure to Comply with Valley Manufacturing and GRC for failure to continue remedial work at the Source Control OU.
December 1992	EPA visits Valley Manufacturing/GRC property and learns that the SVE system had in fact been constructed and was in operation.
January 1993	EPA issues a Second Notice of Failure to Comply with Valley Manufacturing and GRC for failure to submit monthly progress reports on the SVE system.
June 1994	Valley Manufacturing and GRC begin routine submission of monthly progress reports to EPA.

DATE	EVENT
August 1996	EPA issues ESDs for both the Source Control and Management of Migration OUs, modifying the remedies to treat groundwater from both operable units in a combined facility.
April 2000	• GWTF is determined to be completed. • New system starts up and Mill Pond system is shut down.
May 2000	Routine operation and maintenance of GWTF begins.
Mid-2001	Valley Manufacturing ceases operation.
April 2002	SVE system is shut down and abandoned by Potentially Responsible Parties.
April 2004	EPA initiates Source Area re-evaluation.
September 2006	Draft Final Source Area Re-evaluation Report is completed.
September 2007	EPA issues ESD for the Source Control OU to modify the remedy to include an ISTT enhanced SVE system and to establish revised soil cleanup levels.
September 2008	• United States Army Corps of Engineers completes the Thermal Remediation Statement of Work/Conceptual Design for OU2 on behalf of EPA. • EPA retains Nobis Engineering to prepare Final Remedial Design specifications and procure qualified subcontractors to implement the ISTT remedial action.
April – July 2009	• Site preparation and baseline investigations of OU2 soil and groundwater are completed in preparation for ISTT Remedial Design/ Remedial Action. • Request for proposals for implementation of the Source Control Remedial Action (ISTT) is released.
October 2009	Source Control Remedial Action subcontractor selection and award.
February 2010	ISTT Design is finalized.
April – August 2010	ISTT system is constructed.
August 2010	• Startup testing of ISTT system is completed. • Pre-final and final inspections of ISTT system are completed. • Startup the ISTT system is authorized.
August 2010	Routine operation and maintenance of ISTT system begins.
October 2010	• ISTT system shut down due to NAPL breakthrough. • Liquid extraction system upgrades performed and ISTT system restarted.
December 2011	• Steam-enhanced heating system is designed to overcome ongoing heating difficulties and supplement ISTT system. • Steam enhanced heating system is constructed and started. • Vapor cover insulation cap is installed.
February 2011	• Shutdown of ISTT system is authorized by the project team.

DATE	EVENT
February – July 2011	ISTT demobilization activities are completed.
March 2011	First confirmation groundwater monitoring event performed.
April 2011	Confirmation soil sampling event performed.
May 2011	Second confirmation groundwater monitoring event performed.
June 2011	Final inspection of ISTT system demobilization is completed.
August 2011	Third (final) confirmation groundwater monitoring event performed.
July - September 2011	Restoration of Valley Manufacturing and 106 Center Street properties completed.
September 2011	Remedial Action Report is completed.

5.0 CONSTRUCTION QUALITY CONTROL

This section describes the quality control measures and inspections that were completed during ISTT construction activities.

5.1 Description of Construction Oversight Activities

The daily ISTT construction activities at the Site were monitored by the Resident Engineer (Nobis) and included the following tasks:

- Oversaw ISTT construction activities;
- Implemented Nobis' quality and safety policies and procedures;
- Monitored and documented daily Site activities;
- Coordinated with numerous subcontractors to confirm approved methods and materials were used and quality goals were met;
- Coordinated with the OU1 GWTF operator to minimize impacts to the OU1 GWTF;
- Identified problems or deviations in the field and discussed resolutions with the Nobis Project Manager and Subcontractor's Construction Manager; and
- Documented construction activities using photographic documentation (Appendix B).

During ISTT construction activities, the Resident Engineer completed stormwater inspections at the Site. Stormwater inspections were generally completed within one business day of a stormwater event (weather event resulting in an accumulation of precipitation). During a stormwater inspection, the Resident Engineer inspected the following:

- Site and perimeter for ponding and/or stormwater runoff;
- Neighboring properties for ponding and/or stormwater runoff from the Site; and
- Effectiveness of existing Site erosion and sediment controls.

If needed, the Resident Engineer provided recommendations for maintenance of existing erosion and sediment controls or implementation of additional control measures. Stormwater inspections and recommendations were documented in the Resident Engineer's field log book.

The Resident Engineer also completed several safety inspections during the ISTT construction, and a health and safety audit of ISTT construction activities was performed by the Nobis Corporate Health and Site Safety Officer. Safety inspections and the health and safety audit were completed in accordance with the Nobis Health and Safety Plan [Nobis, 2010a]. The following items were reviewed during a Site safety inspection and health and safety audit:

- Personnel training records;
- On-Site training;
- Medical and first aid;
- Personal protective equipment;
- Decontamination procedures;
- Fire prevention/protection;
- Ladders, walking, and working surfaces;
- Excavations and confined spaces;
- Motor vehicles and heavy equipment;
- Hand and power tools;
- Welding and other hot work; and
- Site safety management.

General construction and oversight activities were documented in the Resident Engineer's field log book and the ISTT Construction Status Reports sent to the project team each week (Appendix D). The reports contained the following information:

- Construction activities performed during the reporting week;
- Status of ongoing activities;
- Construction quality control issues;
- Applicable Site photographs;
- Evaluation of any laboratory analytical data received;
- Planned activities for the following week;
- Stormwater and health and safety inspection findings; and
- Description of any action items and applicable responsible party.

ISTT construction activities, progress, and outstanding action items were discussed in weekly status conference calls. The project team participated in weekly status conference calls, and bi-weekly Site meetings and tours of the ISTT construction and operation activities.

5.2 Pre-Final and Final Inspections

Pre-final and final inspections of both the ISTT extraction and ET-DSP™ systems were completed prior to start-up. The ISTT extraction and treatment systems were inspected on August 4, 2010 and the ET-DSP™ system was inspected on August 12 and 16, 2010.

The following items were verified during the pre-final and final inspection of the ISTT extraction and treatment systems completed on August 4, 2010:

- Operation and maintenance procedures;
- Health and safety procedures;
- Evaluation of noise limits per contract requirements;
- Applicability of daily operation and maintenance form;
- Operation of emergency shut offs;
- Emergency power loss transfer procedures;
- Operations and performance monitoring locations;
- Pressure and leak testing of conveyance systems;
- Testing of the ISTT extraction control system logic and alarms; and
- Integration of the ISTT extraction and treatment systems with the OU1 GWTF.

The pre-final inspection served as the final inspection of the ISTT extraction and treatment systems because no operational issues or problems were noted during the pre-final inspection.

The following items were verified by Nobis during the pre-final inspection of the ET-DSP™ system completed on August 12, 2010:

- Operation and maintenance procedures;
- Health and safety procedures;
- ET-DSP™ system operator training;
- Operation of emergency shut offs;
- Web-based monitoring system;
- ET-DSP™ acceptance testing, including step and touch potential testing results;
- Baseline and startup testing voltage levels at neighboring residential properties;
- WCS controls and flow rates from water circulation units;
- Power to electrodes from PDS units;
- Operation of sensor wells; and
- Electronic data transmission to web-based data monitoring system.

The pre-final inspection resulted in the following punch-list items that required completion prior to the final inspection of the ET-DSP™ system:

- ET-DSP™ system operator training documentation;
- Verification of hydraulic control within the ISTT Area A;
- Verification of pneumatic control within the ISTT Areas; and
- Installation of rubber sleeves at extraction wells to prevent contact with touch potentials identified during ET-DSP™ system acceptance testing.

The final inspection was performed on August 16, 2010 by evaluating and confirming the above items.

5.3 Startup Authorization

Following the final inspection of the ISTT extraction systems on August 4, 2010 and receipt of the request for ISTT extraction systems startup on August 9, 2010, startup of the vapor and liquid extraction systems was authorized on August 9, 2010. The ISTT extraction systems were started approximately one week prior to the start of the ET-DSP™ system to establish hydraulic and pneumatic control of the ISTT Areas prior to the start of subsurface heating.

Following the final inspection performed on August 16, 2010 and receipt of TerraTherm's request for ISTT ET-DSP™ system startup the same day, Nobis authorized TerraTherm to start the ET-DSP™ system on August 17, 2010. Initially, more power was applied to the perimeter and deeper electrodes than to the interior electrodes to establish a thermal barrier that prevented lateral and downward contaminant migration.

6.0 OPERATIONS AND MAINTENANCE PERFORMANCE MONITORING

During ISTT operations, several monitoring systems were in place to evaluate overall ISTT operations and performance. ISTT monitoring systems were established in the ISTT Areas and the ISTT extraction systems and data was readily available, in real time, to the project team using a secure website. Monitoring system data was regularly reviewed by the project team and was used to monitor the progress and effectiveness of the ISTT operations. In addition, the monitoring data supported the development of system optimizations, the modification of performance criteria, and the decision to shutdown ISTT operations.

Details of the ISTT monitoring systems, monitoring data and trends, system optimizations, performance criteria modifications, and shutdown decisions are provided below in Sections 6.1 through 6.5. Routine maintenance of the ISTT systems was integral to effective ISTT operation. ISTT system maintenance activities are described in Section 6.6.

The Nobis Resident Engineer monitored system operation and maintenance through routine inspections, and regularly evaluated ISTT monitoring data and laboratory analytical data for extracted fluids. The Resident Engineer prepared weekly ISTT Operations and Optimization Status Reports (Appendix E) which included the following information:

- Operations activities performed during reporting period;

- Optimization activities performed during reporting period;

- Maintenance activities performed during reporting period;

- Status of ongoing activities;

- Description of select ISTT Areas and ISTT extraction systems monitoring parameters;

- Status of ISTT performance objectives and metrics;

- Evaluation of any laboratory analytical data received;

- Description of planned operations and optimization activities for the following week; and

- Evaluation of the VOC mass removed estimate, cumulative energy use, average temperatures within ISTT Areas, ISTT vacuum contours, and ISTT Areas groundwater elevation contours.

The ISTT operations and Optimization Status Reports were sent to the project team for their review each week. ISTT operation and optimization activities were discussed during bi-monthly status conference calls.

6.1 Description of Monitoring Systems

Monitoring systems for the ISTT Areas and ISTT extraction systems were in place throughout ISTT operations. Within the ISTT Areas the following parameters were routinely monitored:

- Subsurface temperature;
- Water level;
- Vacuum;
- Electricity usage;
- Field screening of total VOCs at shallow soil vapor extraction wells; and
- VOCs in groundwater at groundwater monitoring wells.

In addition, the soil vapor and liquid extraction systems were routinely monitored for the following:

- Flow rates;
- Various process parameters;
- Field screening for total VOCs in vapor from the vapor extraction system;
- VOC analysis of vapor samples from the vapor extraction system; and
- VOCs and metals analyses of extracted fluids (groundwater and condensate) from the liquid extraction system.

Monitoring data were recorded in the project database and reported on the project website (for project team review) at various frequencies depending on the type of data. These monitoring data were used to evaluate the overall performance of ISTT operations; to develop operational optimizations, when needed; and to determine when the "point of diminishing returns" was achieved.

6.1.1 ISTT Areas

Subsurface temperatures throughout the ISTT Areas were monitored and automatically recorded using digiTAM™ temperature sensors. A digiTAM™ was installed at 24 sensor locations (including TPV locations) in ISTT Areas A, C, and D and along the perimeter of the ISTT Areas (Figure C103 of Appendix C), with a total network of approximately 250 temperature sensors. The digiTAM™ provided for real-time monitoring of temperatures in the subsurface. Temperatures from individual sensors were automatically reported every minute to the project's database and updated to the project's web page hourly. Temperature data were used to evaluate the performance of the ET-DSP™ system.

Water levels within the ISTT Areas were automatically recorded using digiPAM™ pressure sensors (at TPV sensor wells). TPV sensor wells were installed at 14 locations in ISTT Areas A, C, and D and along the perimeter of the ISTT Areas (Figure C103 of Appendix C). At each TPV sensor well location, a digiPAM™ was installed in a slotted drop tube that allowed for the digiPAM™ to be in constant communication with the surrounding groundwater. Water levels from individual pressure sensor wells were automatically reported to the project's database and website hourly. Water level data were used to evaluate hydraulic control within ISTT Area A.

Vacuum (vapor pressure) within the ISTT Areas was monitored using vacuum monitoring points installed at 14 TPV sensor wells located within and around the perimeter of the ISTT Areas (Figure C103 of Appendix C). Vacuum monitoring was conducted at TPV sensor wells which were screened within the saturated and vadose zones. Vacuum was manually measured at each vacuum monitoring point using a vacuum gauge. In general, ISTT Areas vacuum readings were collected by the operator and reported to the project's database and website daily. Vacuum data were used to evaluate pneumatic control of the ISTT Areas.

Total system power, power and current at each electrode, total phase current, input energy, power density, and PDS and electrode voltage were automatically recorded during ISTT operations. These energy parameters were reported to the project database and website at various frequencies ranging from every second to hourly. These data were closely monitored by the project team and used to evaluate and optimize the performance of the ET-DSP™ system.

Vapor samples were collected at least weekly from 16 shallow SVE wells for VOC screening. The grab samples were collected in 1-Liter Tedlar™ bags for field screening of total VOCs using a calibrated, hand-held photoionization detector (PID) (MiniRAE 3000 equipped with a 11.7 eV lamp). Approximately once per month, split vapor samples were collected from 16 shallow SVE wells for field PID screening and for analysis by the EPA Office of Environmental Measurement and Evaluation (OEME) mobile laboratory. On occasion, a vapor sample was collected from a shallow SVE well for fixed laboratory analysis using a 6-Liter Summa canister, and submitted to the EPA OEME fixed laboratory for VOC analysis by EPA method TO-15 [Nobis, 2010b]. VOC data collected from shallow SVE (Appendix A) wells were used to evaluate the performance of the vapor extraction system and to support shutdown decisions (Section 6.5).

Groundwater samples were generally collected every other week during ISTT operations from MPE wells and groundwater monitoring wells located within and immediately outside the ISTT Areas. Groundwater samples were collected in accordance with the Field Sampling Plan [TerraTherm, 2010a] and Quality Assurance Project Plan [Nobis, 2010b]. Groundwater samples were submitted for VOC analysis using EPA SOW SOM01.2 [Nobis, 2010b]. The VOC data collected from groundwater monitoring and MPE wells were used to monitor the progress and effectiveness of ISTT operations. Groundwater samples collected outside of the ISTT Areas were used to monitor contaminant migration from the wellfield. In addition, the data were used to support ISTT shutdown decisions (Section 6.5).

Perimeter air samples were collected bi-weekly to ensure that there were no unacceptable risks to the adjacent residential properties. The air samples were collected for fixed laboratory analysis using a 6-Liter Summa canister submitted for VOC analysis by EPA method TO-15 in accordance with the Quality Assurance Project Plan [Nobis, 2010b].

6.1.2 ISTT Extraction and Treatment Systems

Flow rates of the ISTT extraction and treatment systems were recorded manually by the operator on a daily basis using various gauges and flow meters. In addition, the water injection rates to the electrodes were automatically recorded to the database (every minute) and website (hourly). These data were used by the project team to evaluate maintenance of pneumatic and hydraulic control of the ISTT Areas. In addition, vapor and process water flow rates from the ISTT extraction systems were used to estimate the VOC mass removed rates.

Various process parameters such as liquid levels, pressures, process equipment temperatures, and meter readings were collected daily by ISTT operators. The process and instrumentation diagram presented in Figure P102 of the Construction As-Builts (Appendix C) describes the monitoring locations. These data were used to evaluate and optimize the performance of the ISTT extraction and treatment systems.

Process vapor samples were collected from the vapor extraction system's GAC vessels at the influent, midfluent, and effluent locations for routine field screening and periodic laboratory analysis. The grab samples were generally collected daily in 1-Liter Tedlar™ bags for VOC screening using a calibrated, hand-held PID (MiniRAE 3000 equipped with a 11.7 eV lamp). Vapor samples from the GAC influent and effluent were collected weekly for fixed laboratory analysis using a 6-Liter Summa canister submitted for VOC analysis by EPA method TO-15 [Nobis, 2010b]. On occasion, a vapor sample was collected from the GAC midfluent for fixed laboratory analysis in support of GAC efficiency evaluations. VOC data collected from the vapor extraction and treatment system were used to evaluate the performance of the system (GAC efficiency), to calculate VOC mass removed rates, and to support shutdown decisions (Section 6.5).

Process liquid samples were collected from the liquid extraction and treatment system effluent (prior to discharge to the OU1 GWTF for final treatment). Samples were generally collected weekly for VOC analysis using EPA SOW SOM01.2 and monthly for metals analysis using EPA SOW ILM05.4 [Nobis, 2010b]. These data were used to determine concentrations prior to discharging the water to the OU1 GWTF, to calculate the VOC mass removed rates, to identify any potential impacts to the OU1 GWTF operations, and to support shutdown decisions (Section 6.5).

6.2 Data Summaries and Trend Analyses

The following sections present data summaries and trend analyses of the following ISTT monitoring data collected during ISTT operations:

- Water balance;
- Vapor balance;
- Energy use;
- Temperature;
- VOCs in groundwater and vapor; and
- VOC mass removed estimate.

Data trend plots are also presented in the Data Trend Report included as Appendix F.

6.2.1 Water Balance

Over ISTT extraction systems operation, from August 9, 2010 to February 24, 2011, the total volume of liquid removed from the ISTT Areas (including both water extracted and steam condensed) was 2,244,363 gallons. The total amount of water extracted from the MPE wells was 1,872,200 gallons, while the amount of water extracted as steam and condensed in the ISTT vapor extraction system was 372,163 gallons. The total volume of water injected into the ISTT Areas through the electrodes was 1,727,412 gallons. The net water extracted from the ISTT Areas was 516,951 gallons (Appendix F, Figure F-1).

The liquid extraction rates were approximately 9.0 to 10.0 gpm during the first months of ISTT operation; but then decreased to approximately 4.0 to 7.0 gpm for the remainder of operations (Appendix F, Figure F-2). The overall project average liquid extraction rate was approximately 6.9 gpm. The production of steam condensate was minimal during the first months of ISTT operations and then stabilized in the range of 1.0 to 3.0 gpm until ISTT operations ended. The average steam extraction rate was approximately 2.0 gpm.

6.2.2 Vapor Balance

An estimated 311 million cubic feet (11.5 million cubic yards) of non-condensable vapors were extracted during ISTT operations (Appendix F, Figure F-3). The total soil volume in the ISTT Areas was approximately 17,450 cubic yards. Assuming a porosity of 0.35, this represents a total pore volume of 6,107 cubic yards. Therefore, the amount of non-condensable vapors extracted corresponds to flushing each pore in the ISTT Areas (ISTT Area A through Area D) approximately 1,900 times during ISTT operations.

The extraction flow rate of non-condensable vapor was approximately 1,400 standard cubic feet per minute (scfm) at the beginning of the project. Following system adjustments in January 2011, the vapor flow rate was approximately 450 scfm with some fluctuations; while steam extraction rates were in the range of 200 to 500 scfm (Appendix F, Figure F-4). These flow rates were sufficient to establish and maintain pneumatic control within the ISTT Areas and capture the mobilized, vaporized VOCs.

6.2.3 Energy Use

The total amount of energy used during ISTT operations was approximately 3,639,520 kilowatt hours (kWh) (Appendix F, Figure F-5). Approximately 87 percent of the total energy use was attributed to the energy injected into the subsurface by the ET-DSP™ System (3,174,488 kWh during the 168 days of heating). Energy was added at varying rates during ISTT operations to optimize and control the temperature of each electrode and target specific locations within the ISTT Areas. The average amount of energy added to the subsurface each day was approximately 18,896 kWh. The total treatment volume was approximately 17,450 cubic yards, yielding an estimated energy usage for the ET-DSP™ System of 182 kWh injected into the subsurface per cubic yard treated.

The balance of the power usage was for operation of the ISTT extraction systems, which used approximately 465,032 kWh over a period of 192 operating days, corresponding to an average power usage of approximately 2,422 kWh per day.

The total energy used during ISTT operations was approximately 19 percent higher than the 3,049,000 kWh projected power usage. This additional energy usage was required due to the extended heating period (Section 6.3).

In addition to the 3,174,488 kWh of energy added to the subsurface by the ET-DSP™ System, another 97,562 kWh was injected as water (warmed through heat exchange processes in the extraction systems), for a total of 3,272,050 kWh energy injected. Approximately 1,026,240 kWh, 412,792 kWh, and 103,164 kWh were extracted as steam, water, and non-condensable vapors, respectively, by the ISTT extraction systems (Appendix F, Figure F-7). Therefore, the net energy injected to the subsurface in the ISTT Areas was 1,729,855 kWh; approximately 54 percent of the injected energy remained in the subsurface.

6.2.4 Temperatures

Temperature performance metrics (Section 3.1) for different portions of the ISTT Areas were reached at different times during ISTT operations. Subsurface temperatures in all ISTT Areas generally increased until October 12, 2010 when the ISTT system shut down for liquid extraction upgrades (Section 6.3). The ISTT system was restarted approximately two weeks later; however, subsurface temperatures continued to decrease. Slowly, temperatures increased to pre-shutdown temperatures. In particular, the shallow vadose zone (0 to 10 ft bgs) was slow to respond to heating efforts. A steam-enhanced heating system was designed (Section 6.3) to facilitate heating in these areas. Following the steam-enhanced heating system implementation, temperatures increased until February 2011, when electrodes were shut down (Section 6.5). A plot of the average temperatures in the ISTT areas where temperature probes were located is included in Appendix F, Figures F-8 through F-11.

In general, the temperature sensors located between the ground surface and 2.5 ft bgs were excluded from average calculations and graphical presentations due to energy loss through the vapor cap.

ISTT Area A was divided into two treatment zones: the vadose and saturated zones. At any one time during treatment, a maximum of approximately 80 percent and 50 percent of the vadose and saturated zones' temperature sensors achieved the target temperature performance goals of 90°C and the boiling point, respectively (Appendix F, Figures F-12 and F-13). This is less than the performance metric of at least 85 percent of locations reaching the target temperatures (Section 3.1). However, 100 percent of sensor locations exceeded the minimum temperature metric of 60°C.

In general, temperatures within ISTT Areas C and D remained below the target temperature of 90°C until the steam-enhanced heating operations began in December 2010 (Section 6.3). Ultimately, approximately 80 percent and 100 percent of the temperature sensors achieved the vadose zone target temperature performance goal of 90°C in ISTT Areas C and D, respectively (Appendix F, Figures F-14 and F-15), compared to the performance metric of reaching target temperatures at 85 percent of the locations.

Temperature measurements continued to be collected for two weeks during Phase III (cooling) operations, after ISTT system shutdown on February 9, 2011.

6.2.5 Volatile Organic Compounds

Following the ISTT system startup, the initial concentration of TCE in the ISTT liquid extraction and treatment system process water was 1,900 µg/L (Appendix F). Concentrations of TCE began to decrease after startup of the ET-DSP™ system and continued to decrease throughout ISTT operations (Appendix F, Figure F-16). Whereas, concentrations of acetone and 2-butanone were observed to increase in process water as the temperature of the groundwater increased (Appendix F, Figure F-16). This increase in the concentrations of acetone and 2-butanone in Site groundwater is believed to be caused by the heat-induced breakdown of humic acid (which is naturally occurring in Site soil) to form ketone compounds including acetone and 2-butanone. As subsurface temperatures cool following ISTT system shutdown, the concentrations of ketone compounds are expected to decrease by degradation and dispersion.

Weekly laboratory analysis of VOCs in process air at the influent of the GAC vessels was used to evaluate the treatment progress and help to "calibrate" the results of the PID screening of process air, which occurred on a more frequent basis. In contrast to process water data, the process air VOC data did not show a clear decreasing trend over the ISTT operations period. Rather, the process air concentrations showed an initial decrease, followed by a large peak approximately one month after the start of heating, followed by steady and variable periods until the end of treatment (Appendix F, Figure F-17). Throughout most of the ISTT operations, the total VOC concentration in process air was less than 4 ppmv.

The PID screening of total VOCs at the influent (Influent), midfluent (Mid1 and Mid2), and effluent (Stack) locations (Appendix F, Figure F-18) of the ISTT vapor extraction system's GAC vessels was used to evaluate that air treatment requirements (95 percent removal of COCs from the vapor stream prior to discharge) were being met. Due to the low influent concentrations and the sensitivity of the PID, the ISTT vapor extraction system destruction removal efficiency at the Site could not be maintained above 95 percent at all times (Appendix F, Figure F-18). However, because of the low influent and effluent concentrations it is concluded that the stack discharges did not cause unacceptable VOC concentrations in ambient air. Ambient air data support this conclusion.

Groundwater samples were collected bi-monthly from select monitoring and MPE wells to evaluate the performance and effectiveness of the ISTT system. In general, concentrations of TCE and cis-1,2-DCE in Site groundwater decreased during ISTT operations (Figures 6-1 through 6-4). In August 2010 (the beginning of ISTT operations), TCE was detected in Groundwater Monitoring Well RW-05 at a concentration of 27,000 µg/L (Figure 6-1, Appendix A). A 99.95 percent reduction of TCE was observed at this monitoring location during the January 2011 ISTT operations groundwater monitoring event, when TCE was detected in Groundwater Monitoring Well RW-05 at a concentration of 14.5 µg/L (Figure 6-3, Appendix A). Overall, concentrations of TCE were observed to decrease on average by approximately 90 percent (Table 6-1). ISTT operations groundwater data were used to support shutdown decisions, discussed in Section 6.5.

Vapor samples were collected weekly for field screening of total VOCs from select shallow SVE wells to evaluate the performance and effectiveness of the ISTT system. Concentrations of total VOCs in shallow SVE wells varied significantly (Appendix F, Figure F-19) during ISTT operations due to the sensitivity of the PID and the "production" of VOCs such as acetone and 2-butanone. However, general decreases in the concentration of TCE at select shallow SVE wells were observed during ISTT operations (Appendix F, Figures F-20 through F-26). These data were used to support shutdown decisions, discussed in Section 6.5.

6.2.6 Volatile Organic Compounds Mass Removed Estimate

The total VOC mass removed during ISTT operations was quantified by monitoring the following media:

- Process Vapor – volatized chemicals in the vapor extracted from the ISTT Areas;
- Process Water – chemicals dissolved in the extracted groundwater and condensate; and
- NAPL.

The estimated amount of contaminant mass removed in the vapor phase was derived by calculating a composite PID response factor for the VOC compounds identified in each process vapor analytical result by using the PID manufacturer's published response factors for these individual constituents. These data together with the PID measurements and system vapor flow rates were used to calculate a Site-specific correlation factor to convert the PID readings to a mass per volume concentration. It was assumed that PID readings reflect the concentration of all organic constituents in the vapors extracted from the ISTT Areas. Based on the PID measurements and the Site-specific correlation factor, it was estimated that a total of 1,158 pounds of VOCs were removed in the vapor phase during ISTT operations.

The total amount of contaminant mass removed in the liquid phase was calculated using analytical data and the liquid flow rates. Using these data, it was estimated that a total of 29 pounds of VOCs were removed in the liquid phase during ISTT operations.

A total of 18.1 gallons of NAPL was recovered by the oil/water separator during ISTT operations. Analysis of the NAPL product revealed it was most likely a weathered hydrocarbon with a density between approximately 0.990 and 1.002 g/ml. Based on these data, it was estimated that a total of 151 pounds of product was recovered during ISTT operations.

The estimated total contaminant mass removed during ISTT operations was approximately 1,338 pounds of VOCs (Figure F-27, Appendix F). VOCs removed in the vapor phase represent over 80 percent of the total estimated contaminant mass removed.

6.3 System Modifications and Optimizations

The ISTT system generally operated continuously, 24-hours a day, seven days a week from the start of operations to completion, with the exception of few temporary shutdowns. Temporary shutdowns were caused by planned groundwater monitoring events or equipment malfunctions, typically lasting less than a few hours, but occasionally lasting longer. The longest shutdown period (9 days), is described below in the section titled "Liquid Extraction System Upgrades."

Several system optimizations for the vapor and liquid extraction and ET-DSP™ systems were designed and implemented throughout the duration of ISTT operations. System optimizations were routinely discussed in the Operations and Optimization Status Reports (Appendix E) and included the following items, which are discussed in the following paragraphs:

- PDS warning signal modifications;
- Saline injections;
- Sound-absorbing curtain installation;
- Liquid extraction system upgrades;
- Steam-enhanced heating; and
- Vapor cover insulation cap installation.

PDS Warning Signal Modifications

Shortly after the ET-DSP™ system startup, a neighbor adjacent to the Site (112 Center Street) voiced concerns about the flashing light associated with the safety warning signal on the PDS units. The warning signals were an important safety feature of the ET-DSP™ system and were used to inform operators and emergency responders that the PDS units were energized. As a result, the project team decided the flashing light could not be shut off to appease the neighbor. Instead, the project team created a guard that focused the flashing light onto the Site and blocked it from the view of the Center Street residents.

Saline Injections

In order to enhance the electrical conductivity of the subsurface materials within the vadose zone in the ISTT Areas, the project team introduced water conditioning salts to the electrode injection water. Saline was injected into the IST wellfield through various targeted electrodes in order to increase the conductivity of the soil. Increasing the salinity of the injection water enhanced the ability of the water to pass an electrical current. Saline injections began in August 2010 and continued throughout the duration of ISTT operations.

Sound-Absorbing Curtain Installation

Following receipt of a complaint from a resident located at 115 Center Street, a sound-absorbing curtain was designed and installed at the Site. Prior to its installation, a sound survey was completed at various locations at the Site and within the neighborhood, including 115 Center Street. Results of sound survey concluded that noise levels collected from the Site were less than the contract-required sound limit of 85 decibels (at 5 feet from process equipment) and noise levels in the neighborhood were lower than 60 decibels, the typical level in a suburban neighborhood setting. However, the residual noise was considered a nuisance due to the high frequency hum of the vapor extraction system blowers. It was concluded by EPA and the project team that installation of a sound-absorbing curtain was necessary to address the citizen's complaint.

The sound-absorbing curtain was installed in October 2010 and remained in place throughout the duration of ISTT operations. The sound-absorbing curtain consisted of three connected panels, each approximately 20 feet tall and 8 feet wide, installed just south of the vapor extraction system blowers. The sound-absorbing curtain reduced the transmission of the high frequency sounds outside the treatment process equipment area and successfully addressed the neighbor's complaint.

Liquid Extraction System Upgrades

Following an unplanned breakthrough of a non-aqueous phase liquid (NAPL) to the OU1 GWTF on October 12, 2010, the project team shut down the liquid extraction and ET-DSP™ systems. Although there were no exceedances of the effluent discharge criteria, the NAPL caused operational and maintenance issues at the OU1 GWTF. Subsequent investigation into the cause of the breakthrough concluded that the NAPL had significantly different physical and chemical properties than anticipated. Most notably, the specific gravity of the recovered NAPL was very close to that of water, with one sample slightly heavier than water and one sample slightly lighter. As a result, separation of the NAPL required more cooling and more settling time than the original design parameters had required. Several liquid extraction system upgrades (Appendix G) were designed and implemented to address these issues and ensure better separation of NAPL. These upgrades are listed below and described in the following paragraphs:

- Installation of several additional cooling plates and a cooling loop, using water from the cooling tower to increase the cooling capacity of the liquid heat exchanger.

- Installation of an 800-gallon weir tank prior to the oil water separator to allow for additional settling and separation of any potential NAPL.

- Installation of a second bag filter skid after the oil water separator containing coalescing bag filters to capture any remaining product that may not have been separated in the weir tank or oil water separator.

- Installation of a 500-pound organoclay media vessel to polish any remaining petroleum products.

- The use of a 5,000-gallon weir tank as the final component of the liquid treatment train to provide for additional settling, if needed, and to allow for visual inspection of the liquid extraction system effluent prior to discharge to the OU1 GWTF.

The liquid extraction and ET-DSP™ systems were restarted on October 20, 2010 and October 21, 2010, respectively. This liquid extraction system shutdown resulted in nine days of ET-DSP™ system downtime and an additional 16 days of heating for subsurface temperatures to recover to pre-shutdown temperatures. The liquid extraction system enhancements remained in place throughout the duration of ISTT operations and were effective in preventing additional NAPL breakthrough.

During ISTT operations, the maintenance of the multi-media and peroxide destruction unit filters within the OU1 GWTF increased significantly due to the unplanned release of a NAPL to the OU1 GWTF and biofouling from iron bacteria. The significant increase in groundwater extraction from the Source Area during ISTT operations is likely the cause of the presence of the iron bacteria. Frequent backwashing and other maintenance of the OU1 GWTF filters began in October 2010 and continued throughout the duration of ISTT operations.

In an effort to manage the iron bacteria biofouling associated with the ISTT process water, the project team re-routed influent flows within the OU1 GWTF on November 11, 2010. The ISTT process water was routed directly to the plate clarifier, while other OU1 GWTF influent water (from downgradient extraction wells outside of the ISTT Areas) was routed to bypass the plate clarifier. This effort allowed for additional ISTT process water retention within the plate clarifier and easier management of maintenance issues associated with the iron-bacteria biofouling. These changes to the OU1 GWTF influent flow remained in operation for approximately 1 month (until December 6, 2010), during ISTT operations.

Steam-Enhanced Heating

During DT-ESP™ operations, the following heating challenges were encountered:

- High permeability geologic units within the ISTT Areas caused difficulty in maintaining the desired moisture content and subsurface electrical conductivity. This problem was particularly evident in the shallow vadose zone (0 to 10 ft bgs).

- Several areas of high resistivity were identified where electrode power was very low (less than 1 kW).

As a result of the above mentioned heating difficulties, the following enhancements were designed to optimize heating at the Site:

- Mobilization and installation of a steam generator;
- Installation of 14 steam spears (layout provided in Appendix H);
- Injection of steam in steam spears and select shallow vapor extraction wells; and
- Decreased vapor extraction within ISTT Areas for efficient heating of shallow vadose zone.

Steam injections within the ISTT Areas began on December 22, 2010 and continued until heating system shutdown was approved for each of the ISTT Areas.

Vapor Cover Insulation Cap Installation

Due to the heating difficulties described above, the expected heating rates were not achieved and the overall heating period was extended. As a result, the heating period of ISTT extended beyond the anticipated completion date of late November 2010 into the winter months. As a result, it became necessary to insulate the vapor cover within the ISTT Areas. Two layers of two-inch thick polystyrene insulating boards were laid directly on the surface of the concrete vapor cover and anchored in place using sand bags. The insulation had a total R value of 20, thus reducing heat losses through the surface by 98 percent, providing additional thermal efficiency, and decreasing heat losses from the shallow vadose zone. The vapor cover insulation was installed in December 2010 and remained in place throughout the duration of ISTT operations.

6.4 Modifications of Performance Criteria

The ISTT system was separated into two heating operation phases defined as follows:

- Phase I was defined as the rapid heat-up of the treatment zone to achieve a uniform target temperature of 90 °C in vadose zone soils and the boiling point of water in the saturated zone.

- Phase II was defined as sustained operation at target temperatures to ensure thorough treatment of the contaminated soil and groundwater.

As previously discussed (Section 6.3), the shallow vadose zone and limited areas in the deeper saturated zone proved to be significantly slower to heat up than the rest of the Site and steam injection was implemented to aid in heating. As a result of these heating challenges, heating at the Site progressed in a rolling manner rather than the uniform manner that was anticipated at the time of ISTT system design. Because of this rolling subsurface response during heating, the project team agreed to reduce the focus on the uniform temperature performance criteria (Section 3.4). Instead, greater emphasis was placed on achieving the overall objectives of reducing contaminant concentrations to Site clean-up goals and/or reaching the point of diminishing returns, when the amount of additional contaminant reduction being achieved diminishes such that continued treatment is not cost effective.

The project team evaluated the specific temperatures achieved within the ISTT Areas in combination with Site's remedial objectives. The revised approach to evaluating the ISTT system performance criteria required that the project team focus performance and shutdown evaluations on temperatures achieved in specific areas of the subsurface and contaminant concentrations present in the associated groundwater and soil vapor.

6.5 Shutdown Decisions

The ISTT extraction system operation began on August 9, 2010 and heating began on August 17, 2010. On February 3, 2011, EPA determined that the ISTT remedial action was operational and functional. This determination was made because the treatment area minimum temperature performance goals were achieved.

The heating system shutdowns began on February 3, 2011 with the shutdown of heat to the saturated zone in ISTT Area A, followed by shutdown of heat to the vadose zone located in the Valley Manufacturing interior (ISTT Areas B, C, and D) and exterior (ISTT Areas A, B, and C) on February 4 and 9, 2011, respectively, marking the end of active heating operations. The ISTT extraction system shutdown occurred on February 24, 2011, marking the end of ISTT operations. Details of the shutdown decisions are provided below.

In January and February 2011, the project team held several meetings, in addition to the routine weekly project status communication, to review ISTT progress. Several shutdown decisions were made during these times, based on the achievement of temperature performance criteria and/or remedial objectives. ISTT progress was presented using a variety of graphs which described temperature, VOC concentrations in the vapor and liquid extraction systems, and VOC concentrations in ISTT Areas (Appendix F). Heating operations were shut down at various stages based on temperatures and corresponding contaminant concentrations in the ISTT Areas. Following the shutdown of all heating operations within each ISTT Area (conclusion of Phase I and II), the cooling phase (Phase III) began and continued for two weeks. ISTT system operations were concluded at the completion of Phase III.

A comprehensive groundwater monitoring event was conducted on January 25, 2011 to determine the status of treatment in the ISTT Area A saturated zone. TCE was detected at concentrations ranging from below the detection limit of 5 µg/L to 180 µg/L (at RW-03). TCE was detected at a concentration above the clean up goal (5 µg/L) at nine of the 24 monitoring and extraction wells sampled. Cis-1,2-DCE was generally detected at concentrations below the clean up goal (70 µg/L), with the exception of the sample collected at RW-03 (at a concentration of 88 µg/L). An average TCE mass reduction of approximately 90 percent was observed (Table 6-1) in comparison to the baseline groundwater monitoring event completed in August 2009 (Appendix A). At the time that the comprehensive groundwater sampling data was being evaluated, the percentage of temperature sensors within the ISTT Area A saturated zone that had reached the temperature performance criterion (100 °C) was slightly under 50 percent (Figure F-13 of Appendix F). However, 100 percent of sensor locations exceeded the minimum temperature metric of 60°C. Despite not reaching the temperature criterion, the project team supported a decision to cease heating operations within the ISTT Area A saturated zone based on evaluation of the overall TCE mass reductions and relatively low residual TCE concentrations. Electrodes located in the ISTT Area A saturated zone were shut down on February 3, 2011.

The vadose zone located beneath the Valley Manufacturing building reached the temperature performance criterion in January 2011 (Figure F-11, Appendix F). To support the potential shutdown of the interior vadose zone electrodes, soil vapor samples were collected from select shallow SVE wells within the interior of the Valley Manufacturing building using a 6-Liter Summa canister and submitted to the EPA OEME fixed laboratory for VOC analysis by EPA method TO-15 [Nobis, 2010b]. Samples were collected from select shallow SVE wells located within ISTT Areas B (SVE-13), C (SVE-20), and D (SVE-29) on January 28, 2011. Relatively low concentrations of TCE (ranging from 0.36 to 1.9 parts per billion by volume [ppbv]) were detected in vapor at these sample locations (Figures F-22 to F-24, Appendix F). In addition, no significant mass flux of TCE was observed at the vapor extraction system influent (Figure F-17, Appendix F). As a result, the vadose zone electrodes within the interior of the Valley Manufacturing building, with the exception of interior ISTT Area A electrodes, were shut down on February 4, 2011.

The remaining portions of the vadose zone in ISTT Areas A, B, and C reached the minimum temperature performance criteria by February 3, 2011 (Figures F-9 and F-10, Appendix F). A comprehensive soil vapor sampling event was conducted on February 7, 2011 to evaluate remaining soil vapor concentrations at active shallow SVE wells, prior to shutdown. Soil vapor samples were collected from select shallow SVE wells for mobile laboratory analysis of select VOCs by the EPA OEME mobile laboratory [Nobis, 2010b]. TCE, tetrachloroethene, and cis-1,2-DCE were detected in soil vapor samples at concentrations ranging from 342 ppbv to 8,350 ppbv, 4 ppbv to 72 ppbv, and 338 ppbv to 4,500 ppbv, respectively. The concentration of TCE generally decreased in ISTT Area A SVE wells (Figure F-25, Appendix F). In general, the concentration of TCE increased slightly in the exterior ISTT Areas B and C SVE wells, SVE-25 and SVE-19, respectively (Figures F-26 and F-27, Appendix F), when compared to the limited data collected during ISTT operations from these locations. Despite the slight TCE concentration increases in the SVE wells in the exterior ISTT Areas B and C, no significant flux of TCE was observed in the vapor extraction system influent (Figure F-17, Appendix F). Therefore, the project team decided to cease heating operations at the remaining vadose zone electrodes because the temperature criterion had been achieved in these areas and a significant flux of TCE was not observed in the vapor extraction system. The remaining electrodes (vadose zone electrodes in ISTT Area A and exterior ISTT Areas B and C) were shut down on February 9, 2011, indicating the end of Phase II operations and the beginning of Phase III, cooling phase, operations.

The temperature performance metric of 85 percent of the thermocouples reaching 90 °C within the vadose zone was generally achieved in each of the ISTT Areas (Figure F-9 through F-11, Appendix F). This achievement, combined with the observation of no significant VOC mass flux in the vapor extraction system (Figure F-17, Appendix F), supported the rolling shutdown decisions (February 4 and 9, 2011) within the vadose zone.

Following approximately two weeks of vapor extraction system operation without heating, Phase III cooling efforts were discontinued on February 24, 2011. Temperatures monitored at temperature sensor well locations were generally below the boiling point of water, with the exception of Temperature Sensor Wells TPV-04 and T-05. These temperature sensor wells are located in the northwest corner of ISTT Area A, approximately 60-feet away from the nearest residential property line.

In total, the ISTT extraction system operated for 192 days, and the ET-DSP™ system operated for 168 days. These durations exclude the 8 days of extraction system down-time and 9 days of heating system down-time during completion of the liquid extraction system upgrades (beginning October 12, 2010). However, the durations do include the 16 days of additional heating required to regain the temperature loss experienced during the shutdown. In total, the ISTT system operated for 58 days longer than the 134 days estimated in the Final Design.

6.6 Maintenance

An Operation and Maintenance (O&M) Plan was developed for the ISTT system [TerraTherm, 2010c] that includes the general maintenance procedures for all systems and equipment and detailed maintenance instructions for specific pieces of equipment. Nobis reviewed and approved the O&M Plan prior to the startup of the ISTT extraction. During system operations, Nobis' Resident Engineer performed routine inspections to ensure that the routine and preventative maintenance procedures were being followed. A general summary of ISTT maintenance is described below. Details are provided in the O&M Plan [TerraTherm, 2010c].

Routine maintenance activities focused primarily on the ISTT extraction and treatment systems. Preventative maintenance for the ET-DSP™ system is minimal. The most crucial step to proper operation of an ISTT system is a clear understanding of normal operating conditions. The System Operator must be familiar with temperature, sound, and appearance of wells, piping, and equipment. These observations are critical to diagnosing and correcting any potential operation issues.

All rotating devices, areas of high vibration, and high voltage devices were inspected daily, with attention focused on unusual noises, loose fittings and connectors, hot spots in piping and/or rotating equipment, and damaged insulation. On high voltage devices, attention was focused on access doors to ensure that they are secure against unauthorized access. Routine and preventative maintenance was performed for each piece of equipment as detailed in the O&M Plan [TerraTherm, 2010c], with some maintenance items performed daily and some less frequently.

7.0 CONFIRMATION SAMPLING ACTIVITIES

Following the completion of ISTT remediation activities, Nobis collected confirmation samples from subsurface soil and groundwater at select locations within the Source Area and at different times to determine whether treatment objectives had been achieved. This section contains a summary of the confirmation sampling performed and the sampling results. Details of the investigation methods and complete analytical results are provided in the ISTT Confirmation Data Summary Technical Memorandum included in the Data Summary Report, Appendix A.

7.1 Confirmation Sampling Methodologies

The confirmation sampling investigation included the following sampling events:

- Soil Confirmation Sampling in ISTT Areas – April 5 to 12, 2011;
- Confirmation Groundwater Sampling Event No. 1 – March 21 to 23, 2011;
- Confirmation Groundwater Sampling Event No. 2 – May 2 to 4, 2011; and
- Confirmation Groundwater Sampling Event No. 3 – August 1 to 4, 2011.

The confirmation soil sampling event was conducted after the subsurface temperatures in the treatment zone were below 100°C and following the first groundwater confirmation sampling event. Confirmation soil samples were collected at 16 boring locations (Figure 7-1), selected based on grid spacing of approximately 900 square-feet through the treatment area. Within each grid square, the boring locations were selected mainly from random locations, with a few locations selected in the vicinity of “hot spots” identified during the baseline investigation. One to three samples from each boring were selected for laboratory analysis, for a total of 44 field samples analyzed. The sample intervals for laboratory analysis were selected based on a combination of PID headspace readings, soil lithology, results of baseline soil samples, and random selection. In general, one or two soil samples were collected from the vadose zone and one soil sample was collected from the saturated overburden. All the confirmation soil samples were analyzed for VOCs and ten percent were analyzed for TOC, in accordance with the QAPP [Nobis, 2010b].

Groundwater sampling events were scheduled at 6, 12, and 24 weeks following completion of ISTT to identify any changes in contaminant concentrations as the subsurface in the ISTT Area cooled and moved toward an equilibrium condition. During each event, samples were collected from 16 well locations within and near the ISTT Area and analyzed for VOCs in accordance with the QAPP [Nobis, 2010b]. The wells sampled included the 12 replacement monitoring wells installed during the baseline investigation, one source area extraction well, and three existing monitoring wells located just outside the ISTT Area (confirmation sampling locations are shown on Figure 7-2). The same wells were sampled during each event, with the exception of one location (RW-07/MPE-06), where the original well (RW-07) could not be sampled (due to an obstruction within the well) during the second confirmation event so the adjacent well (MPE-06) was selected as a surrogate (Appendix A).

7.2 Confirmation Soil Sample Results

Figures 7-3 through 7-5 describe TCE concentrations in confirmation soil samples with respect to the cleanup goal of 77 µg/kg. TCE concentrations exceeding the cleanup goal were detected in only two of the 44 confirmation samples. However, elevated concentrations of acetone (up to 3,200 µg/kg) in 18 of the 44 confirmation samples, including the two confirmation samples with TCE concentrations exceeding the cleanup goal, caused interference during laboratory analysis. The elevated acetone concentrations in the soil are believed to be caused by the heat-induced breakdown of humic acid (which is naturally occurring in soil) to form ketone compounds including acetone. As subsurface temperatures continue to cool, the concentrations of ketones are expected to decrease. As a result of the elevated acetone concentrations, some of the confirmation soil samples' quantitation limits exceeded the project-required quantitation limits and the Site cleanup goals. Quantitation limits for these samples ranged from 240 to 490 µg/kg (Appendix A).

Similar to the baseline investigation (Section 4.2.3), the highest contaminant concentrations were observed in the vadose zone at locations CSB-10 (5,600 µg/kg at a depth of 23 to 25 feet bgs) and CSB-13 (7,000 µg/kg at a depth of 3 to 5 feet bgs) below the paved Former Porch Area. TCE was not detected in samples collected from below the water table within either borehole (Appendix A) or at similar depth intervals in nearby confirmation soil borings (Figures 7-3 and 7-4).

In the Former Porch Area, where the highest concentrations of contaminants were detected during the baseline soil investigation, TCE and cis-1,2-DCE were detected in 38 and 23 percent of the confirmation soil samples, versus detection in 100 and 77 percent of the baseline soil samples, respectively (Table 7-1). During the baseline investigation, the maximum concentration of TCE was 20,000 µg/kg from E-43 (at 4 to 5 feet bgs), which is located less than ten feet from confirmation soil boring CSB-13. The TCE concentration detected at CSB-13 from 3 to 5 feet bgs was 7,000 µg/kg, representing a 65 percent reduction of TCE in this area. Overall, a 72 percent reduction of TCE concentrations in Former Porch Area soil samples is observed when comparing the mean TCE concentration from the baseline (3,700 μg/kg) and confirmation (1,029 μg/kg) sampling events (Table 7-1).

7.3 Confirmation Groundwater Sample Results

The following confirmation groundwater sampling events are described in the paragraphs below:

- Confirmation Groundwater Sampling Event No. 1 – March 21 to 23, 2011;
- Confirmation Groundwater Sampling Event No. 2 – May 2 to 4, 2011; and
- Confirmation Groundwater Sampling Event No. 3 – August 1 to 4, 2011.

Confirmation Groundwater Sampling Event No. 1

Figures 7-6 and 7-7 describe the TCE and cis-1,2-DCE concentrations detected in groundwater during the first confirmation sampling event, with respect to groundwater cleanup goals (5 μg/L for TCE and 70 μg/L for cis-1,2-DCE). TCE was detected at a concentration exceeding the cleanup goal in 7 of the 16 confirmation groundwater samples. Cis-1,2-DCE was not detected above the groundwater cleanup goal during Confirmation Groundwater Sampling Event No. 1.

The highest TCE concentration was detected at TW-31 (at a concentration of 130 μg/L), located outside of the ISTT treatment area (Figure 7-6). Concentrations of TCE generally decreased significantly when compared to the baseline groundwater investigation (Table 7-2), especially at groundwater monitoring wells RW-03 and RW-05 located within the Former Porch Area.

Confirmation Groundwater Sampling Event No. 2

Figures 7-8 and 7-9 describe the TCE and cis-1,2-DCE concentrations detected in groundwater during the second confirmation sampling event, with respect to groundwater cleanup goals. TCE was detected at a concentration exceeding the cleanup goal in 8 of the 16 confirmation groundwater samples. Cis-1,2-DCE was not detected above the groundwater cleanup goal during Confirmation Groundwater Sampling Event No. 2.

The highest TCE concentration was detected at a concentration of 83 μg/L from groundwater monitoring well TW-31 (Figure 7-8). In general, concentrations of TCE continued to decrease when compared to the baseline and Confirmation Groundwater Sampling Event No. 1 (Table 7-2).

Confirmation Groundwater Sampling Event No. 3

Figures 7-10 and 7-11 describe the TCE and cis-1,2-DCE concentrations detected in groundwater during the third confirmation sampling event, with respect to groundwater cleanup goals. TCE and cis-1,2-DCE were detected at concentrations exceeding the cleanup goal in 8 and 1, respectively, of the 16 confirmation groundwater samples. The highest TCE and cis-1,2-DCE concentrations were detected in samples from groundwater monitoring well RW-05 (78 µg/L of both compounds) (Tables 7-2 and 7-3). In general, concentrations of TCE and cis-1,2-DCE continued to decrease when compared to the baseline and other confirmation events.

7.4 Confirmation Sampling Summary

The confirmation soil sampling results indicate that TCE concentrations have been significantly reduced and the remaining elevated concentrations of TCE are localized in two relatively small areas in the vadose zone below the paved Former Porch Area. Based on confirmation groundwater sampling results, the remaining TCE in the vadose zone does not appear to affect groundwater. The migration of TCE to groundwater in these localized areas is not expected because concentrations are relatively low, the Former Porch Area is paved, and significant surface water infiltration is not anticipated.

The confirmation groundwater sampling results indicate that a significant reduction of TCE and cis-1,2-DCE has occurred at the Site, especially at groundwater monitoring wells RW-03 and RW-05, located in the Former Porch Area. TCE and cis-1,2-DCE concentrations in groundwater were reduced over 99 and 75 percent, respectively, at these locations (Tables 7-2 and 7-3) when compared to the initial Baseline Investigation. However, TCE concentrations remained above the Site cleanup goals in 8 of 16 locations and cis-1,2-DCE remained above cleanup goals in 1 well.

Concentrations of TCE and cis-1,2-DCE generally remained relatively constant or continued to decrease during the confirmation groundwater sampling events that were conducted over a 6 month period. No significant increases, or rebound, of TCE or cis-1,2-DCE were observed. In addition, acetone and 2-butanone concentrations were observed to decrease significantly during confirmation groundwater sampling events (Appendix A).

8.0 DEMOBILIZATION AND SITE RESTORATION

Details of the ISTT demobilization and Site restoration are included in the Demobilization As-Builts (Appendix I) and following sections.

8.1 Demobilization

Demobilization activities began in February 2011, following the shutdown of the ISTT extraction systems and ET-DSP system, and concluded in July 2011. Demobilization activities included the following:

- Removal of groundwater extraction pumps in MPE wells;
- Removal of temperature, pressure, and vacuum sensors from sensor wells;
- Dismantling the ISTT extraction system piping;
- Decontamination of ISTT extraction system process equipment;
- Disconnection of electrical equipment and the transformer; and
- Removal of the vapor cover.

After removal of pumps and sensors, the ISTT wells (shallow SVE, MPE, sensor, and electrode wells) were abandoned in accordance with the MassDEP protocols, with the exception of extraction well MPE-03 which was converted into a monitoring well at the request of MassDEP.

Shallow SVE, MPE, and sensor wells were abandoned by injecting a grout mixture into the bottom of the well by tremie method. The grout mixture extended the full depth of the well to the bottom of the protective casing. The top portions of the well risers were removed to approximately 3 to 4 ft bgs. Grout was used to fill the well void to the ground surface.

The electrodes were abandoned in place because their design (stacked electrodes spaced five feet apart with granular media filling all the annular space in the boring) makes removal difficult, but also limits the available contaminant transport pathways through the borehole. The only available transport pathways in the electrode wells were the water injection and return lines. Therefore, abandonment of the electrode wells entailed cutting off the water lines close to the top of the cement grout plug constructed at the top of the electrode, injecting grout into the water return and injection hoses and pouring a concrete cap over the water lines to encapsulate them.

Several wastes, including non-hazardous and hazardous, were generated during ISTT construction, operation, and demobilization. These wastes were properly disposed of off-site during demobilization activities.

Non-hazardous wastes included the following:

- Construction debris, including trash, wood, plastic, and non-metals
- Decontaminated vapor and liquid extraction conveyance lines and manifolds
- Vapor cover materials
- Vapor cover insulation cap materials

Hazardous wastes included the following:

- NAPL
- Spent GAC (regenerated not disposed of),
- Liquid extraction system bag filters,
- Liquid extraction system organoclay media
- Contaminated personal protective equipment
- Decontamination fluids that could not be processed by OU1 GWTF due to potential NAPL content
- Investigation derived wastes generated during confirmation soil sampling activities

The Resident Engineer oversaw demobilization activities and confirmed that activities were complete. The Resident Engineer prepared and distributed to the project team weekly Demobilization Status Reports (Appendix J) which included the following information:

- Assigned responsible party, status, and estimated task completion dates
- Planned activities for the following week
- Confirmation sampling schedule
- Applicable photographs

8.2 Site Restoration

Restoration activities at the Site and at the neighboring residential property, 106 Center Street, began in August 2011 and concluded in September 2011.

Restoration activities at the Site included the following:

- Removal of temporary construction fences
- Installation of permanent fence and gate located between the Valley Manufacturing and OU1 GWTF properties
- Re-grading of Site soils
- Relocation of crushed stone into the truck well
- Repairs to OU1 GWTF drainage swale
- Application of grass seeds at Valley Manufacturing and GWTP properties
- Restoration of OU1 GWTF wall to seal a hole cut for pipe entry and restore damaged brick veneer at the pipe entry location and two other locations near the loading dock
- Installation of electrical and mechanical conduit and controls to support restoration of OU1 Extraction Wells EW-S1, EW-S2, and EW-S3

Restoration activities at 106 Center Street included the following:

- Placement of loam and re-grading on the north portion of property
- Landscaping, including application of grass seed and installation of requested plants
- Installation of permanent replacement fence on north portion of property

The Resident Engineer oversaw restoration activities and confirmed that the activities were complete. The groundwater extraction infrastructure (electrical and control conduits and wiring) at OU1 Extraction Wells EW-S1, EW-S2, and EW-S3 has been restored. However, the wells are not yet operational because the current groundwater temperatures remain above the temperature tolerances of the pumping equipment and groundwater conveyance to the treatment facility. The groundwater temperature at the wells on September 13, 2011 ranged between 114°F and 120°F and the threshold temperature for safe operation of the extraction wells is 100°F. As a result, the extraction pumps have been assembled for installation but have not been placed back in the wells. The current operators of the OU1 GWTF (contractors to MassDEP) will complete this activity once groundwater temperatures are less than 100°F.

9.0 CONCLUSIONS AND RECOMMENDATIONS

The ISTT system was designed to reduce contaminant concentrations in the source area soils and overburden groundwater. Removal of source area contaminants by the ISTT operations is anticipated to shorten the OU1 GWTF operation duration necessary to reach groundwater cleanup goals. Construction of the ISTT system began in April 2009 and concluded in August 2010, and operated from August 2010 to February 2011. The ISTT system operated continuously with the exception of temporary shutdowns due to scheduled sampling events. In October 2011, the ISTT was shut down for approximately nine days following the breakthrough of a NAPL from the ISTT liquid extraction system effluent to the OU1 GWTF. Several liquid extraction system upgrades were implemented to ensure better separation of NAPL.

During ISTT operations, monitoring systems were established to monitor the progress and effectiveness of the ISTT system. In total, the ISTT system removed over two million gallons of water and condensate, 311 million cubic feet of non-condensable vapors, and 1,300 lbs of VOCs (including over 18 gallons of NAPL) from the ISTT Areas while using over three million kWh of energy over the period of 192 operating days.

The ISTT system was shutdown in February 2011 in various stages based on subsurface temperatures and contaminant concentrations in groundwater and vapor in the various ISTT Areas, and an evaluation of diminishing returns. Ongoing optimizations of the ET-DSP™ system, extended heating operations, and enhanced heating using steam injection into the upper vadose zone achieved sufficient subsurface temperatures to meet the overall remedial objective of reducing contaminant concentrations.

Confirmation soil and groundwater sampling events were conducted at the conclusion of ISTT operations at the Site. Significant reductions of TCE and cis-1,2-DCE were observed in both the soil and groundwater at the Site. Two small areas of elevated TCE concentrations remain in the vadose zone soils below a paved portion of the Site. Based on groundwater sampling results, the localized TCE remaining in the vadose zone soil does not appear to be significantly affecting groundwater. In addition, no rebound of TCE or cis-1,2-DCE concentrations was observed during the confirmation sampling events. Infiltration of significant surface water is not anticipated in this area. Therefore, significant migration of TCE to groundwater from the remaining areas of elevated TCE concentrations in vadose zone soil is not expected.

Although ISTT significantly reduced the concentrations of TCE and cis-1,2-DCE in Site groundwater, TCE concentrations remain above the Site cleanup goals in 8 of 16 locations and cis-1,2-DCE remains above cleanup goals in one well. As a result, the project team concluded that the source area groundwater extraction wells (EW-S1, EW-S2, and EW-S3), which are located immediately downgradient of the Former Porch Area, should be restored to their original functional condition. These wells were decommissioned during ISTT construction. Restoring these wells requires re-installation of electrical and mechanical conduit and controls.

Subsequent to ISTT operations, the following is recommended at the Site:

- The operation of OU1 GWTF and the OU1 extraction wells (EW-S1, EW-S2, and EW-S3), located immediately downgradient from the Former Porch Area, should resume after the temperature of groundwater in the source area drops below 100°F (the maximum safe operation temperature of the extraction pumps and conveyance). Operation should continue until concentrations of VOCs in Site groundwater are below cleanup goals or natural attenuation is evaluated.

- Groundwater sampling of the existing groundwater monitoring well network (including downgradient OU1 monitoring wells) should continue to evaluate current groundwater contaminant concentrations and potential rebound effects.

- Institutional controls should be implemented in the areas where groundwater contaminant concentrations exceed cleanup goals to prevent the use of and human exposure to contaminated groundwater until groundwater cleanup goals are achieved.

- Five Year Reviews should continue to be performed. Potential contaminant rebound effects should be considered during the next Five Year Review:

The following considerations and enhancements to ISTT remedial actions are recommended for implementation at similar Sites:

- An effort should be made to determine the baseline electrical resistivities of the different types of soil present at the site prior to the remedial design to allow for use of the data during design. If resistivity values for wet and dry soil samples vary significantly, efforts should be made to confirm which values are more representative of actual conditions at the site. This is especially important at sites with highly permeable geologic units.

- The use of combined thermal treatment technologies should be considered at sites with varying geologic units.

- To prevent adverse effects of operating an ISTT system in cold weather climates, use of a thermal insulation vapor cover should be considered to prevent unintentional heat losses in shallow soils. Also, winterization of above ground piping should be completed well before the occurrence of freezing temperatures to minimize downtime associated with freezing.

- When integrating ISTT extraction systems with existing treatment operations, care should be taken to bridge the ISTT and existing grounding systems to prevent the occurrence of voltage potentials that may be harmful to site workers.

10.0 SUMMARY OF PROJECT COSTS

This section provides a summary of ISTT Remedial Action costs. The overall cost for performing the ISTT Remedial Action at the Groveland Site is estimated to be $6,264,000. This total includes the following cost elements:

- ISTT Subcontract Cost = $3,617,610 – *ISTT design, construction, operation and maintenance, demobilization, and reporting*;

- ISTT Electricity Cost = $603,963 – *Direct cost of electricity to operate ISTT heating and extraction systems*;

- Other Subcontract Costs = $284,452 – *Services provided by 16 subcontractors for activities including clearing and grubbing, utility survey, structural engineering* *assessment, mold assessment, monitoring well abandonment, well replacement, waste disposal, fence removal and installation, land surveying, soil borings, laboratory analysis, and electrical/automated controls services*; and

- Other Costs = $1,757,975 – *Other costs include RAC contractor (Nobis) labor costs (for project management, community involvement activities, preparation of project plans and specifications, procurement of subcontractors, field oversight of subcontractor field activities and ISTT operations and maintenance, planning and execution of baseline and confirmatory soil and groundwater investigations, collection of ambient air samples, data management and evaluation, and preparation of reports); and costs for sampling equipment and supplies, consumable materials, and transportation.*

Based on the costs provided above and the ISTT treatment volume of 17,450 cubic yards, the unit treatment cost for ISTT treatment is approximately $207 per cubic yard, based solely on ISTT Subcontract costs for ISTT design, construction, operation and maintenance, demobilization, and reporting. If electricity costs are included along with ISTT Subcontract costs, the treatment cost is approximately $242 per cubic yard. If all project costs are included, the unit treatment cost increases to approximately $359 per cubic yard.

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TABLES

Table 2-1
Soil and Groundwater Cleanup Goals
Groveland Wells Superfund Site
Groveland, Massachusetts

Chemical of Concern	Vadose Zone Soil (µg/kg)	Overburden Groundwater (µg/L)
Trichloroethene (TCE)	77	5
1,1-Dichloroethene (11-DCE)	45	7
trans-1,2-Dichloroethene (tDCE)	626	100
cis-1,2-Dichloroethene (cDCE)	418	70
Methylene chloride (MC)	22	5
Tetrachloroethene (PCE)	56	5
1,1,1-Trichloroethane (111-TCA)	1,388	200
Toluene	22,753	1000
Vinyl chloride	11	2

Notes:
µg/kg – microgram per kilogram
µg/L – microgram per liter

Table 3-1
In-Situ Thermal Treatment Area and Volume Summary
Groveland Wells Superfund Site
Groveland, Massachusetts

Zone Description	Area (ft^2)	Depth (ft bgs)	Volume (yd^3)
Area A	8,460	0 to 45[1]	14,100
Area B	910	0 to 25	850
Area C	2,950	0 to 10[2]	1,600
Area D	2,510	0 to 10	930
Total	14,830	Varies	17,450

Notes:
ft^2 – square feet
ft bgs – feet below ground surface. Ground surface is below concrete slab, where applicable.
yd^3 – cubic yards

(1) Area A extended vertically from the ground surface to bedrock, which is estimated to be approximately 45 ft bgs.
(2) As a result of the baseline groundwater investigation, a portion of Area C below the Valley Building was extended deeper.

Table 3-2
In-Situ Thermal Treatment Performance Metrics
Groveland Wells Superfund Site
Groveland, Massachusetts

Performance Objectives	Performance Metrics
Heating	
1. Rapid heat-up of the treatment zone (i.e. Phase 1 Heating) to achieve a uniform target temperature of 90°C in vadose zone soils and the boiling point of water in the saturated zone. 2. Sustain target temperatures (i.e. Phase 2 Heating) to ensure thorough treatment of the contaminated soil and groundwater. Comments: A. Allowable exceptions to these temperature objectives may include lower near surface temperatures because of limited infiltration of atmospheric air into the shallow vadose zone.	Measure and record temperatures in the subsurface directly using thermocouples (TCs) or other approved means installed throughout the treatment zones at reasonable depth intervals to allow adequate monitoring of the subsurface temperature distribution during and after heating of the subsurface. The Subcontractor's system shall attain all of the Performance Metrics for temperature, as specified below: 1. Temperature compliance monitoring locations shall be installed at a minimum density of one per 900 sq. ft. and placed at centroid locations (i.e. center of the group of immediately surrounding heating wells/electrodes). 2. Each temperature compliance monitoring location shall have multiple TCs installed at depth intervals no greater than 5 feet apart vertically, including one near the surface. These TCs are referred to as the Compliance Monitoring TCs. 3. Additional temperature monitoring locations shall be installed at the perimeter of the treatment zone to further define the temperature distribution and confirm hydraulic control. A minimum of 10 perimeter temperature monitoring locations shall be provided. 4. The Minimum Target Temperature for the vadose zone is 90°C. 5. The Minimum Target Temperature for the saturated overburden is the boiling point of the site groundwater at each TC depth interval. Because the boiling point of groundwater increases with depth below the water table, and may also change because of contaminant concentrations, the Minimum Target Temperature will vary depending on the depth below the water table and contaminant concentrations. 6. The *in situ* thermal treatment (ISTT) system will achieve the Minimum Target Temperatures when: A. The temperature is greater than or equal to 90°C at a minimum of 85 percent of the Compliance Monitoring TCs in the vadose zone; B. The temperature is the boiling point of the groundwater at a minimum of 85 percent of the Compliance Monitoring TCs in the saturated zone; and C. The temperature is greater than or equal to 60°C at 100 percent of the Compliance Monitoring TCs in the saturated and vadose zones. Additional TCs installed for monitoring temperatures outside the perimeter of the Treatment Zone shall not be included in the calculation to determine attainment of the Minimum Target Temperatures. Temperature monitoring shall commence a minimum of 3 days before start of the heating in order to provide representative background conditions and end upon completion of Phase 3 operations (Task 5).
Pneumatic Containment	
1. Capture, extraction, and treatment of all subsurface contaminant vapors generated during operation of the ISTR system. 2. Prevent migration of subsurface vapors to any off-site receptors.	1. Install and operate vapor extraction wells throughout the treatment zone in a manner that will ensure capture of vapors generated during operation of the ISTT system. 2. Install subsurface vapor monitoring probes throughout the treatment zone and outside the perimeter of the treatment zone in locations that will provide effective verification that the vapor extraction system is containing and capturing all vapors generated during and after operation of the ISTT system. 3. Monitor subsurface vapor monitoring probes throughout operation of the ISTT system in order to verify containment of all vapors generated during operation of the ISTT system. 4. Provide pneumatic containment until it is demonstrated that vapors emanating from the treatment zone do not present a risk to off-site receptors (completion of Phase 3 of Operations).
Hydraulic Containment	
1. Capture contaminated groundwater in the treatment zone in order to prevent downgradient migration of groundwater contaminants.	1. Operate the ISTT system such that sufficient groundwater is extracted in the form of steam or entrained water such that an inward and vertically upward hydraulic gradient is maintained during the heat-up and treatment phases of operation (Phases 1 and 2 of operation). 2. Monitor groundwater temperature using the TCs installed at the perimeter of the treatment zone (10 minimum) prior to startup, and during heating, and the initial cool-down phases of operation (Phases 1, 2, and 3 of operation) in order to demonstrate hydraulic containment of contaminated groundwater in the treatment zone.

Table 4-1
Replacement Well Construction Details
Groveland Wells Superfund Site
Groveland, Massachusetts

Well ID	Formation	Screened Interval (ft bgs)	Screen Slot Size (Inches)	Diameter (Inches)	MP Elevation (feet above MSL)	Mass. State Plane Coordinates	
						Northing	Easting
RW-01	OB	30-40	0.010	2	79.05	635648.313	722819.98
RW-02	OB	41-51	0.010	2	77.90	635609.054	722870.418
RW-03	OB	30-40	0.010	2	79.43	635649.37	722867.222
RW-04	OB	29.5-39.5	0.010	2	79.78	635670.361	722892.16
RW-05	OB	36-46	0.010	2	79.50	635641.909	722895.156
RW-06	OB	26-36	0.010	2	76.21	635729.172	722933.803
RW-07	OB	35-45	0.010	2	77.45	635668.51	722922.546
RW-07B	BR	80-100	0.020	4	76.31	635671.573	722926.247
RW-08	OB	39-49	0.010	2	76.86	635617.264	722916.145
RW-09	OB	29.5-39.5	0.010	2	75.43	635611.93	722947.237
RW-10	OB	29-39	0.010	2	74.52	635654.208	722951.426
RW-10B	BR	55-75	0.020	4	73.91	635651.798	722947.43

Notes:

OB - Overburden
BR - Bedrock
MSL - Mean Sea Level
ft bgs feet below ground surface

Table 6-1
Trichloroethene Reductions in Site Groundwater
Groveland Wells Superfund Site
Groveland, Massachusetts

Monitoring Well Location	Date of Initial Sample	Initial Sample Concentration (µg/L)	Final Sample Concentration (µg/L)[1]	Trichloroethene Mass Reduction (%)
Groundwater Monitoring Wells				
RW-01	8/25/09	<5	<5	-
RW-02	8/25/09	15	<5	100%
RW-03	8/26/09	11000	180	98%
RW-04	8/24/09	290	2.6	99%
RW-05	8/26/09	11000	14.5	100%
RW-06	8/25/09	<5	1	-
RW-07	8/25/09	83	1.1	99%
RW-07B	8/26/09	52	<5	100%
RW-08	8/25/09	4	1.5	63%
RW-09	8/26/09	10	12	-20%
RW-10B	8/26/09	1.4	<5	100%
Groundwater Extraction Wells				
MPE-02	9/30/10	340	<5	100%
MPE-03	8/16/10	24	<5	100%
MPE-05	9/30/10	93	<5	100%
MPE-09	9/30/10	4200	7.2	100%
MPE-14	8/16/10	17	<5	100%
MPE-15	9/30/10	8500	26	100%
MPE-17	9/30/10	1550	19	99%
MPE-18	9/30/10	<5	<5	-
MPE-21	8/16/10	2600	4.4	100%
Average TCE Reduction in Groundwater Monitoring and Extraction Wells				90%

Notes:

µg/L - Micrograms per Liter

[1] Groundwater samples were collected on January 25, 2011 as part of the comprehensive groundwater monitoring event.
TCE values <5 (non-detect values) are assumed to be zero for calculation of mass reduction

Table 7-1
Statistical Analysis of Baseline and Confirmation Soil Sampling Results in the Former Porch Area
Groveland Wells Superfund Site
Groveland, Massachusetts

Chemical Name	Minimum Detection	Maximum Detection	Mean(1)	Standard Deviation(1)	Frequency of Detections	
Baseline Soil Samples (2)						
1,1,1-Trichloroethane	1.4	38	12	17.453	4 / 22	18%
1,1,2-Trichloroethane	9.5	58	41.5	27.717	3 / 22	14%
1,1-Dichloroethane	5.1	5.1	5.1	--	1 / 22	5%
1,1-Dichloroethene	1.2	63	20.2	29.266	4 / 22	18%
1,2,4-Trichlorobenzene	74	74	74	--	1 / 22	5%
2-Butanone	2	98	31.1	44.949	4 / 22	18%
Acetone	4.8	150	40.7	47.424	8 / 22	36%
Bromomethane	13	13	13	--	1 / 22	5%
Carbon Disulfide	80	80	80	--	1 / 22	5%
Chloroethane	10	10	10	--	1 / 22	5%
Chloroform	250	250	250	--	1 / 22	5%
Chloromethane	11	11	11	--	1 / 22	5%
Cis-1,2-Dichloroethene	4.9	2100	304.5	522.836	17 / 22	77%
Ethylbenzene	71	71	71	--	1 / 22	5%
Isopropylbenzene	68	68	68	--	1 / 22	5%
M,P-Xylene	250	250	250	--	1 / 22	5%
Methyl Acetate	5.4	350	82.6	105.833	8 / 22	36%
Tetrachloroethene	1.7	1900	314.8	611.889	9 / 22	41%
Toluene	520	520	520	--	1 / 22	5%
Total Organic Carbon (TOC)	1200	4600	2900	2404.163	2 / 2	100%
Trans-1,2-Dichloroethene	3	4.3	3.65	0.919	2 / 22	9%
Trichloroethene	5.7	20000	3700	4721.383	22 / 22	100%
Vinyl Chloride	2.3	5.2	3.75	2.051	2 / 22	9%
Confirmation Soil Samples (3)						
2-Butanone	1.8	1,000	214	265	3 / 13	23%
Acetone	15	3,100	1,099	1,069	13 / 13	100%
Carbon Disulfide	0.72	0.72	78	62	1 / 13	8%
Cis-1,2-Dichloroethene	4.8	1,700	205	454	3 / 13	23%
Methylene Chloride	1.3	360	135	121	13 / 13	100%
Trichloroethene	3.7	7,000	1,029	2,357	5 / 13	38%

Notes:

All concentrations are in µg/kg.

All detected compounds are presented. The complete analytical data are included in Appendix A.

(1) The mean and standard deviation calculations for the confirmation soil samples include non-detect values at half of the of the quantitation limit. Due to the high quantitation limits resulting from elevated acetone concentrations in confirmation samples the mean and standard deviation values for TCE and cis-1,2-DCE may not be representative.

(2) Data set includes samples collected from Baseline soil borings E-27, E-42, E-43, E-46, E-49, E-53, RW-03, and RW-05.

(3) Data set includes samples collected from Confirmation soil borings CSB-09, CSB-10, CSB-13, and CSB-15.

Table 7-2
Baseline and Confirmation Groundwater Data Comparison -Trichloroethene
Groveland Wells Superfund Site
Groveland, Massachusetts

Sample Location	Baseline Event		Confirmation Event No.1		Confirmation Event No.2		Confirmation Event No.3		TCE Mass Reduction[(1)]
	June, July, & August 2009		March 2011		May 2011		August 2011		
	Result	Qualifier	Result	Qualifier	Result	Qualifier	Result	Qualifier	
EW-S3	**28**		**36**		**15**		**38**		-36%
RW-01	5	U	5	U	5	U	5	U	-
RW-02	**15**		**1**	**J**	5	U	5	U	100%
RW-03	**11000**	**D**	**5.9**		**17**		**17**		100%
RW-04	**290**	**D**	**24**		**25**		**20**		93%
RW-05	**11000**	**D**	**37**		**15**		**78**		99%
RW-06	5	U	**1.2**	**J**	5	U	**8.9**		-
RW-07*	**83**		**28**		**9.6**		**11**		87%
RW-07B	**52**		**4.6**	**J**	**5.8**		**7.2**		86%
RW-08	**4**	**J**	**1.2**	**J**	5	U	5	U	100%
RW-09	**10**		**12**		5	U	5	U	100%
RW-10	**390**	**D**	**3.3**	**J**	**10**		**1.9**	**J**	100%
RW-10B	**1.4**	**J**	5	U	5	U	5	U	100%
TW-31	**8.7**	**B**	**130**		**83**		**38**		-337%
TW-40	5	U	5	U	5	U	5	U	-
TW-47	**8.3**	**B**	**2.3**	**J**	**1.3**	**J**	5	U	100%

Notes:
All values are in micrograms per kilograms (µg/L)
CUG of trichloroethene is 5 µg/L
Bold - Detected Concentration
Shaded - Detected Concentrations Exceeds the CUG
TCE - Trichloroethene
CUG - Interim Cleanup Goal - based on current Federal and State Maximum Contaminant Levels, per the Record of Decisions (1991).
(1) Mass reduction was calculated using baseline event and confirmation event no. 3. Zero was used for non-detect values.
* Well MPE-06 was used as a substitute for RW-07 during Confirmation Sampling Event No. 2 only because of a problem with well RW-07.

Laboratory Qualifiers:
J - Quantitation is estimated as it is below the Sample-Specific Detection Limit (SSDL).
U - Not detected above the SSDL.
B - Analyte detected in laboratory blanks.
D - Concentration is reported from a dilution of the sample.

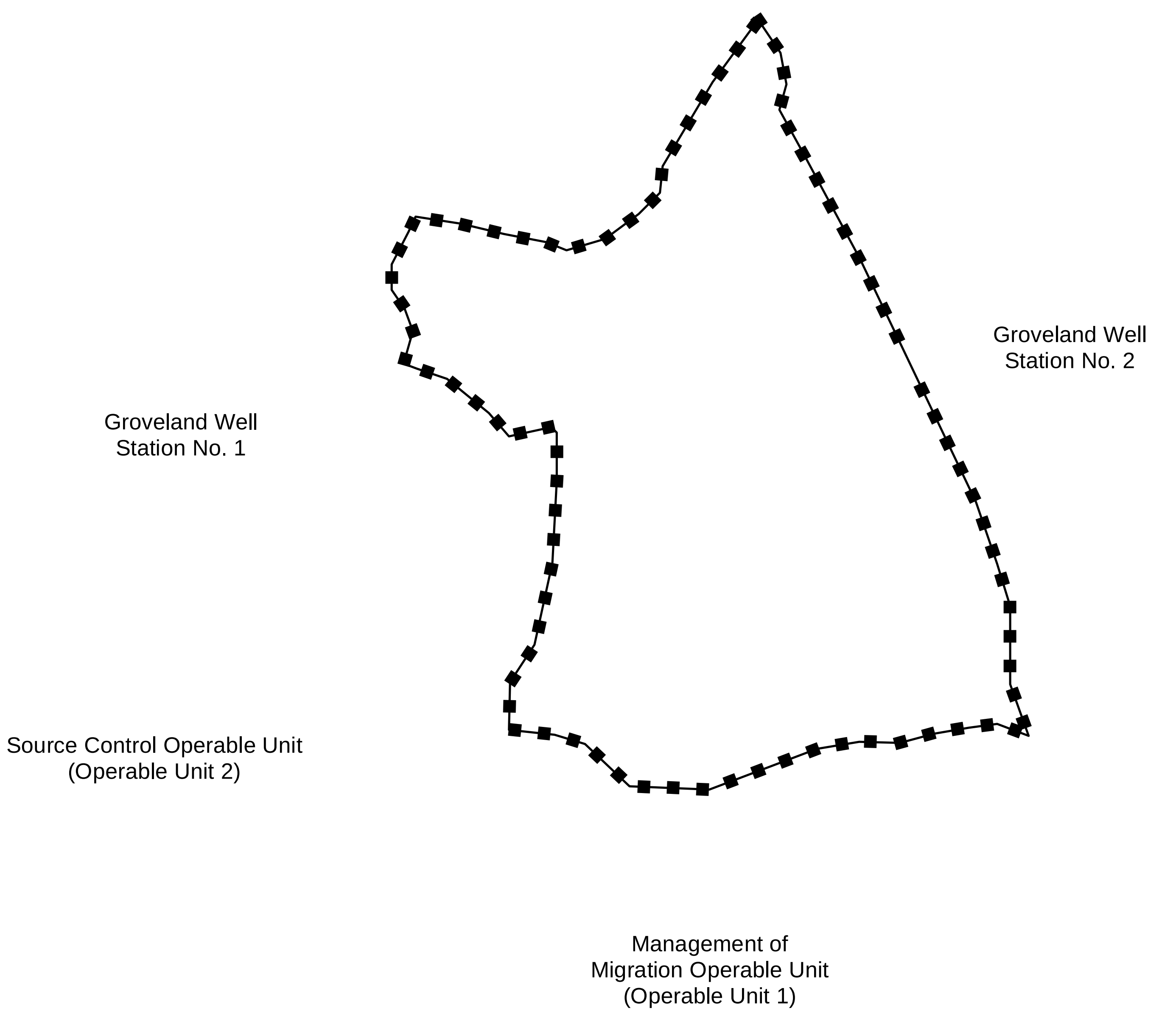
Table 7-3
Baseline and Confirmation Data Comparison - Cis-1,2-Dichloroethene
Groveland Wells Superfund Site
Groveland, Massachusetts

Sample Location	Baseline Event		Confirmation Event No.1		Confirmation Event No.2		Confirmation Event No.3		cis-1,2-DCE Mass Reduction(1)
	June, July, & August 2009		March 2011		May 2011		August 2011		
	Result	Qualifier	Result	Qualifier	Result	Qualifier	Result	Qualifier	
EW-S3	**6.6**		**17**		**6.1**		**17**		-158%
RW-01	5	U	5	U	5	U	5	U	-
RW-02	**3.1**	**J**	**2**	**J**	5	U	5	U	100%
RW-03	**260**	**DJ**	**2.8**	**J**	**7.8**		**11**		96%
RW-04	**57**		**8.6**		**9.6**		**14**		75%
RW-05	**325**	**DJ**	**19**		**13**		**78**		76%
RW-06	5	U	5	U	5	U	**4.7**	**J**	-
RW-07*	**37**		**13**		**5.2**		**9.2**		75%
RW-07B	**4.5**	**J**	5	U	**1.1**	**J**	5	U	100%
RW-08	5	U	**1.2**	**J**	5	U	5	U	-
RW-09	**2.8**	**J**	**8.9**		5	U	5	U	100%
RW-10	**180**	**D**	5	U	**5.9**		**1.9**	**J**	99%
RW-10B	5	U	5	U	5	U	5	U	-
TW-31	5	U	5	J	**4.6**	**J**	**4.1**	**J**	-
TW-40	5	U	5	U	5	U	5	U	-
TW-47	**1.3**	**J**	5	U	5	U	5	U	100%

Notes:
All values are in micrograms per kilograms (µg/L)
CUG of cis-1,2-dichloroethene is 70 µg/L.
Bold - Detected Concentration
Shaded - Detected Concentrations Exceeds the CUG
cis-1,2-DCE - cis-1,2-Dichloroethene
CUG - Interim Cleanup Goal - based on current Federal and State Maximum Contaminant Levels, per the Record of Decisions (1991)
(1) Mass reduction was calculated using baseline event and confirmation event no. 3. Zero was used for non-detect values.
* Well MPE-06 was used as a substitute for RW-07 during Confirmation Sampling Event No. 2 only because of a problem with well RW-07.

Laboratory Qualifiers:
J - Quantitation is estimated as it is below the Sample-Specific Detection Limit (SSDL).
U - Not detected above the SSDL.
D - Concentration is reported from a dilution of the sample.

FIGURES



0 1,000 2,000 4,000

Feet

1 inch = 2,000 feet

N

Notes:
1. Topography from USGS, Haverhill and Lawrence quadrangles, 1987.

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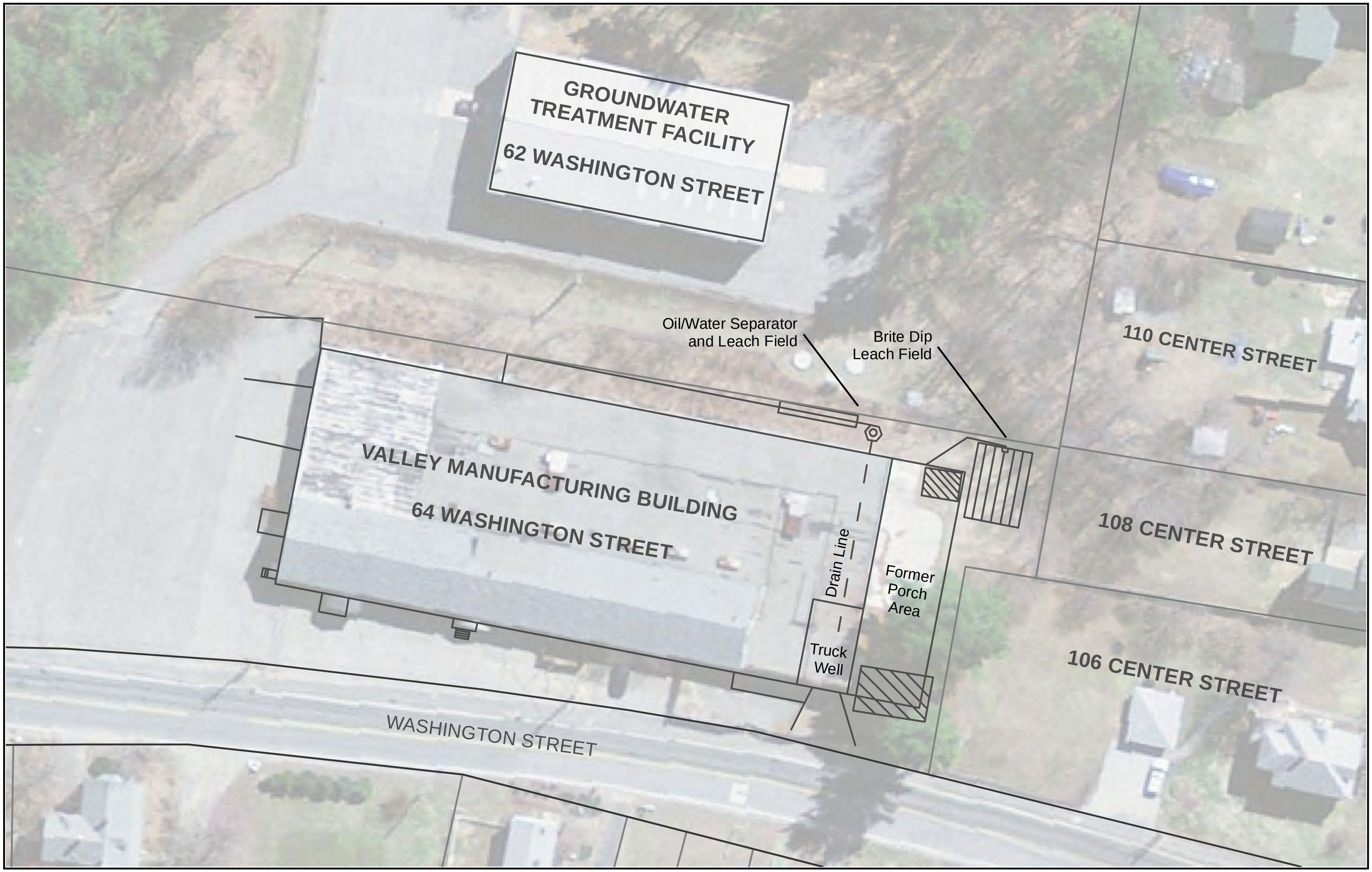
FIGURE 1-1

SITE LOCUS PLAN
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JMH	CHECKED BY: LS
PROJECT NO. 80037	DATE: 5/17/2011 Rev 01

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Community Involvement Plan\Fig_1-1_Site_Locus_Plan.mxd



Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Community Involvement Plan\Fig_1-2_Site Plan.mxd

Legend

Approximate Location of Former Underground Storage Tanks

Notes:

1. Aerial photograph provided by MassGIS

N

0 20 40 80

Feet

1 inch = 60 feet

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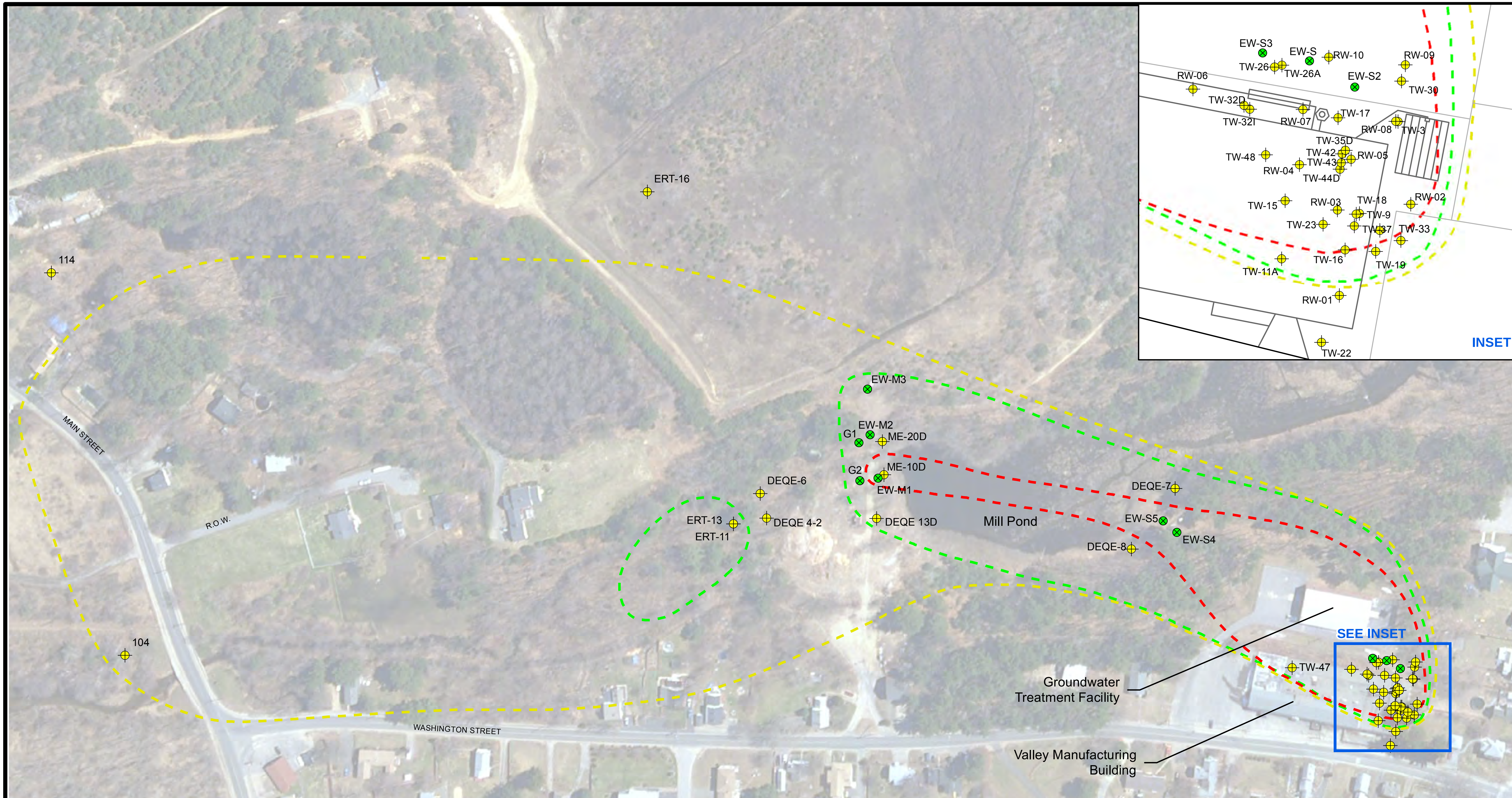
FIGURE 1-2

SITE PLAN
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JMH	CHECKED BY: LS
PROJECT NO. 80037	DATE: 5/17/2011 Rev 01



Legend

DEQE-8 — Overburden Monitoring Well

EW-M1 — Management of Mitigation Extraction Well

Extent of TCE Overburden Plume < 5 µg/L Prior to System Startup in 2000

Extent of TCE Overburden Plume> 5 µg/L in 2006

Extent of TCE Overburden Plume < 5 µg/L in 2010

N

Notes:
1. Aerial photograph provided by MassGIS.

APPROXIMATE SCALE

190 95 0 190 Feet

INSET SCALE

50 25 0 50 Feet

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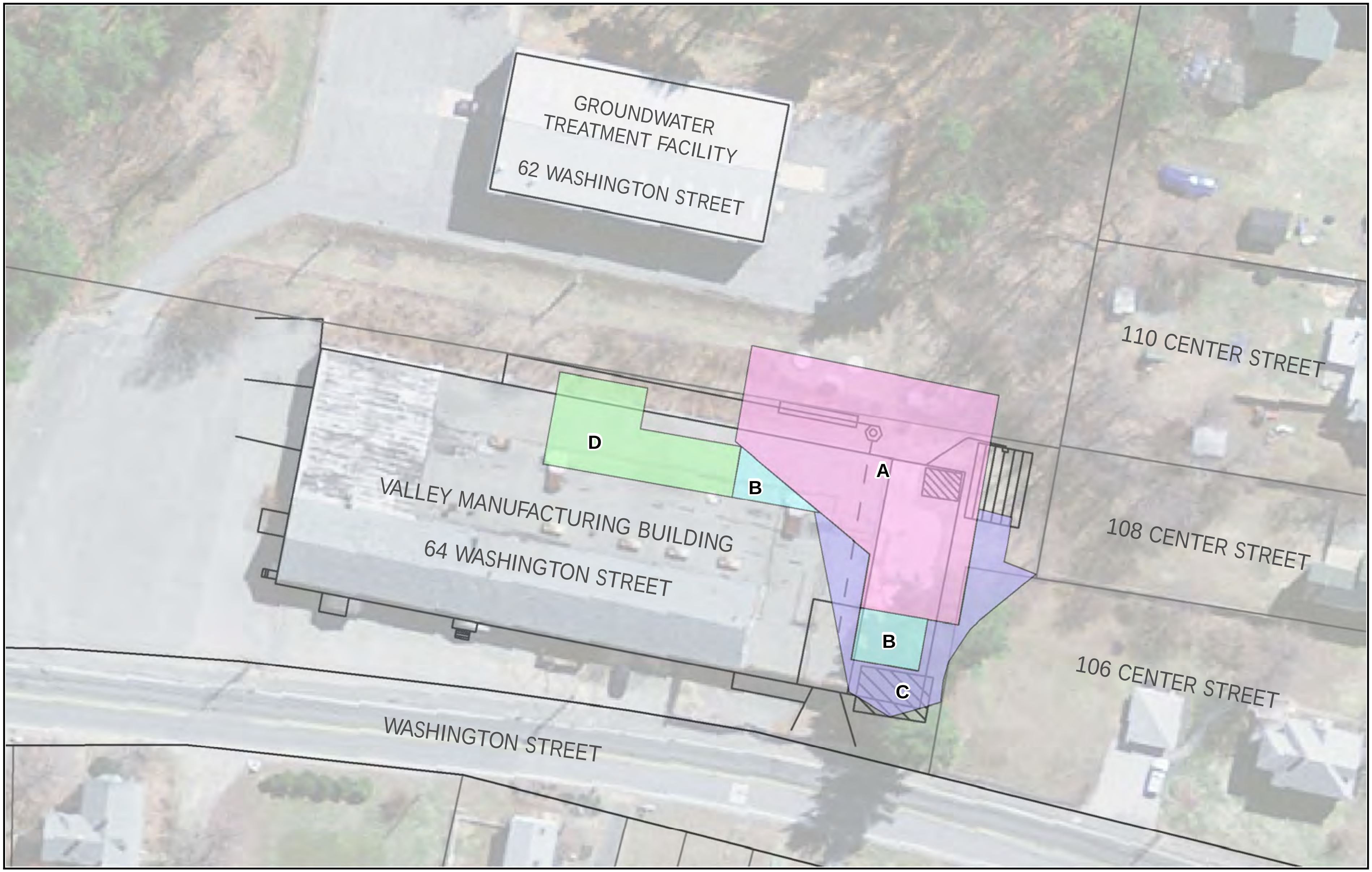
FIGURE 2-1

OVERBURDEN GROUNDWATER
TRICHLOROETHENE PLUME
2000, 2006, AND 2010
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JMH	CHECKED BY: LS
PROJECT NO. 80037	DATE: 8/18/2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Community Involvement Plan\Fig_2-1_Overburden_TCE_ Plume.mxd



In Situ Treatment Zones

- ISTT Area A, 0 to 45 feet below ground surface (8,460 ft^2)
- ISTT Area B, 0 to 25 feet below ground surface (910 ft^2)
- ISTT Area C, 0 to 10 feet below ground surface (2,950 ft^2)
- ISTT Area D, 0 to 10 feet below ground surface (2,370 ft^2)

N

0 20 40 80

Feet

1 inch = 60 feet

Notes:
1. Aerial photograph provided by MassGIS

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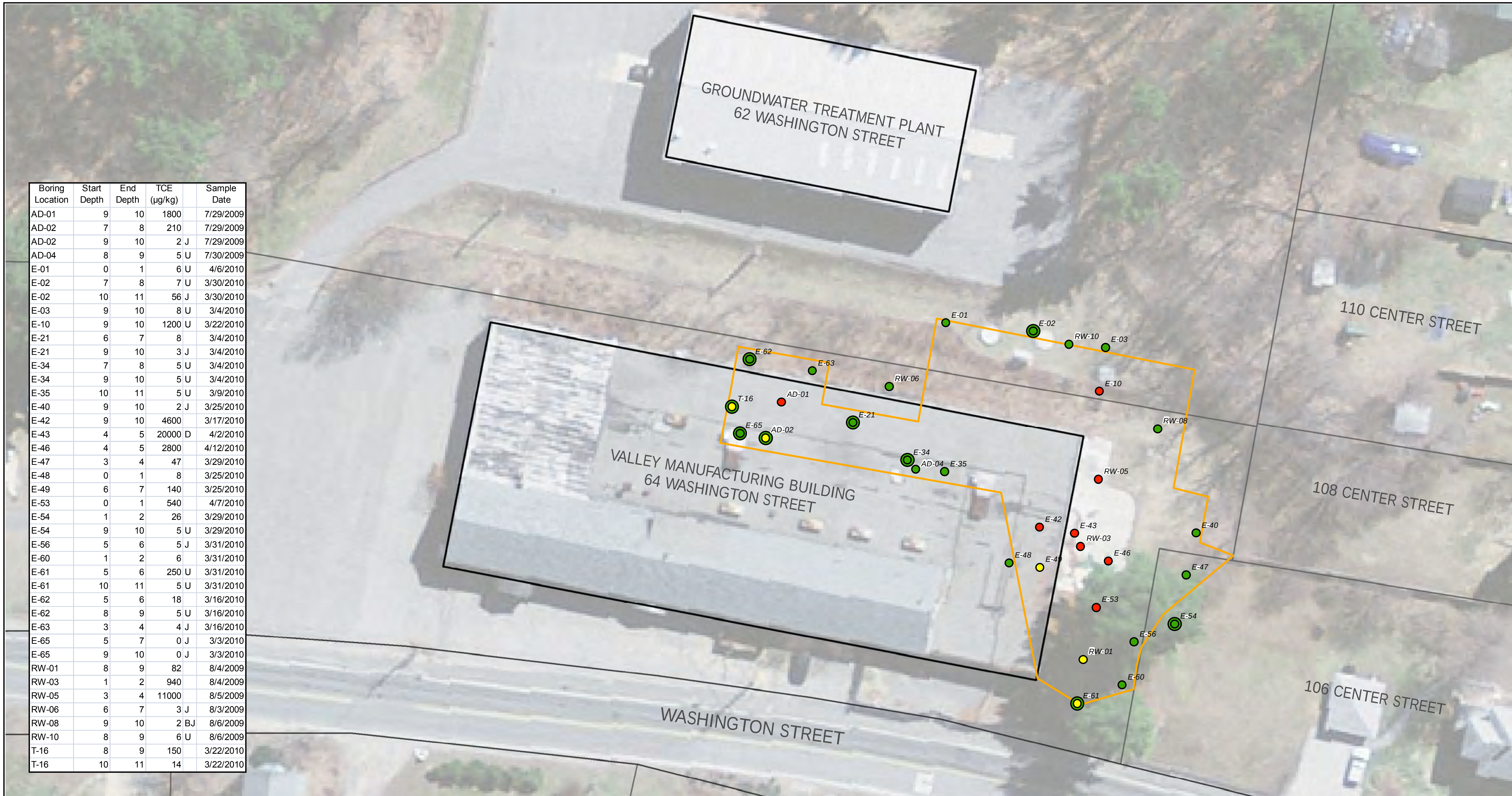
FIGURE 3-1

IN SITU THERMAL TREATMENT AREAS
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JMH	CHECKED BY: LS
PROJECT NO. 80037	DATE: 8/18/2011



Boring Location	Start Depth	End Depth	TCE (µg/kg)		Sample Date
AD-01	9	10	1800		7/29/2009
AD-02	7	8	210		7/29/2009
AD-02	9	10	2	J	7/29/2009
AD-04	8	9	5	U	7/30/2009
E-01	0	1	6	U	4/6/2010
E-02	7	8	7	U	3/30/2010
E-02	10	11	56	J	3/30/2010
E-03	9	10	8	U	3/4/2010
E-10	9	10	1200	U	3/22/2010
E-21	6	7	8		3/4/2010
E-21	9	10	3	J	3/4/2010
E-34	7	8	5	U	3/4/2010
E-34	9	10	5	U	3/4/2010
E-35	10	11	5	U	3/9/2010
E-40	9	10	2	J	3/25/2010
E-42	9	10	4600		3/17/2010
E-43	4	5	20000	D	4/2/2010
E-46	4	5	2800		4/12/2010
E-47	3	4	47		3/29/2010
E-48	0	1	8		3/25/2010
E-49	6	7	140		3/25/2010
E-53	0	1	540		4/7/2010
E-54	1	2	26		3/29/2010
E-54	9	10	5	U	3/29/2010
E-56	5	6	5	J	3/31/2010
E-60	1	2	6		3/31/2010
E-61	5	6	250	U	3/31/2010
E-61	10	11	5	U	3/31/2010
E-62	5	6	18		3/16/2010
E-62	8	9	5	U	3/16/2010
E-63	3	4	4	J	3/16/2010
E-65	5	7	0	J	3/3/2010
E-65	9	10	0	J	3/3/2010
RW-01	8	9	82		8/4/2009
RW-03	1	2	940		8/4/2009
RW-05	3	4	11000		8/5/2009
RW-06	6	7	3	J	8/3/2009
RW-08	9	10	2	BJ	8/6/2009
RW-10	8	9	6	U	8/6/2009
T-16	8	9	150		3/22/2010
T-16	10	11	14		3/22/2010

Legend

TCE RESULTS 0-11 ft bgs (µg/kg)

- < 77
- 77 - 500
- > 500

Multiple samples collected within Figure depth range.

Thermal Treatment Area

Notes:

1. The site cleanup goal for TCE in vadose zone soil is 77 µg/kg.
2. Qualifiers:
   - U - Not detected above the sample-specific detection limit.
   - J - Quantitation is estimated as it is below the sample-specific detection limit.
   - D - Concentration is reported from a dilution of the sample.
   - B - Analyte detected in laboratory blank.

N

0 20 40 80

Feet

1 inch = 40 feet

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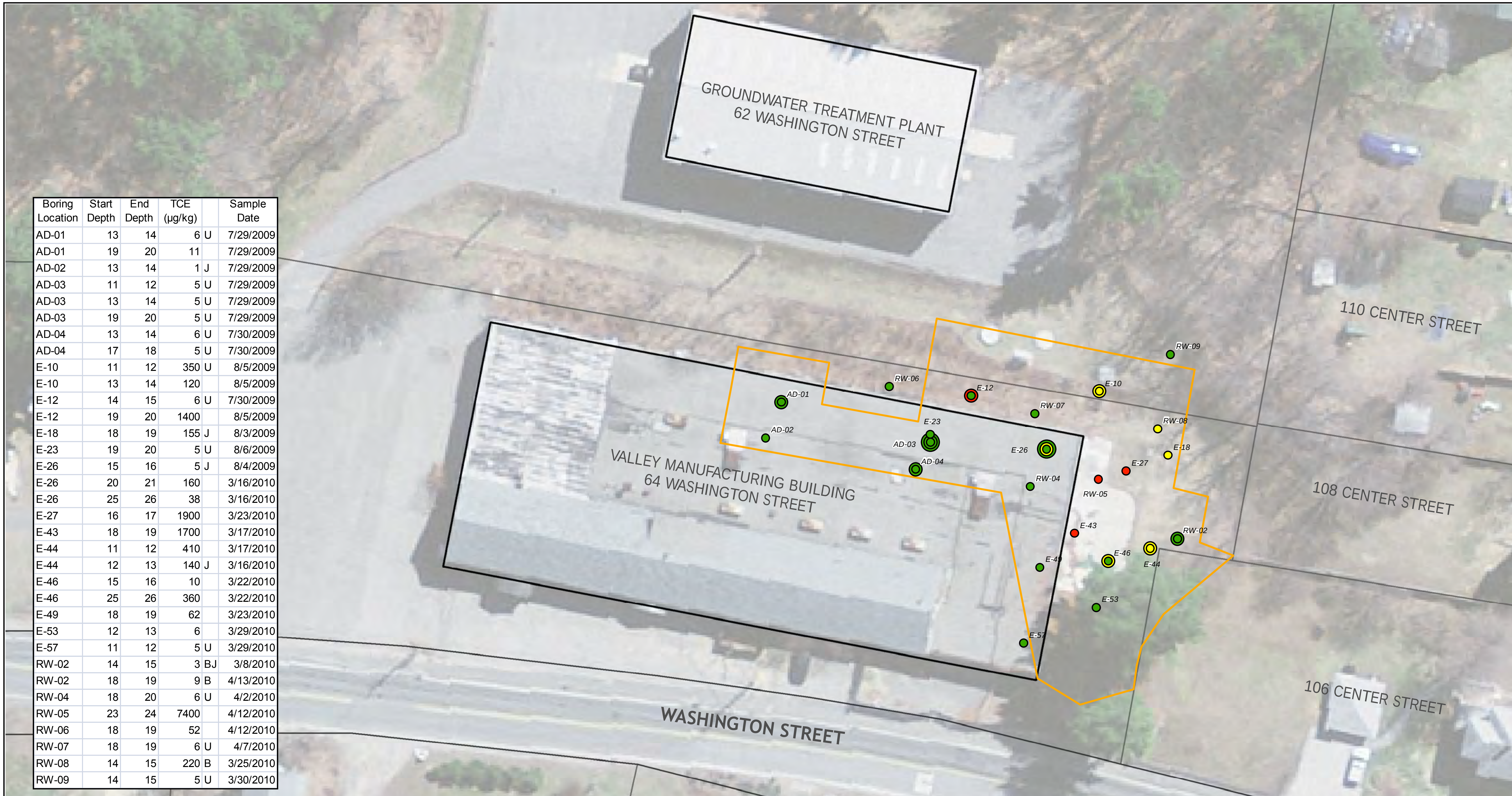
FIGURE 4-1

BASELINE TRICHLOROETHENE RESULTS IN SOIL - 0-11 FT BGS
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Soil Maps\Fig_4-1_Baseline_Soil_TCE_0-11ft.mxd



Boring Location	Start Depth	End Depth	TCE (µg/kg)		Sample Date
AD-01	13	14	6	U	7/29/2009
AD-01	19	20	11		7/29/2009
AD-02	13	14	1	J	7/29/2009
AD-03	11	12	5	U	7/29/2009
AD-03	13	14	5	U	7/29/2009
AD-03	19	20	5	U	7/29/2009
AD-04	13	14	6	U	7/30/2009
AD-04	17	18	5	U	7/30/2009
E-10	11	12	350	U	8/5/2009
E-10	13	14	120		8/5/2009
E-12	14	15	6	U	7/30/2009
E-12	19	20	1400		8/5/2009
E-18	18	19	155	J	8/3/2009
E-23	19	20	5	U	8/6/2009
E-26	15	16	5	J	8/4/2009
E-26	20	21	160		3/16/2010
E-26	25	26	38		3/16/2010
E-27	16	17	1900		3/23/2010
E-43	18	19	1700		3/17/2010
E-44	11	12	410		3/17/2010
E-44	12	13	140	J	3/16/2010
E-46	15	16	10		3/22/2010
E-46	25	26	360		3/22/2010
E-49	18	19	62		3/23/2010
E-53	12	13	6		3/29/2010
E-57	11	12	5	U	3/29/2010
RW-02	14	15	3	BJ	3/8/2010
RW-02	18	19	9	B	4/13/2010
RW-04	18	20	6	U	4/2/2010
RW-05	23	24	7400		4/12/2010
RW-06	18	19	52		4/12/2010
RW-07	18	19	6	U	4/7/2010
RW-08	14	15	220	B	3/25/2010
RW-09	14	15	5	U	3/30/2010

Legend

TCE RESULTS
11-26 ft bgs (µg/kg)
- < 77
- 77 - 500
- > 500

Multiple samples collected within Figure depth range.

Thermal Treatment Area

Note:
1. The site cleanup goal for TCE in vadose zone soil is 77 µg/kg.
2. Qualifiers:
   U - Not detected above the sample-specific detection limit.
   J - Quantitation is estimated as it is below the sample-specific detection limit.
   B - Analyte detected in laboratory blank.

N

0 20 40 80
Feet
1 inch = 40 feet

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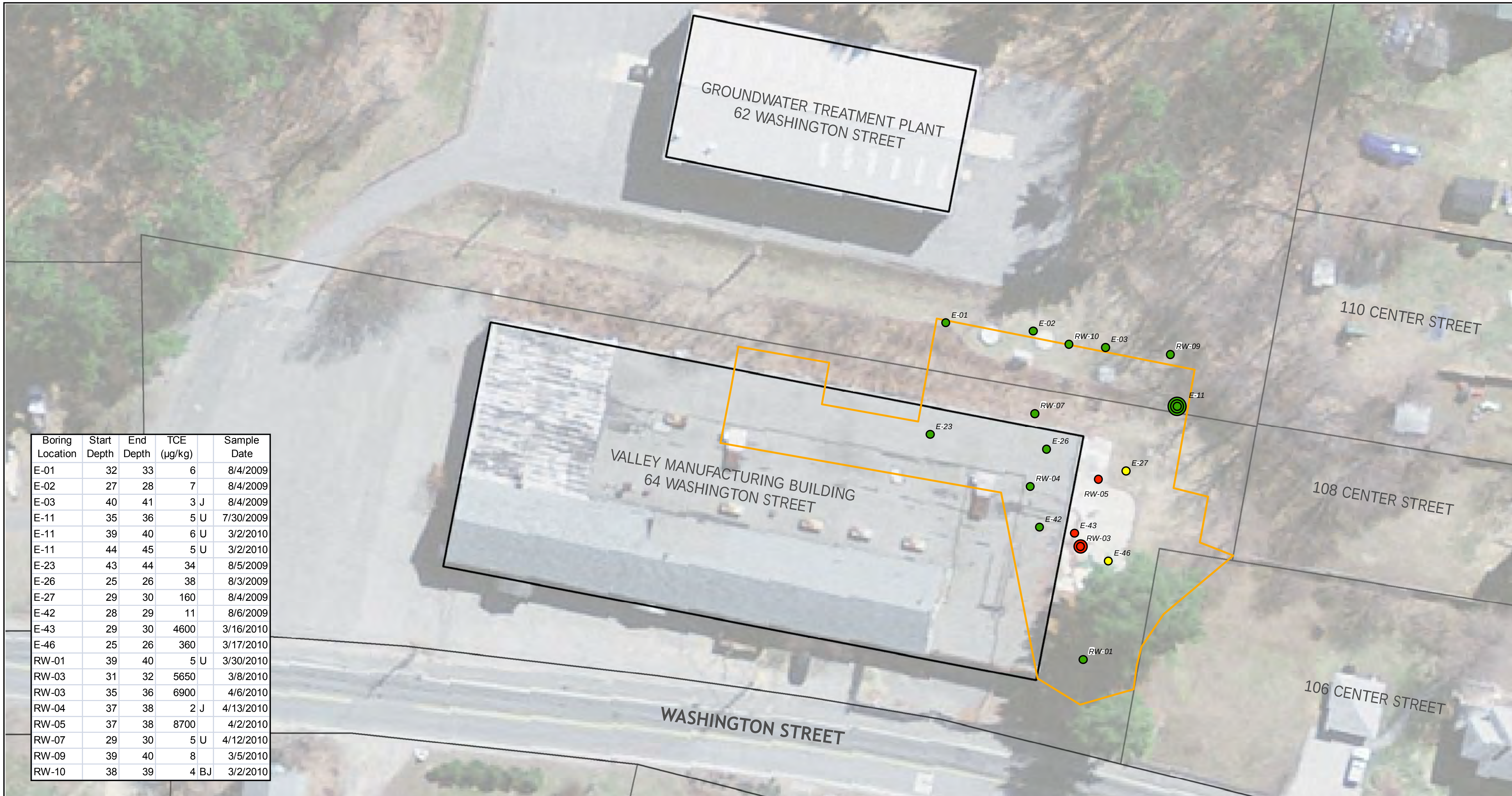
FIGURE 4-2

BASELINE TRICHLOROETHENE RESULTS
IN SOIL - 11-26 FT BGS
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Soil Maps\Fig_4-2_Baseline_Soil_TCE_11-26ft.mxd



Boring Location	Start Depth	End Depth	TCE (µg/kg)		Sample Date
E-01	32	33	6		8/4/2009
E-02	27	28	7		8/4/2009
E-03	40	41	3	J	8/4/2009
E-11	35	36	5	U	7/30/2009
E-11	39	40	6	U	3/2/2010
E-11	44	45	5	U	3/2/2010
E-23	43	44	34		8/5/2009
E-26	25	26	38		8/3/2009
E-27	29	30	160		8/4/2009
E-42	28	29	11		8/6/2009
E-43	29	30	4600		3/16/2010
E-46	25	26	360		3/17/2010
RW-01	39	40	5	U	3/30/2010
RW-03	31	32	5650		3/8/2010
RW-03	35	36	6900		4/6/2010
RW-04	37	38	2	J	4/13/2010
RW-05	37	38	8700		4/2/2010
RW-07	29	30	5	U	4/12/2010
RW-09	39	40	8		3/5/2010
RW-10	38	39	4	BJ	3/2/2010

Legend

TCE RESULTS 26-45 ft bgs (µg/kg)

- < 77
- 77 - 500
- > 500

Multiple samples collected within Figure depth range.

Thermal Treatment Area

Notes:

1. The site cleanup goal for TCE in vadose zone soil is 77 µg/kg.
2. Qualifiers:
   U - Not detected above the sample-specific detection limit.
   J - Quantitation is estimated as it is below the sample-specific detection limit.
   B - Analyte detected in laboratory blank.

0 20 40 80
Feet
1 inch = 40 feet

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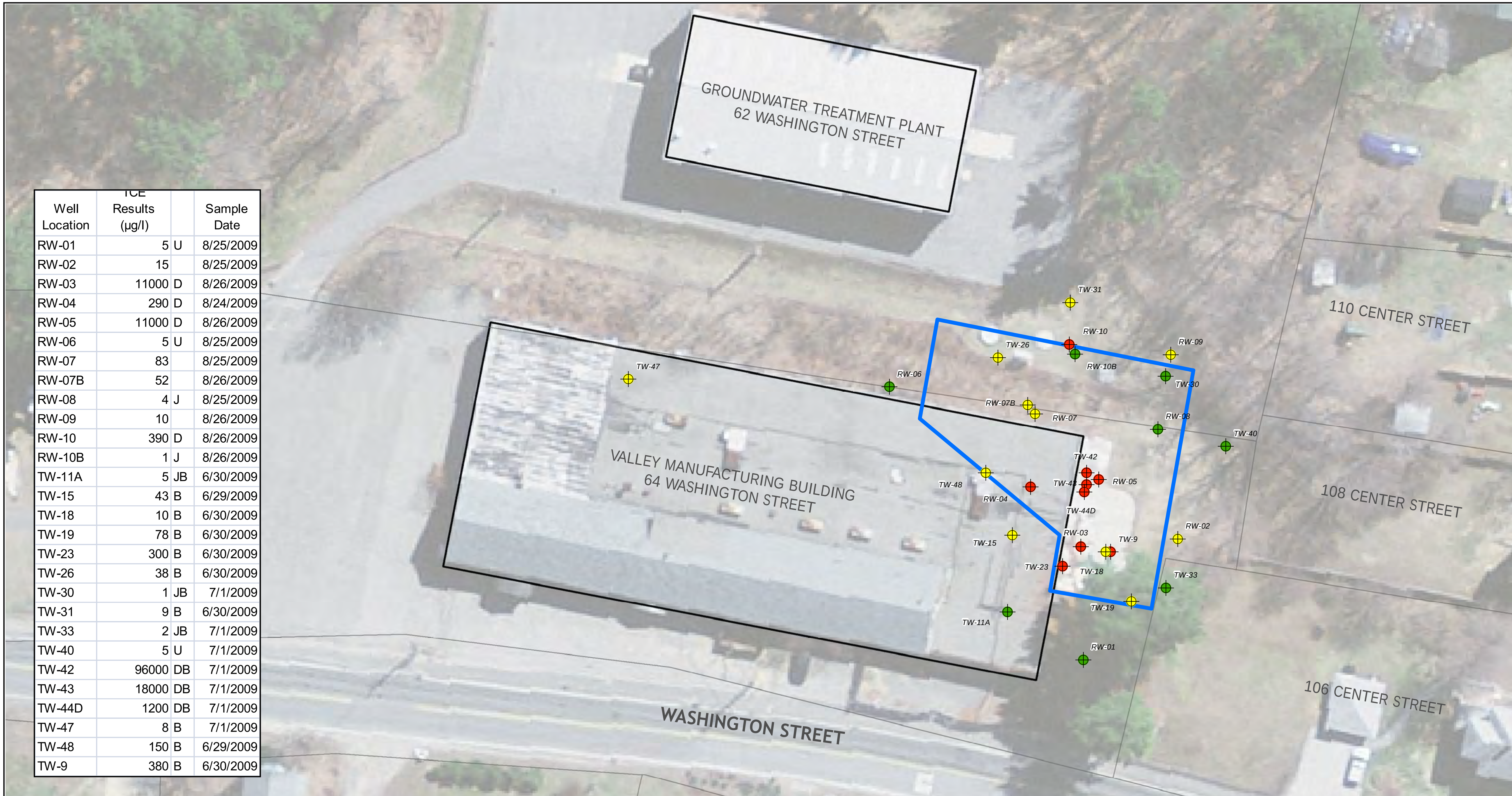
FIGURE 4-3

BASELINE TRICHLOROETHENE RESULTS IN SOIL - 26-45 FT BGS
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011



Well Location	TCE Results (µg/l)		Sample Date
RW-01	5	U	8/25/2009
RW-02	15		8/25/2009
RW-03	11000	D	8/26/2009
RW-04	290	D	8/24/2009
RW-05	11000	D	8/26/2009
RW-06	5	U	8/25/2009
RW-07	83		8/25/2009
RW-07B	52		8/26/2009
RW-08	4	J	8/25/2009
RW-09	10		8/26/2009
RW-10	390	D	8/26/2009
RW-10B	1	J	8/26/2009
TW-11A	5	JB	6/30/2009
TW-15	43	B	6/29/2009
TW-18	10	B	6/30/2009
TW-19	78	B	6/30/2009
TW-23	300	B	6/30/2009
TW-26	38	B	6/30/2009
TW-30	1	JB	7/1/2009
TW-31	9	B	6/30/2009
TW-33	2	JB	7/1/2009
TW-40	5	U	7/1/2009
TW-42	96000	DB	7/1/2009
TW-43	18000	DB	7/1/2009
TW-44D	1200	DB	7/1/2009
TW-47	8	B	7/1/2009
TW-48	150	B	6/29/2009
TW-9	380	B	6/30/2009

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig_4-4_Aug_2009_TCE.mxd

Legend

TCE RESULTS (µg/l)
- < 5
- 5 - 200
- > 200

ISTT Area A Boundary

Notes:
1. The site cleanup goal for TCE in groundwater is 5 µg/kg.
2. Qualifiers:
   - U - Not detected above the sample-specific detection limit.
   - J - Quantitation is estimated as it is below the sample-specific detection limit.
   - D - Concentration is reported from a dilution of the sample.
   - B - Analyte detected in laboratory blank.

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FIGURE 4-4

BASELINE TRICHLOROETHENE RESULTS IN GROUNDWATER
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JMH	CHECKED BY: DB
PROJECT NO. 80037	DATE: August 2011

Well Location	CIS-1,2-DCE Results (µg/l)		Sample Date
RW-01	5	U	8/25/2009
RW-02	3	J	8/25/2009
RW-03	260	DJ	8/26/2009
RW-04	57		8/24/2009
RW-05	325	DJ	8/26/2009
RW-06	5	U	8/25/2009
RW-07	37		8/25/2009
RW-07B	5	J	8/26/2009
RW-08	5	U	8/25/2009
RW-09	3	J	8/26/2009
RW-10	160		8/26/2009
RW-10B	5	U	8/26/2009
TW-31	5	U	6/30/2009
TW-9	340		6/30/2009
TW-11A	5	U	6/30/2009
TW-15	17		6/29/2009
TW-18	2	J	6/30/2009
TW-19	20		6/30/2009
TW-23	160		6/30/2009
TW-26	8		6/30/2009
TW-30	5	U	7/1/2009
TW-31	5	U	6/30/2009
TW-33	5	U	7/1/2009
TW-40	5	U	7/1/2009
TW-42	1000	U	7/1/2009
TW-43	170		7/1/2009
TW-44D	200	D	7/1/2009
TW-47	1	J	7/1/2009
TW-48	120		6/29/2009

Legend

CIS 1,2 DCE RESULTS (µg/l)

- < 70
- 70 - 200
- > 200

ISTT Area A Boundary

Notes:

1. The site cleanup goal for CIS 1,2 DCE in groundwater is 70 µg/kg.
2. Qualifiers:
   - U - Not detected above the sample-specific detection limit.
   - J - Quantitation is estimated as it is below the sample-specific detection limit.
   - D - Concentration is reported from a dilution of the sample.

N

0 20 40 80

Feet

1 inch = 40 feet

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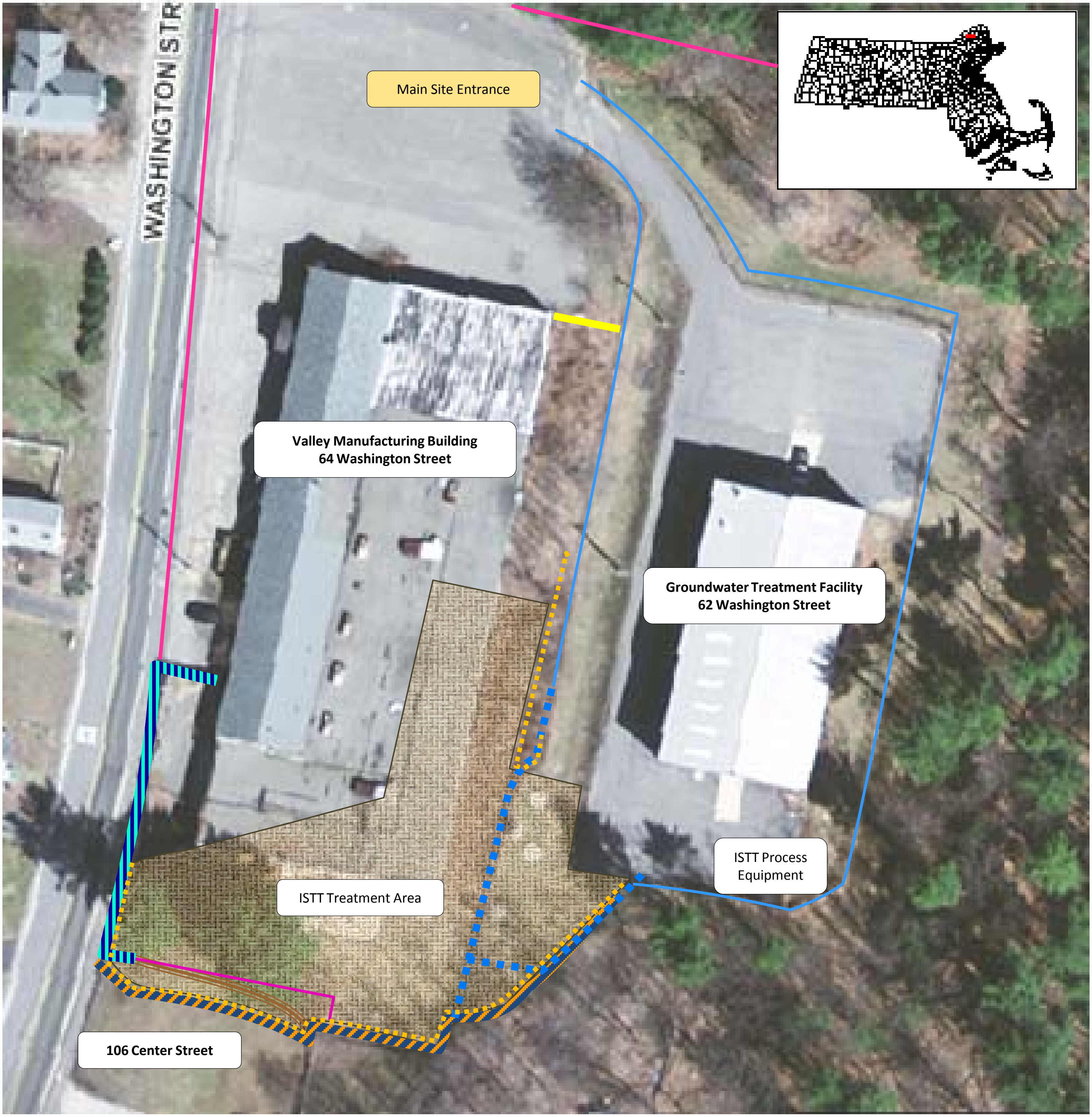
FIGURE 4-5

BASELINE CIS-1,2-DICHLOROETHENE RESULTS IN GROUNDWATER
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JMH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig_4-5_Aug_2009_1,2 DCE.mxd



Approximate Property Limit

Replaced Chain Link Fence & Gates

Location of Temporary Fence

Wooden Stockade Fence Removed for ISTT Construction

Location of ISTT Construction Activities

Location of Straw Bales and Silt Fences

New Chain Link Fence

Existing Chain Link Fence

Chain Link Fence & Gate – Removed and Preserved for ISTT Construction

Notes:

1. All locations are approximate.
2. Aerial photograph used with permission from MASS GIS – USGS 2008 30 cm Color Ortho.

FIGURE 4-6

FENCE MODIFICATIONS AND SEDIMENT AND EROSION CONTROLS

GROVELAND WELLS Nos. 1 & 2 SUPERFUND SITE GROVELAND, MA

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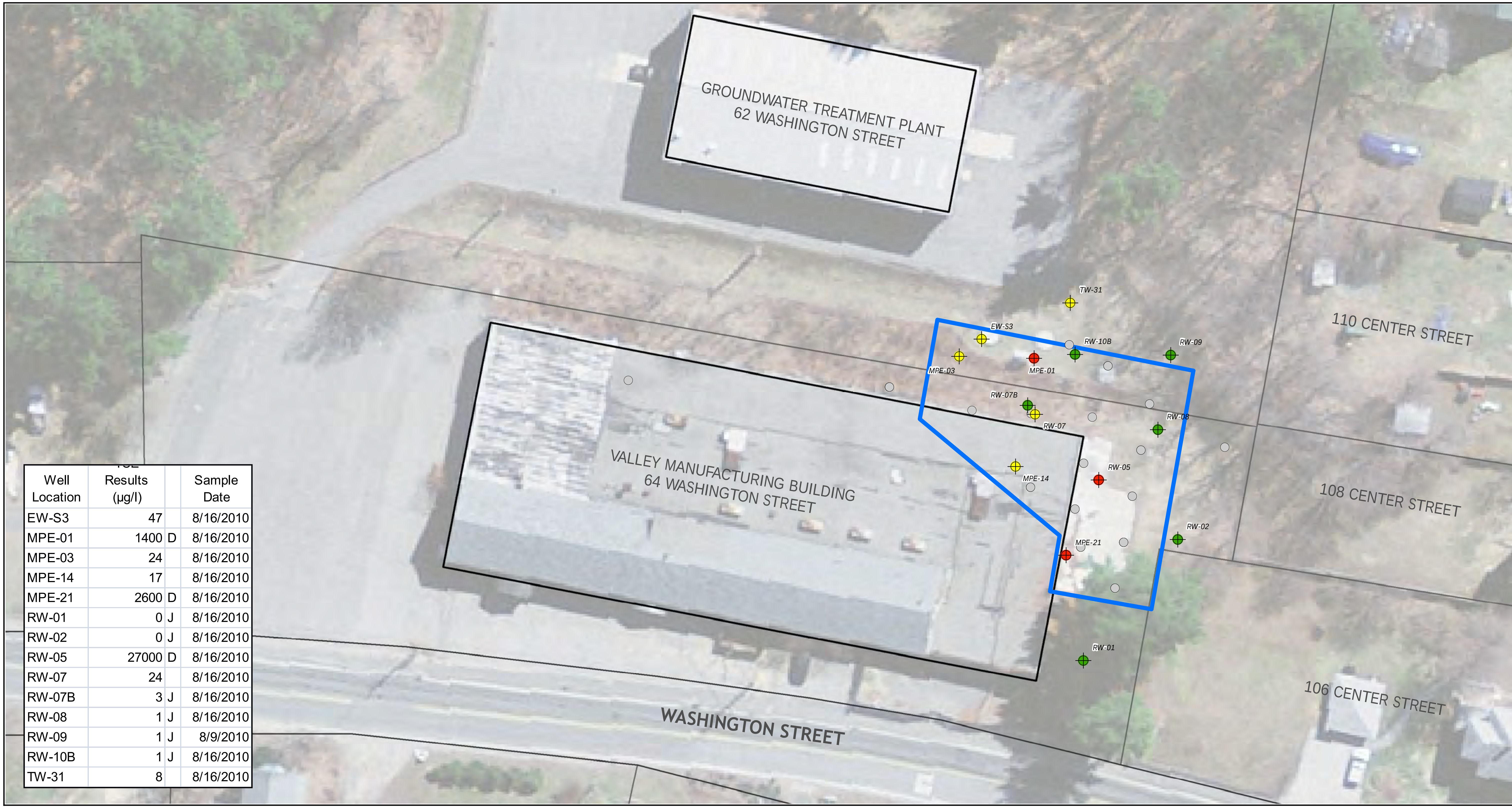
DATE:	28 April 2011
PROJECT NO.:	80037.11
DESIGNED BY:	LDS
DRAWN BY:	PJY
REVIEWED BY:	DB
SCALE:	As Shown

N



Well Location	TCE Results (µg/l)		Sample Date
EW-S3	47		8/16/2010
MPE-01	1400	D	8/16/2010
MPE-03	24		8/16/2010
MPE-14	17		8/16/2010
MPE-21	2600	D	8/16/2010
RW-01	0	J	8/16/2010
RW-02	0	J	8/16/2010
RW-05	27000	D	8/16/2010
RW-07	24		8/16/2010
RW-07B	3	J	8/16/2010
RW-08	1	J	8/16/2010
RW-09	1	J	8/9/2010
RW-10B	1	J	8/16/2010
TW-31	8		8/16/2010

Legend

TCE RESULTS (µg/l)
- < 5
- 5 - 200
- > 200
- Not Sampled

ISTT Area A Boundary

Notes:
1. The site cleanup goal for TCE in groundwater is 5 µg/kg.
2. Qualifiers:
   J - Quantitation is estimated as it is below the sample-specific detection limit.
   D - Concentration is reported from a dilution of the sample.

N

0 20 40 80
Feet

1 inch = 40 feet

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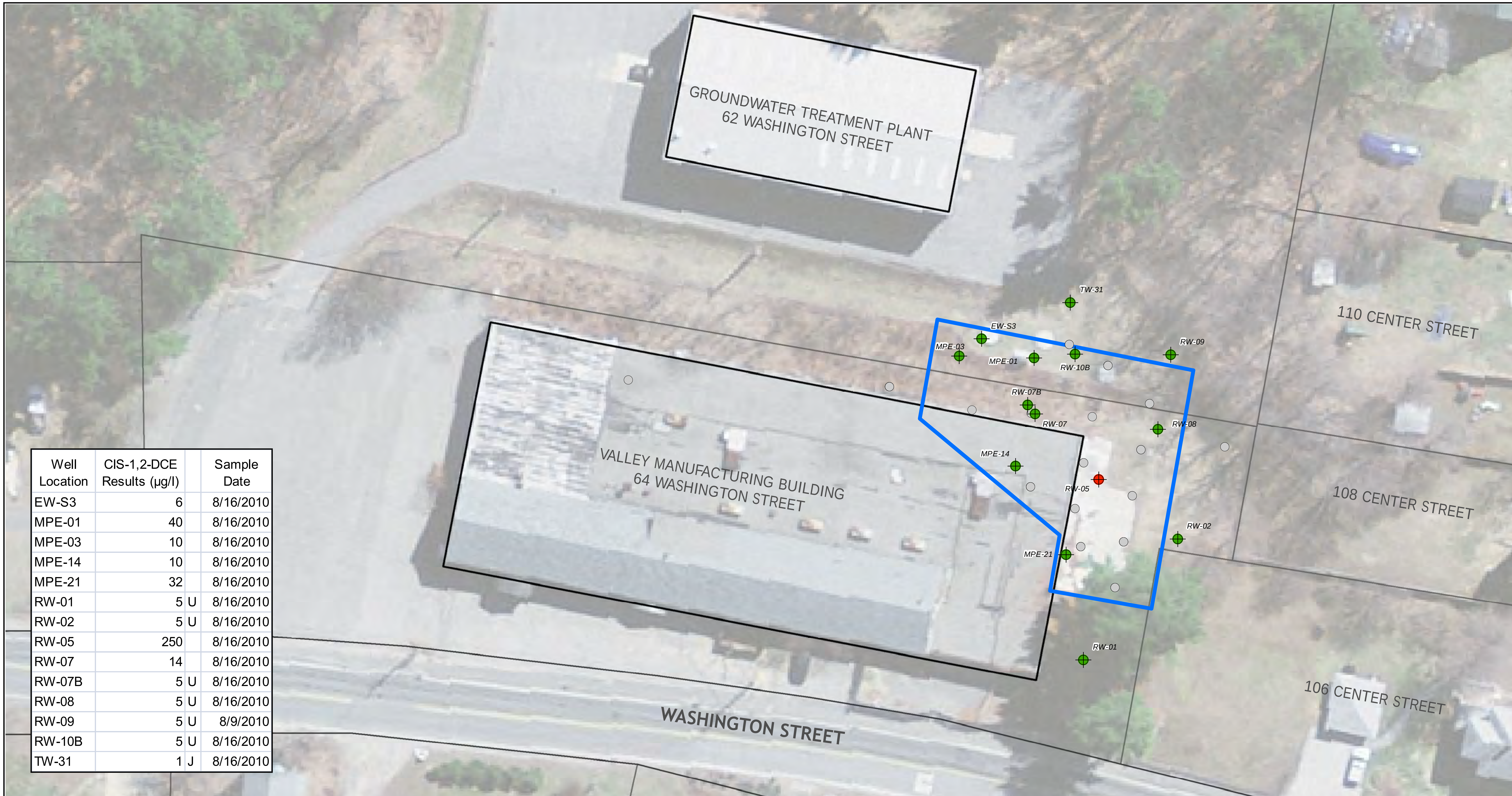
FIGURE 6-1

ISTT OPERATIONS
TRICHLOROETHENE RESULTS
IN GROUNDWATER - AUGUST 2010
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JMH	CHECKED BY: DB
PROJECT NO. 80037	DATE: August 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig_6-1_Aug_2010_TCE.mxd



Well Location	CIS-1,2-DCE Results (µg/l)		Sample Date
EW-S3	6		8/16/2010
MPE-01	40		8/16/2010
MPE-03	10		8/16/2010
MPE-14	10		8/16/2010
MPE-21	32		8/16/2010
RW-01	5	U	8/16/2010
RW-02	5	U	8/16/2010
RW-05	250		8/16/2010
RW-07	14		8/16/2010
RW-07B	5	U	8/16/2010
RW-08	5	U	8/16/2010
RW-09	5	U	8/9/2010
RW-10B	5	U	8/16/2010
TW-31	1	J	8/16/2010

Legend

CIS-1,2-DCE RESULTS (µg/l)

- < 70
- 70 - 200
- > 200
- Not Sampled

ISTT Area A Boundary

Notes:

1. The site cleanup goal for CIS 1,2 DCE in groundwater is 77 µg/kg.
2. Qualifiers:
   - U - Not detected above the sample-specific detection limit.
   - J - Quantitation is estimated as it is below the sample-specific detection limit.

N

0 20 40 80

Feet

1 inch = 40 feet

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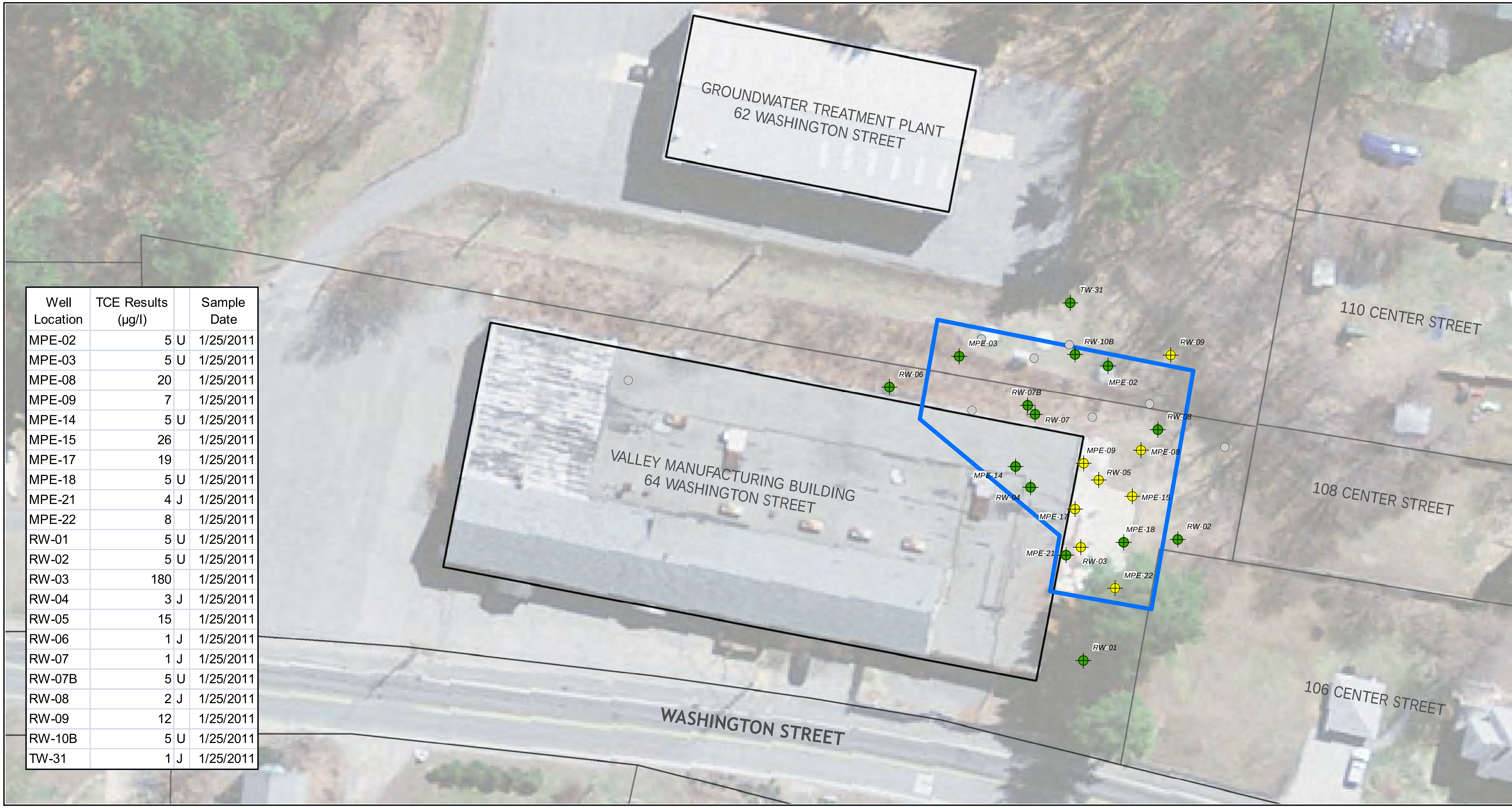
FIGURE 6-2

ISTT OPERATIONS
CIS-1,2-DICHLOROETHENE
RESULTS IN GROUNDWATER - AUGUST 2010
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JMH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig_6-2_Aug_2010_1,2 DCE.mxd



Well Location	TCE Results (µg/l)		Sample Date
MPE-02	5	U	1/25/2011
MPE-03	5	U	1/25/2011
MPE-08	20		1/25/2011
MPE-09	7		1/25/2011
MPE-14	5	U	1/25/2011
MPE-15	26		1/25/2011
MPE-17	19		1/25/2011
MPE-18	5	U	1/25/2011
MPE-21	4	J	1/25/2011
MPE-22	8		1/25/2011
RW-01	5	U	1/25/2011
RW-02	5	U	1/25/2011
RW-03	180		1/25/2011
RW-04	3	J	1/25/2011
RW-05	15		1/25/2011
RW-06	1	J	1/25/2011
RW-07	1	J	1/25/2011
RW-07B	5	U	1/25/2011
RW-08	2	J	1/25/2011
RW-09	12		1/25/2011
RW-10B	5	U	1/25/2011
TW-31	1	J	1/25/2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig_6-3_Jan_2011_TCE.mxd

Legend

TCE RESULTS (µg/l)

- < 5
- 5 - 200
- > 200
- Not Sampled

ISTT Area A Boundary

Notes:
1. The site cleanup goal for TCE in groundwater is 5 µg/kg.
2. Qualifiers:
   U - Not detected above the sample-specific detection limit.
   J - Quantitation is estimated as it is below the sample-specific detection limit.

Z

0 20 40 80
Feet
1 inch = 40 feet

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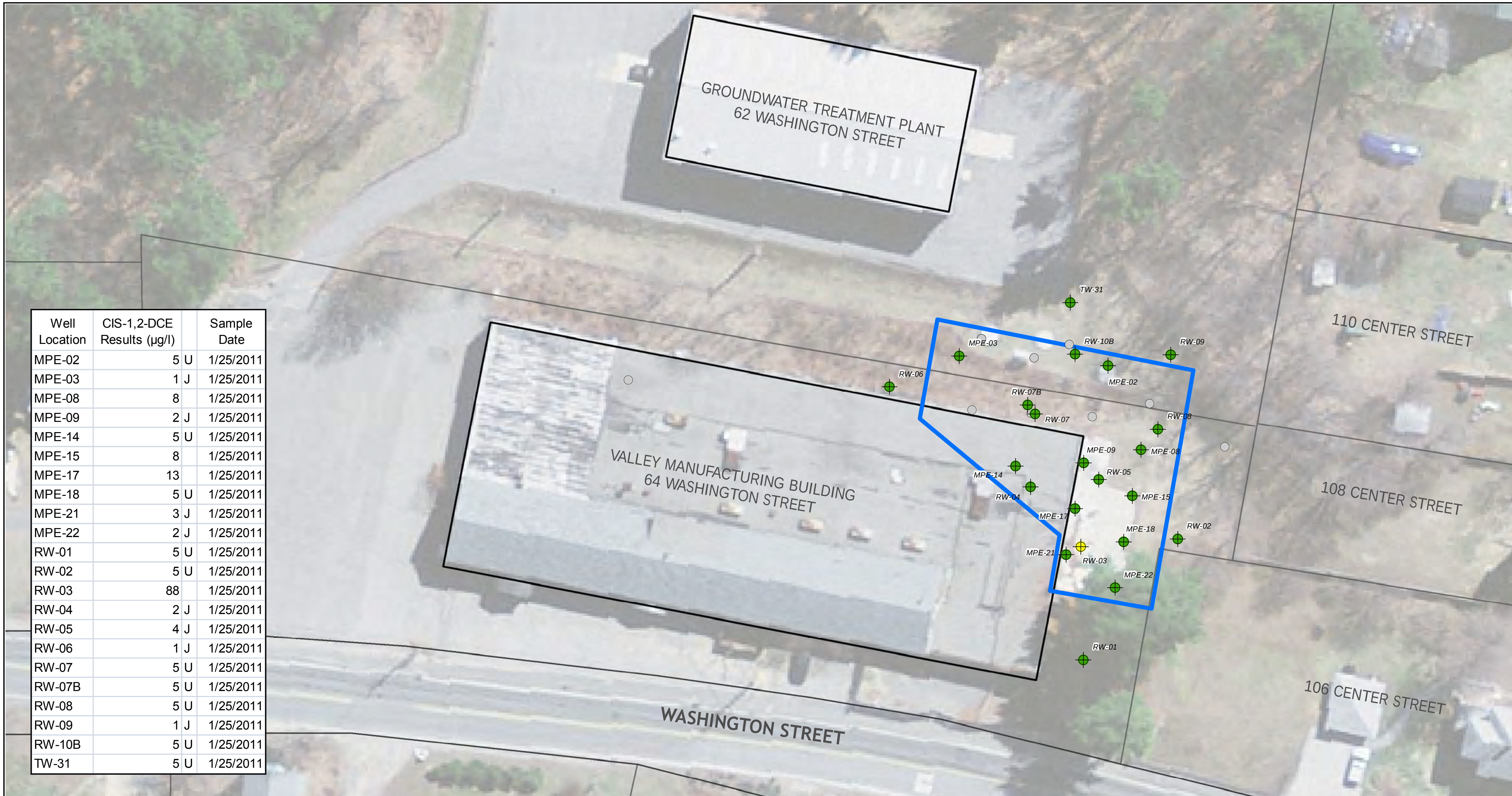
FIGURE 6-3

ISTT OPERATIONS
TRICHLOROETHENE RESULTS
IN GROUNDWATER - JANUARY 2011
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JMH	CHECKED BY: DB
PROJECT NO. 80037	DATE: August 2011



Well Location	CIS-1,2-DCE Results (µg/l)		Sample Date
MPE-02	5	U	1/25/2011
MPE-03	1	J	1/25/2011
MPE-08	8		1/25/2011
MPE-09	2	J	1/25/2011
MPE-14	5	U	1/25/2011
MPE-15	8		1/25/2011
MPE-17	13		1/25/2011
MPE-18	5	U	1/25/2011
MPE-21	3	J	1/25/2011
MPE-22	2	J	1/25/2011
RW-01	5	U	1/25/2011
RW-02	5	U	1/25/2011
RW-03	88		1/25/2011
RW-04	2	J	1/25/2011
RW-05	4	J	1/25/2011
RW-06	1	J	1/25/2011
RW-07	5	U	1/25/2011
RW-07B	5	U	1/25/2011
RW-08	5	U	1/25/2011
RW-09	1	J	1/25/2011
RW-10B	5	U	1/25/2011
TW-31	5	U	1/25/2011

Legend

CIS-1,2 DCE RESULTS (µg/l)

- < 70
- 70 - 200
- > 200
- Not Sampled

ISST Area A Boundary

Notes:

1. The site cleanup goal for CIS 1,2 DCE in groundwater is 70 µg/kg.
2. Qualifiers:
   U - Not detected above the sample-specific detection limit.
   J - Quantitation is estimated as it is below the sample-specific detection limit.

N

0 20 40 80

Feet

1 inch = 40 feet

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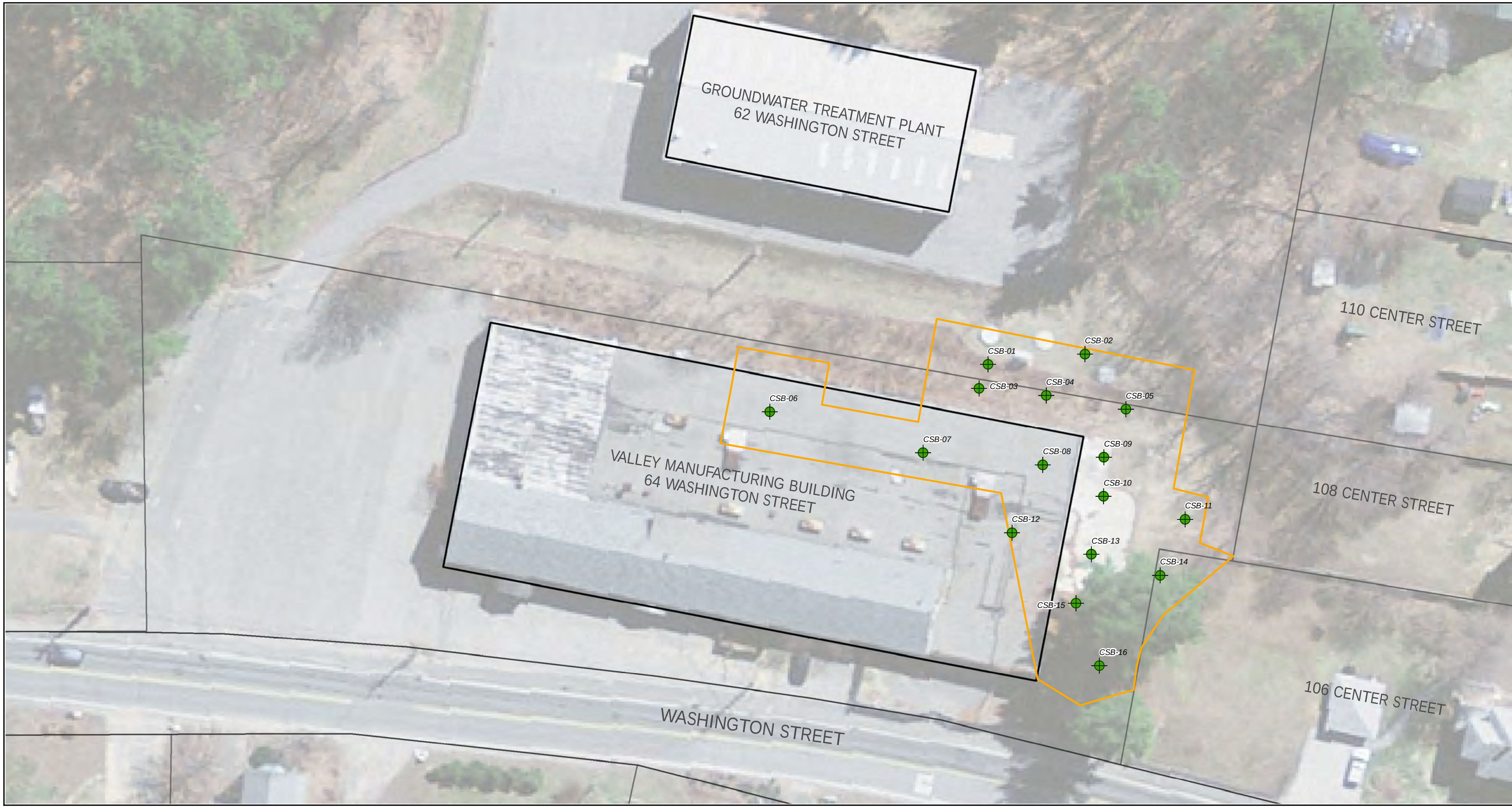
FIGURE 6-4

ISTT OPERATIONS
CIS-1,2-DICHLOROETHENE RESULTS
IN GROUNDWATER - JANUARY 2011
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JMH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig_6-4_Jan_2011_1,2 DCE.mxd 1:05:44 PM



Legend
- Confirmation Soil Borings
- Thermal Treatment Area

N

0 20 40 80

Feet

1 inch = 40 feet

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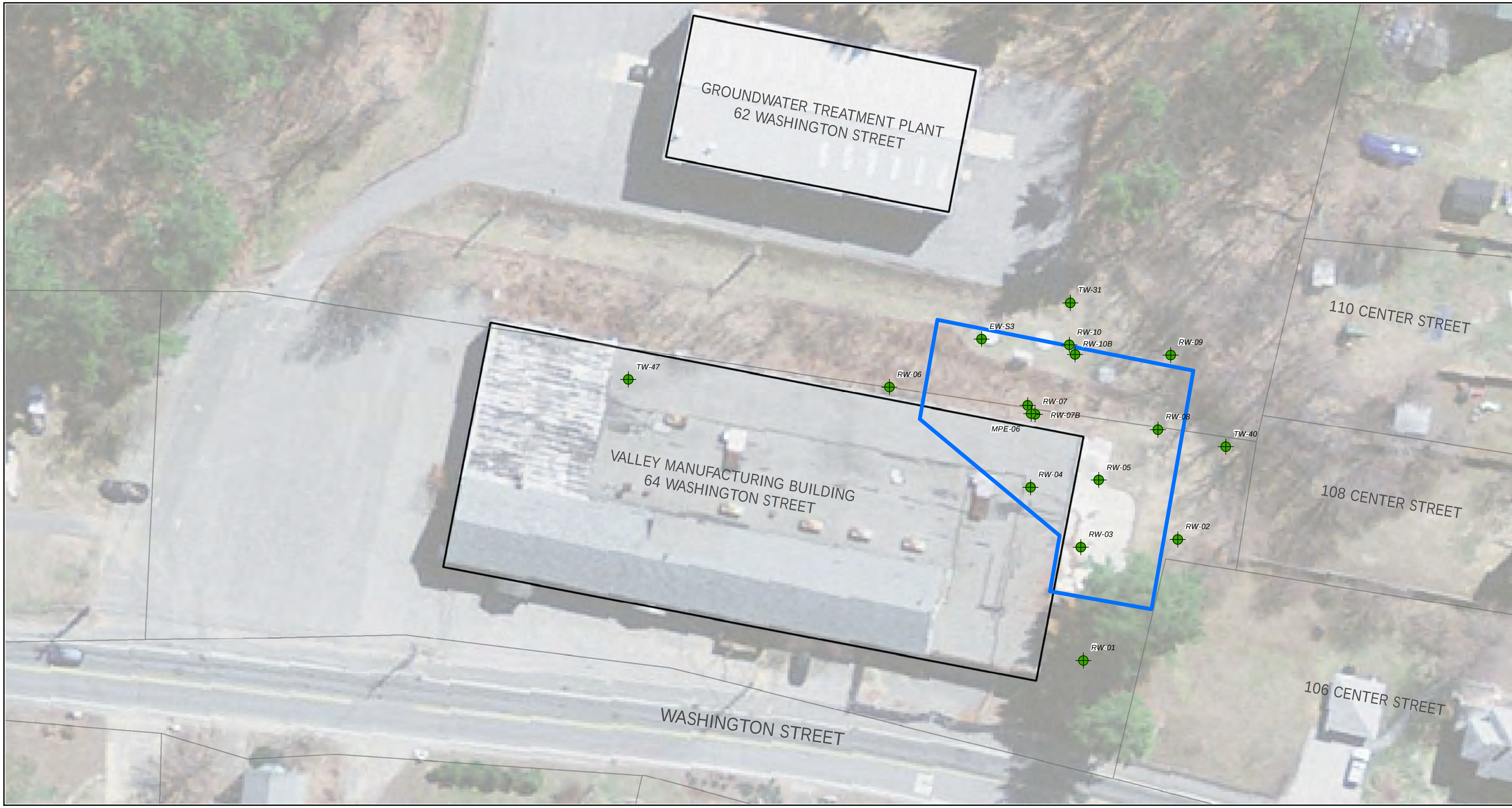
FIGURE 7-1

CONFIRMATION SOIL BORING LOCATIONS
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: 8/22/2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Soil Maps\Fig_7-1_Confirmation_Soil_TCE_0-11ft.mxd



Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig_7-2_Conf_GW_Locations.mxd

Legend

- Groundwater Monitoring Wells
- ISTT Area A Boundary

Note:
Well MPE-06 was used as a substitute for RW-07 during the second confirmation sampling event only.

N

0 20 40 80

Feet

1 inch = 40 feet

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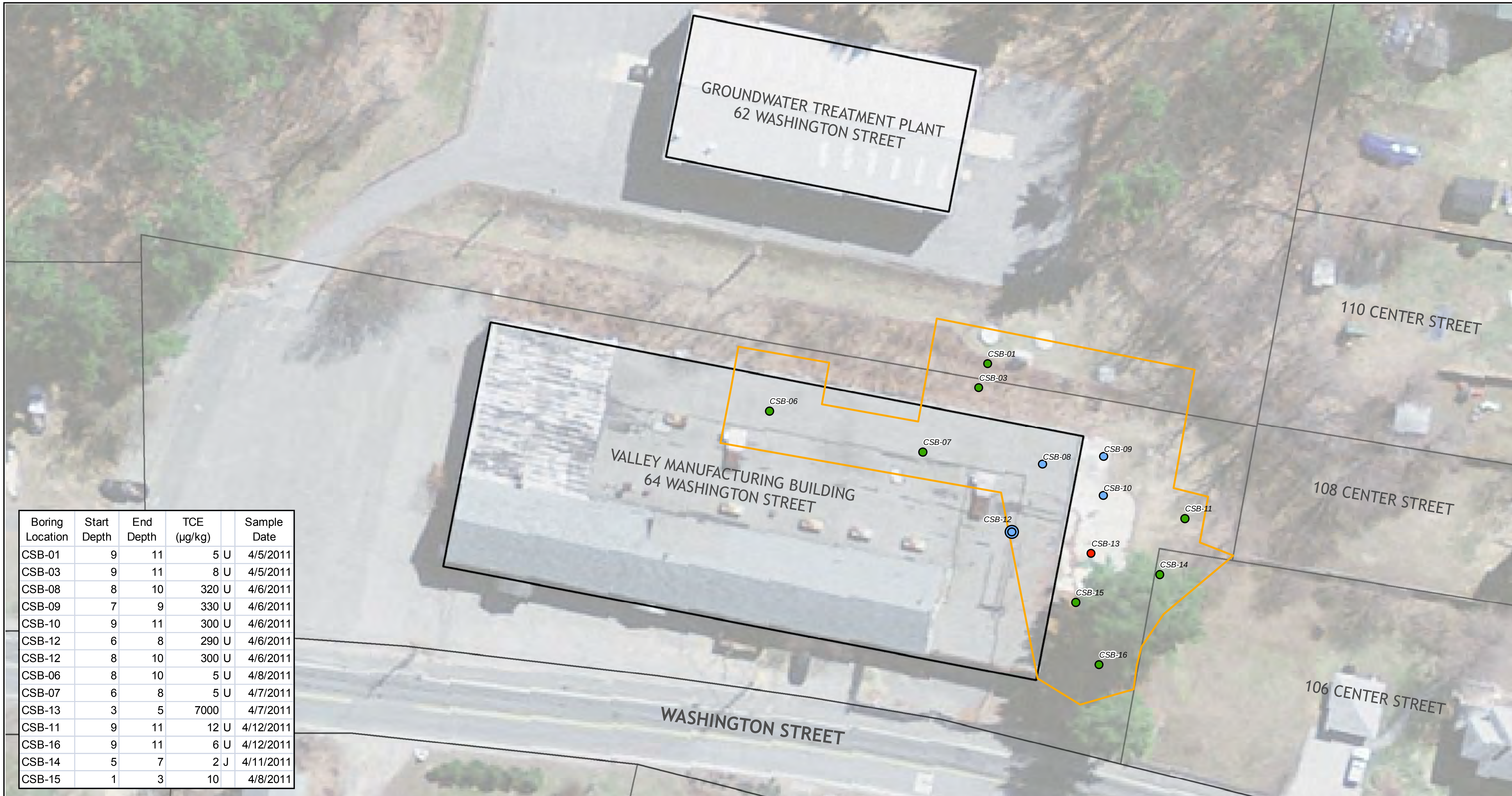
FIGURE 7-2

CONFIRMATION GROUNDWATER SAMPLING LOCATIONS
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JMH	CHECKED BY: DB
PROJECT NO. 80037	DATE: 8/22/2011



Boring Location	Start Depth	End Depth	TCE (µg/kg)		Sample Date
CSB-01	9	11	5	U	4/5/2011
CSB-03	9	11	8	U	4/5/2011
CSB-08	8	10	320	U	4/6/2011
CSB-09	7	9	330	U	4/6/2011
CSB-10	9	11	300	U	4/6/2011
CSB-12	6	8	290	U	4/6/2011
CSB-12	8	10	300	U	4/6/2011
CSB-06	8	10	5	U	4/8/2011
CSB-07	6	8	5	U	4/7/2011
CSB-13	3	5	7000		4/7/2011
CSB-11	9	11	12	U	4/12/2011
CSB-16	9	11	6	U	4/12/2011
CSB-14	5	7	2	J	4/11/2011
CSB-15	1	3	10		4/8/2011

Legend

TCE RESULTS
0-11 ft BGS (µg/kg)
- < 77
- 77 - 500
- > 500
- 290 - 330 U

Multiple samples collected within Figure depth range

Thermal Treatment Area

Notes:
1. The site cleanup goal for TCE in vadose zone soil is 77 µg/kg.
2. Qualifiers:
   U - Not detected above the sample-specific detection limit.
   J - Quantitation is estimated as it is below the sampling-specific detection limit.

N

0 20 40 80
Feet
1 inch = 40 feet

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FIGURE 7-3

CONFIRMATION SOIL SAMPLING
TRICHLOROETHENE - 0-11 FT BGS
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Soil Maps\Fig_7-3_Confirmation_Soil_TCE_0-11ft.mxd 9/16/2011 1:19:47 PM

Boring Location	Start Depth	End Depth	TCE (µg/kg)		Sample Date
CSB-02	14	16	6	U	4/4/2011
CSB-03	19	21	400	U	4/5/2011
CSB-04	11	13	310	U	4/12/2011
CSB-04	15	17	255	U	4/12/2011
CSB-05	13	15	220	U	4/11/2011
CSB-06	10	12	6	U	4/8/2011
CSB-07	10	12	6	U	4/7/2011
CSB-07	16	18	5	U	4/7/2011
CSB-08	20	22	400	U	4/6/2011
CSB-08	24	26	250	U	4/7/2011
CSB-09	15	17	330	U	4/6/2011
CSB-10	23	25	5600		4/6/2011
CSB-11	11	13	2	U	4/12/2011
CSB-13	15	17	290	U	4/7/2011
CSB-14	11	13	7	U	4/11/2011
CSB-15	17	19	390	U	4/8/2011
CSB-16	11	13	6	U	4/12/2011

Legend

TCE RESULTS
11-26 ft bgs (µg/kg)

- < 77
- 77 - 500
- > 500
- 220 - 400 U

Multiple samples collected within Figure depth range.

Thermal Treatment Area

Notes:
1. The site cleanup goal for TCE in vadose zone soil is 77 µg/kg.
2. Qualifiers:
   U - Not detected above the sample-specific detection limit

N

0 20 40 80
Feet
1 inch = 40 feet

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FIGURE 7-4

CONFIRMATION SOIL SAMPLING
TRICHLOROETHENE - 11-26 FT BGS
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: August 2011

Boring Location	Start Depth	End Depth	TCE (µg/kg)		Sample Date
CSB-01	27	29	5	U	4/5/2011
CSB-01	33	35	1	J	4/5/2011
CSB-02	28	30	1	J	4/4/2011
CSB-02	38	40	5	U	4/4/2011
CSB-03	33	35	1	J	4/5/2011
CSB-04	29	31	340	U	4/12/2011
CSB-05	27	29	6	U	4/11/2011
CSB-05	39	41	5	U	4/12/2011
CSB-09	27	29	5	U	4/6/2011
CSB-10	39	41	4	J	4/7/2011
CSB-13	41	42	300	U	4/7/2011
CSB-14	31	33	4	U	4/11/2011
CSB-15	37	39	5	U	4/8/2011

Legend

TCE RESULTS
26-45 ft bgs (µg/kg)

- < 77
- 77 - 500
- > 500
- 300 - 340 U

Multiple samples collected within Figure depth range.

Thermal Treatment Area

Notes:
1. The site cleanup goal for TCE in vadose zone soil is 77 µg/kg.
2. Qualifiers:
   U - Not detected above the sample-specific detection limit.
   J - Quantitation is estimated as it is below the sample-specific detection limit.

N

0 20 40 80

Feet

1 inch = 40 feet

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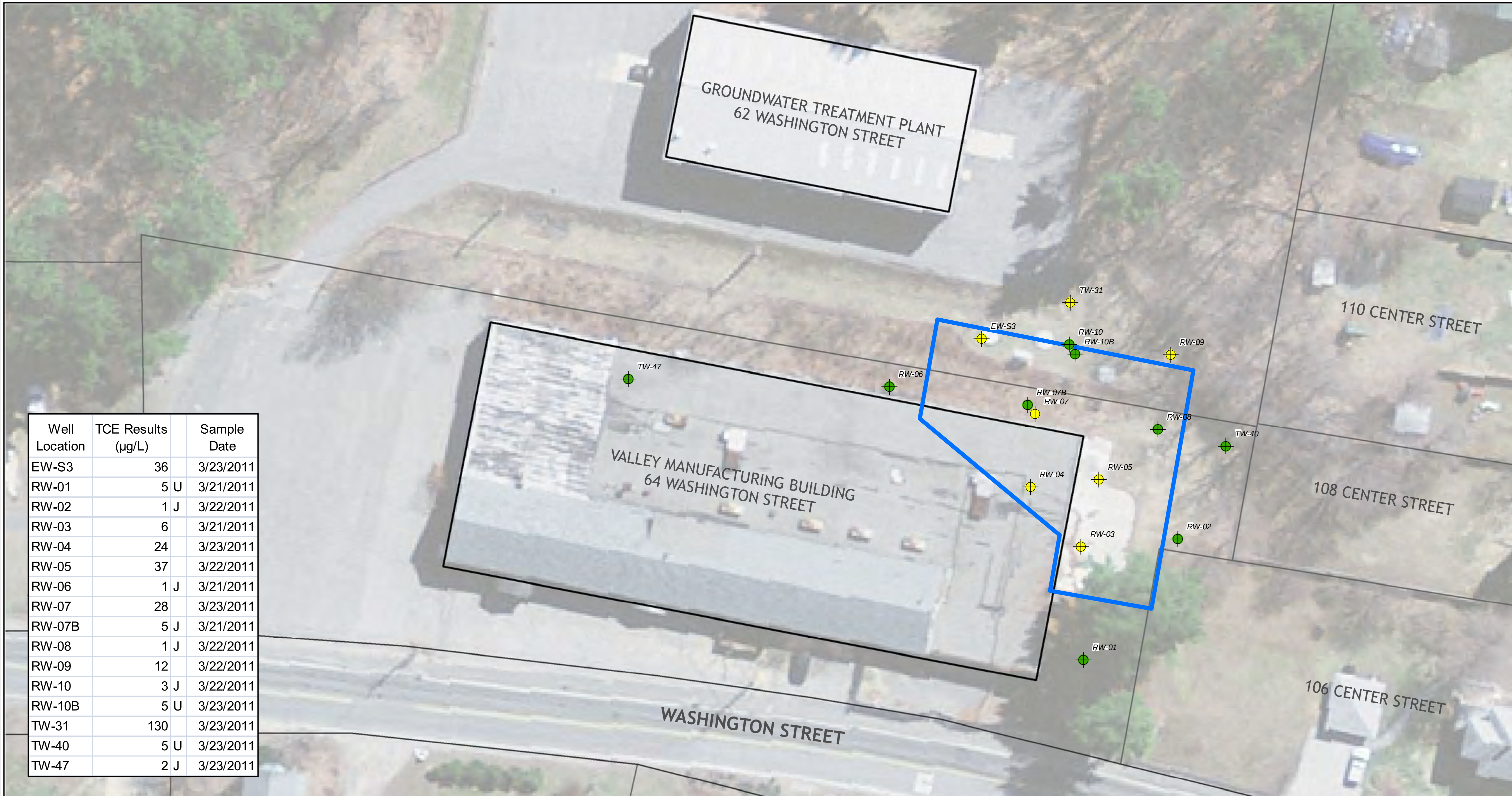
FIGURE 7-5

CONFIRMATION SOIL SAMPLING
TRICHLOROETHENE - 26-45 FT BGS
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: August 2011



Well Location	TCE Results (µg/L)		Sample Date
EW-S3	36		3/23/2011
RW-01	5	U	3/21/2011
RW-02	1	J	3/22/2011
RW-03	6		3/21/2011
RW-04	24		3/23/2011
RW-05	37		3/22/2011
RW-06	1	J	3/21/2011
RW-07	28		3/23/2011
RW-07B	5	J	3/21/2011
RW-08	1	J	3/22/2011
RW-09	12		3/22/2011
RW-10	3	J	3/22/2011
RW-10B	5	U	3/23/2011
TW-31	130		3/23/2011
TW-40	5	U	3/23/2011
TW-47	2	J	3/23/2011

Legend

TCE RESULTS (µg/l)
- ≤ 5
- 5 - 200
- > 200

ISTT Area A Boundary

Notes:
1. The site cleanup goal for TCE in groundwater is 5 µg/l.
2. Qualifiers:
   U - Not detected above the sample-specific detection limit.
   J - Quantitation is estimated as it is below the sample-specific detection limit.

N

0 20 40 80
Feet
1 inch = 40 feet

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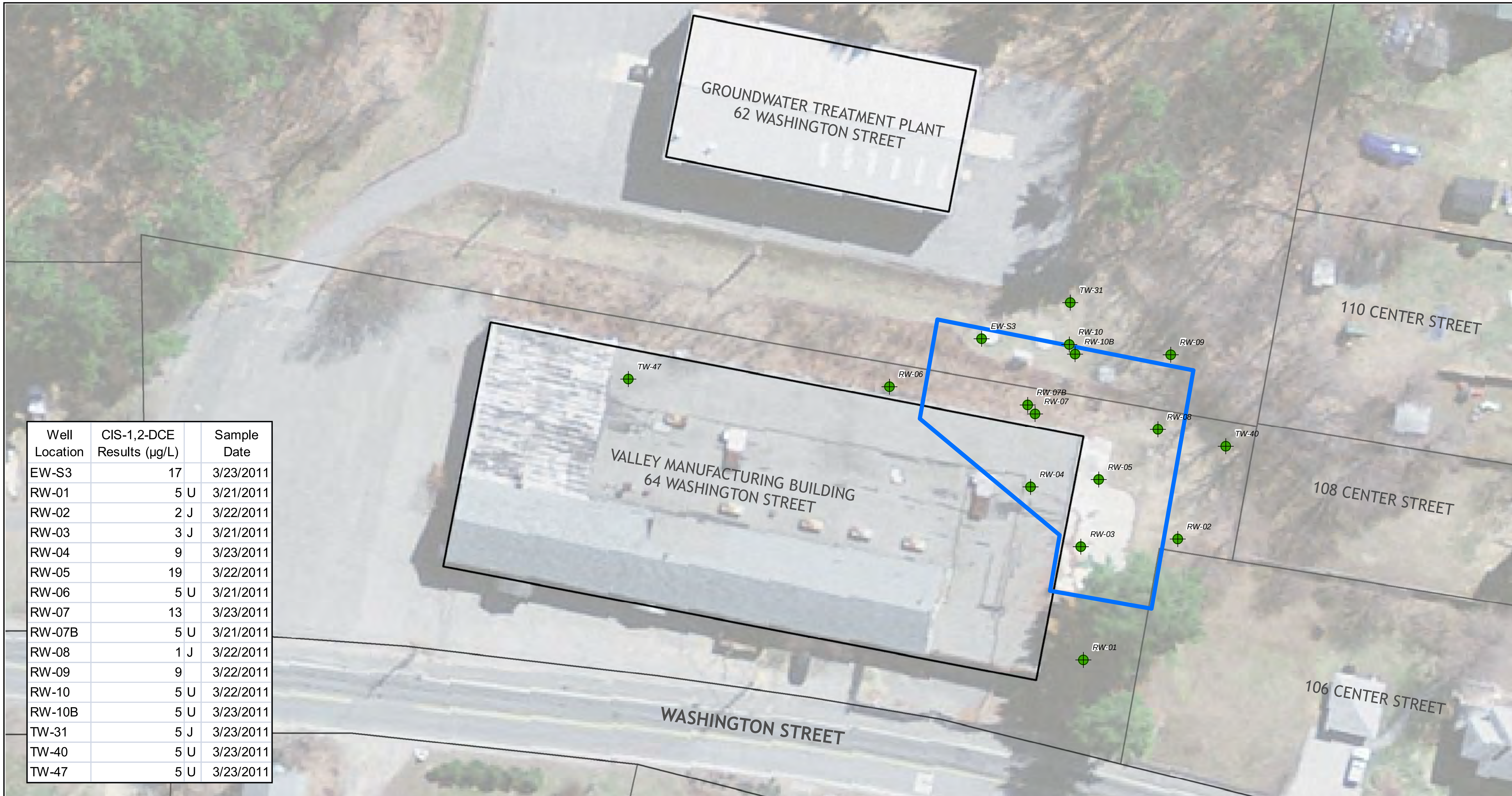
FIGURE 7-6

CONFIRMATION GROUNDWATER SAMPLING EVENT NO. 1
TRICHLOROETHENE RESULTS
MARCH 21-23, 2011
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: August 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig_7-6_Mar_2011_TCE.mxd



Well Location	CIS-1,2-DCE Results (µg/L)		Sample Date
EW-S3	17		3/23/2011
RW-01	5	U	3/21/2011
RW-02	2	J	3/22/2011
RW-03	3	J	3/21/2011
RW-04	9		3/23/2011
RW-05	19		3/22/2011
RW-06	5	U	3/21/2011
RW-07	13		3/23/2011
RW-07B	5	U	3/21/2011
RW-08	1	J	3/22/2011
RW-09	9		3/22/2011
RW-10	5	U	3/22/2011
RW-10B	5	U	3/23/2011
TW-31	5	J	3/23/2011
TW-40	5	U	3/23/2011
TW-47	5	U	3/23/2011

Legend

CIS 1,2 DCE RESULTS (µg/l)

- < 70
- 70-200
- > 200

ISTT Area A Boundary

Notes:

1. The site cleanup goal for CIS 1,2 DCE in groundwater is 70 µg/l.
2. Qualifiers:
   U - Not detected above the sample-specific detection limit
   J - Quantitation is estimated as it is below the sample-specific detection limit.

Z

0 20 40 80

Feet

1 inch = 40 feet

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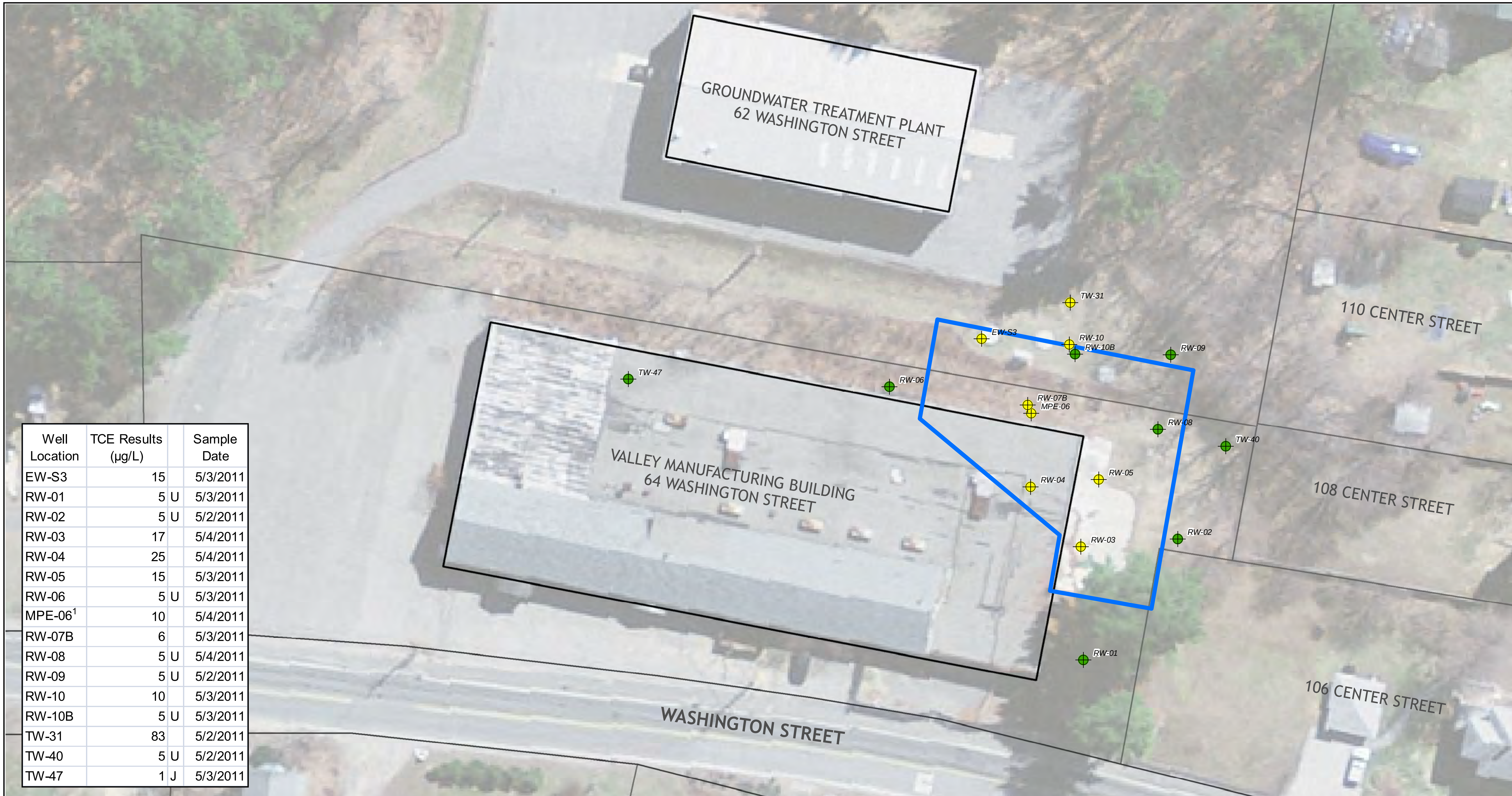
FIGURE 7-7

CONFIRMATION GROUNDWATER SAMPLING EVENT NO. 1
CIS-1,2-DICHLOROETHENE RESULTS
MARCH 21-23, 2011
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011



Well Location	TCE Results (µg/L)		Sample Date
EW-S3	15		5/3/2011
RW-01	5	U	5/3/2011
RW-02	5	U	5/2/2011
RW-03	17		5/4/2011
RW-04	25		5/4/2011
RW-05	15		5/3/2011
RW-06	5	U	5/3/2011
MPE-06[1]	10		5/4/2011
RW-07B	6		5/3/2011
RW-08	5	U	5/4/2011
RW-09	5	U	5/2/2011
RW-10	10		5/3/2011
RW-10B	5	U	5/3/2011
TW-31	83		5/2/2011
TW-40	5	U	5/2/2011
TW-47	1	J	5/3/2011

Legend

TCE RESULTS (µg/l)
- ≤ 5
- 5 - 200
- > 200

ISTT Area A Boundary

Notes:
1. Well MPE-06 was used as a substitute for RW-07 during the Confirmation Groundwater Sampling Event No. 2 only.
2. The site cleanup goal for TCE in groundwater is 5 µg/l.
3. Qualifiers:
   U - Not detected above the sample-specific detection limit
   J - Quantitation is estimated as it is below the sample-specific detection limit

N

0 20 40 80
Feet
1 inch = 40 feet

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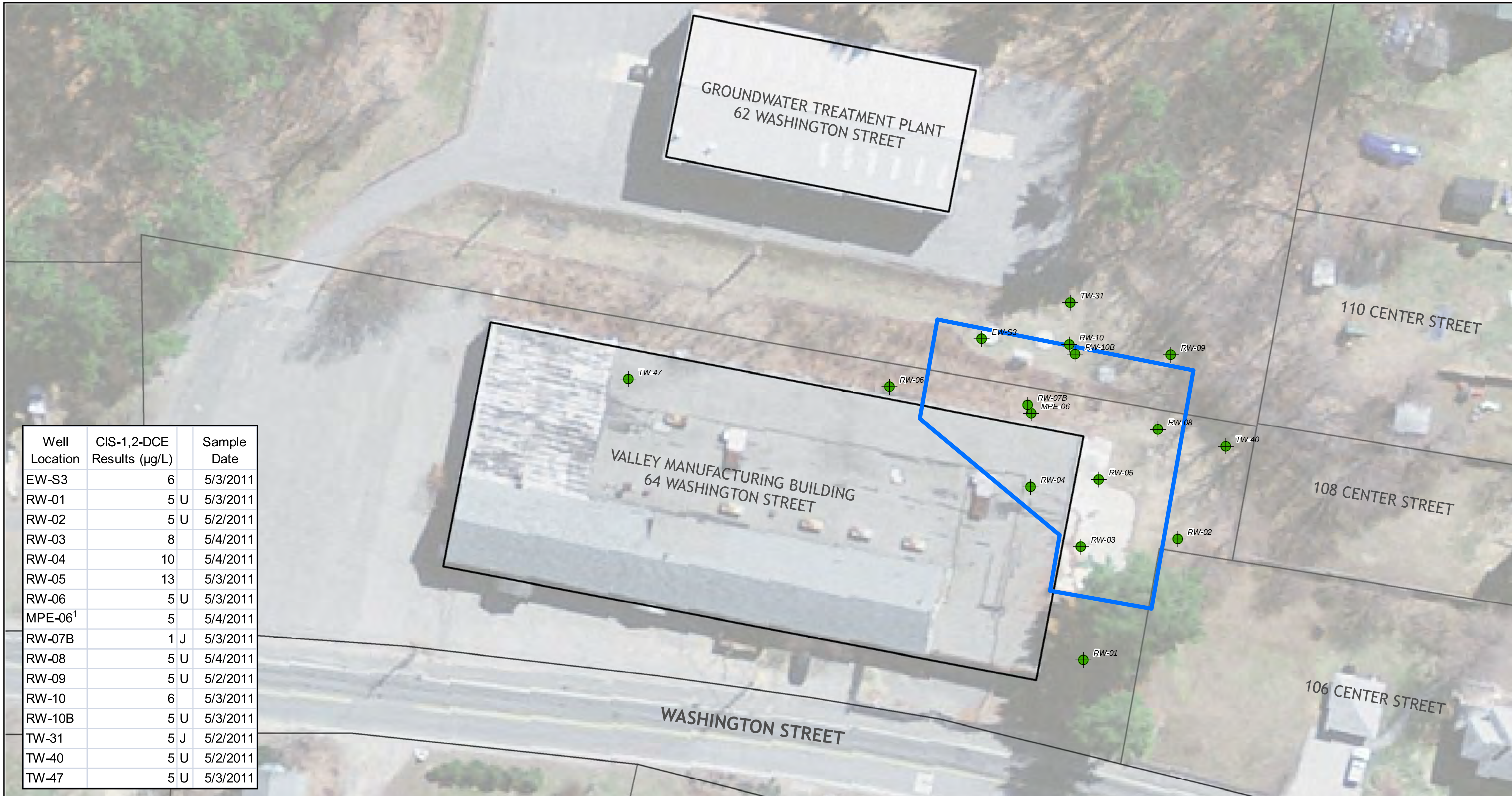
FIGURE 7-8

CONFIRMATION GROUNDWATER SAMPLING EVENT NO. 2
TRICHLOROETHENE RESULTS
MAY 2-4, 2011
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: August 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig_7-8_May_2011_TCE.mxd



Well Location	CIS-1,2-DCE Results (µg/L)		Sample Date
EW-S3	6		5/3/2011
RW-01	5	U	5/3/2011
RW-02	5	U	5/2/2011
RW-03	8		5/4/2011
RW-04	10		5/4/2011
RW-05	13		5/3/2011
RW-06	5	U	5/3/2011
MPE-06[1]	5		5/4/2011
RW-07B	1	J	5/3/2011
RW-08	5	U	5/4/2011
RW-09	5	U	5/2/2011
RW-10	6		5/3/2011
RW-10B	5	U	5/3/2011
TW-31	5	J	5/2/2011
TW-40	5	U	5/2/2011
TW-47	5	U	5/3/2011

Legend

CIS 1,2 DCE RESULTS (µg/l)
- < 70
- 70 - 200
- > 200

ISTT Area A Boundary

Notes:
1. Well MPE-06 was used as a substitute for RW-07 during the second confirmation sampling event only.
2. The site cleanup goal for CIS 1,2 DCE in groundwater is 70 µg/l.
3. Qualifiers:
   U - Not detected above the sample-specific detection limit
   J - Quantitation is estimated as it is below the sample-specific detection limit

N

0 20 40 80
Feet
1 inch = 40 feet

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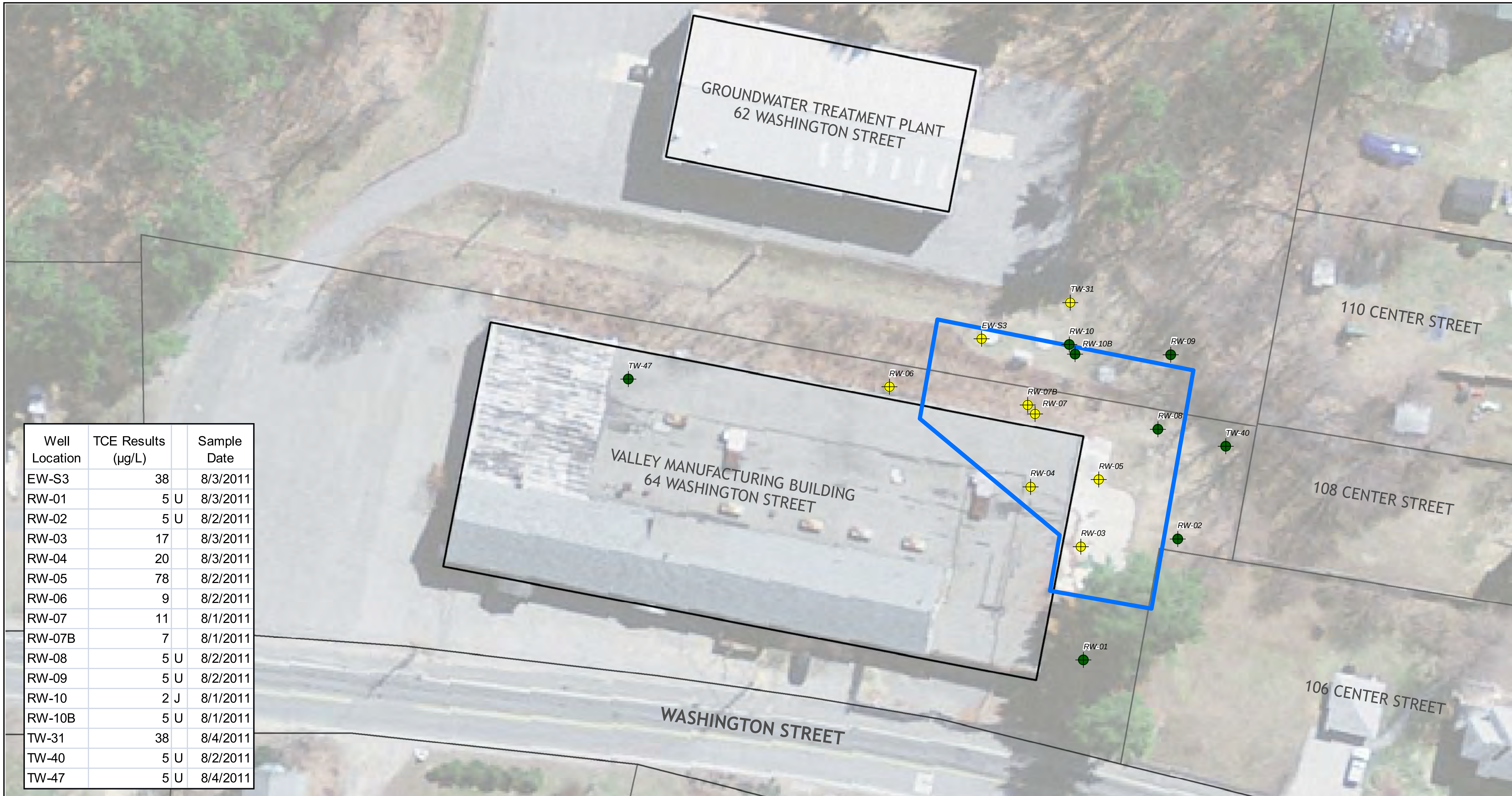
FIGURE 7-9

CONFIRMATION GROUNDWATER SAMPLING EVENT NO. 2
CIS-1,2-DICHLOROETHENE RESULTS
MAY 2-4, 2011
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig_7-9_May_2011_1_2 DCE.mxd 9/19/2011 12:05:48 PM



Well Location	TCE Results (µg/L)		Sample Date
EW-S3	38		8/3/2011
RW-01	5	U	8/3/2011
RW-02	5	U	8/2/2011
RW-03	17		8/3/2011
RW-04	20		8/3/2011
RW-05	78		8/2/2011
RW-06	9		8/2/2011
RW-07	11		8/1/2011
RW-07B	7		8/1/2011
RW-08	5	U	8/2/2011
RW-09	5	U	8/2/2011
RW-10	2	J	8/1/2011
RW-10B	5	U	8/1/2011
TW-31	38		8/4/2011
TW-40	5	U	8/2/2011
TW-47	5	U	8/4/2011

Legend

TCE RESULTS (µg/l)
- < 5
- 5 - 200
- > 200

ISTT Area A Boundary

Notes:
1. The site cleanup goal for TCE in groundwater is 5 µg/l.
2. Qualifiers:
   U - Not detected above the sample-specific detection limit
   J - Quantitation is estimated as it is below the sample-specific detection limit

N

0 20 40 80
Feet
1 inch = 40 feet

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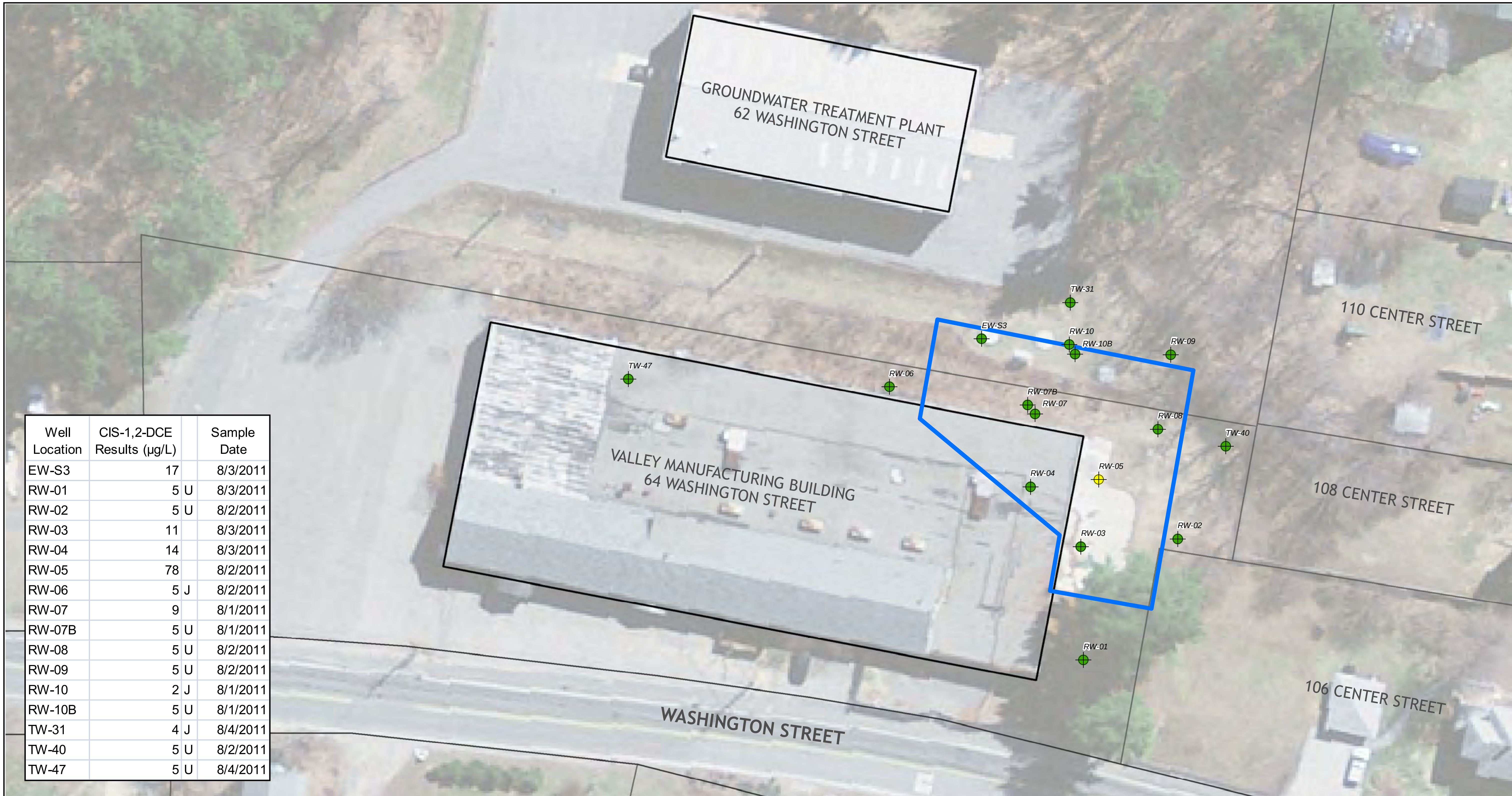
FIGURE 7-10

CONFIRMATION GROUNDWATER SAMPLING EVENT NO. 3
TRICHLOROETHENE RESULTS
AUGUST 1-4, 2011
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig_7-10_Aug_2011_TCE.mxd



Well Location	CIS-1,2-DCE Results (µg/L)		Sample Date
EW-S3	17		8/3/2011
RW-01	5	U	8/3/2011
RW-02	5	U	8/2/2011
RW-03	11		8/3/2011
RW-04	14		8/3/2011
RW-05	78		8/2/2011
RW-06	5	J	8/2/2011
RW-07	9		8/1/2011
RW-07B	5	U	8/1/2011
RW-08	5	U	8/2/2011
RW-09	5	U	8/2/2011
RW-10	2	J	8/1/2011
RW-10B	5	U	8/1/2011
TW-31	4	J	8/4/2011
TW-40	5	U	8/2/2011
TW-47	5	U	8/4/2011

Legend

CIS 1,2 DCE RESULTS (µg/l)

- < 70
- 70 - 200
- > 200

ISTT Area A Boundary

Notes:

1. The site cleanup goal for CIS 1,2 DCE in groundwater is 70 µg/l.
2. Qualifiers:
   - U - Not detected above the sample-specific detection limit
   - J - Quantitation is estimated as it is below the sample-specific detection limit

N

0 20 40 80

Feet

1 inch = 40 feet

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FIGURE 7-11

CONFIRMATION GROUNDWATER SAMPLING EVENT NO. 3
CIS-1,2-DICHLOROETHENE RESULTS
AUGUST 1-4, 2011
GROVELAND WELLS SUPERFUND SITE
GROVELAND, MASSACHUSETTS

PREPARED BY: JH	CHECKED BY: DB
PROJECT NO. 80037	DATE: September 2011

Path: R:\80000 Task Orders\80037 Groveland Wells RA\Technical Data - new and previous\GIS\Nobis Maps\Groundwater Maps\Fig_7-11_Aug_2011_1,2 DCE.mxd 9/19/2011 12:07:06 PM