URS

May 28, 2010

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SUBJECT: Contract No. W91238-07-D-0006, Task Order 0004, Modesto Groundwater Superfund Site, Modesto, California
Quarterly Operations and Monitoring Report for the First Quarter 2010

Dear Mr. Mackenzie:

Enclosed is the Quarterly Operations and Monitoring Report for First Quarter 2010. The format of the document has changed slightly from past reports, primarily with the inclusion of much of the background data and information on the enclosed compact disc (CD).

If you have any questions or comments, please call me at (916) 679-2279.

Sincerely,

Rich Beyak, PE
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QUARTERLY OPERATIONS AND MONITORING REPORT GROUNDWATER TREATMENT AND SOIL VAPOR EXTRACTION REMEDIATION SYSTEMS FIRST QUARTER 2010

MODESTO GROUNDWATER SUPERFUND SITE MODESTO, CALIFORNIA

May 2010

Contract W91238-07-D-0006
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Prepared For:

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by:

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MODESTO GROUNDWATER SUPERFUND SITE QUARTERLY OPERATIONS AND MONITORING REPORT GROUNDWATER TREATMENT AND SOIL VAPOR EXTRACTION REMEDIATION SYSTEMS FIRST QUARTER 2010

This report was prepared by URS staff under our supervision. Interpretations, conclusions, and recommendations in the report are based on background information, design basis, and other data furnished to URS by the U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, and/or third parties. URS has relied on this information as furnished and is neither responsible for nor has confirmed the accuracy of this information. Our experience and professional judgment governed the data interpretation, conclusions, and recommendations presented in the report.

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LIST OF ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
City	City of Modesto
DNAPL	dense nonaqueous-phase liquid
DQO	data quality objectives
EPA	U.S. Environmental Protection Agency
GAC	granular activated carbon
gpm	gallons per minute
GWT	groundwater treatment
LCS	laboratory control sample
LDC	Laboratory Data Consultants
MCL	maximum contaminant level
MDL	method detection limit
msl	mean sea level
MS/MSD	matrix spike/matrix spike duplicate
MWH	MHW Americas, Inc.
O&M	operation and maintenance
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCE	tretrachloroethene
ppbv	parts per billion by volume
PQL	practical quantitation limit
P&ID	process and instrumentation diagram
RPD	relative percent difference
SAP	sampling and analysis plan
scfm	standard cubic feet per minute
SVE	soil vapor extraction
TDS	total dissolved solid
URS	URS Group, Inc.
VOC	volatile organic compound
µg/L	micrograms per liter
1Q10	first quarter 2010

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1.0 INTRODUCTION

This is the first quarter 2010 (1Q10) Quarterly Operations and Monitoring (O&M) Report for the Modesto Groundwater Superfund Site. The reporting period is from January 1 through March 31, 2010. This report describes the monitoring and sampling program, summarizes the performance of the systems, and provides results of routine system operations. This section gives an overview of the site history and report organization.

1.1 Site History

The City of Modesto (City) is located approximately 80 miles southeast of Sacramento, in Stanislaus County, California (Figure 1-1). The Modesto Groundwater Superfund Site is located in a commercial area on McHenry Avenue, south of Orangeburg Avenue, behind Halford's Cleaners (941 McHenry Avenue).

In 1984, through routine sampling of water supply wells, the City discovered contamination in Municipal Well 11 at the corner of Magnolia and Mensinger Avenues (Figure 1-2). Laboratory analysis of the Municipal Well 11 sample collected in 1984 indicated tetrachloroethene (PCE) in excess of the federal and state maximum contaminant level (MCL) of 5 micrograms per liter (µg/L). PCE is an industrial solvent commonly used in dry cleaning, and was found to have originated at Halford's Cleaners, approximately 1,000 feet away from Municipal Well 11.

Municipal Well 11 was taken out of service by the City in 1984 and reactivated in April 1987 when levels of PCE and other chlorinated solvents were not detected at concentrations above MCLs. In February 1989, Municipal Well 11 was again taken out of service after PCE concentrations exceeded the MCL a second time. The well remained out of service until the City installed a wellhead granular activated carbon (GAC) treatment system in May 1991. The GAC system reduced the PCE concentration to below the MCL before the water entered the public supply system. Municipal Well 11 was returned to service in June 1991 and operated until October 1995, when the City indefinitely deactivated the well because naturally occurring uranium was detected above the MCL of 20 picoCuries per liter.

The Modesto Groundwater Superfund Site was placed on the U.S. Environmental Protection Agency's (EPA's) National Priorities List on March 31, 1989. In December 1989, the EPA's Emergency Response Section collected soil and soil vapor samples in the vicinity of Halford's Cleaners. Based on the data obtained, the EPA selected the technology for treatment and removal of the contamination. The selected treatment technology for the Modesto Groundwater Superfund Site includes a soil vapor extraction (SVE) system and a groundwater treatment (GWT) system. The objectives of the SVE and GWT systems are to remediate the source area and contain the groundwater contamination plume. The treatment systems were constructed by Diversified Remediation Controls, installed by Tyree Organization, and operated by Ecology and Environment, Inc. Installation of the SVE and GWT systems was completed on May 16, 2000, and June 12, 2000, respectively.

The groundwater monitoring well network and the SVE system were expanded in 2008. Beginning on October 13, 2008, MWH Americas, Inc., (MWH) installed 16 additional groundwater monitoring wells to delineate the lateral and vertical extents of the groundwater plume. All fieldwork was performed in accordance with the *Addendum to Work Plan for Supplemental Site Investigation and Remedial Optimization: Well Installation* (MWH, 2008a). Section 2.2 of the *Quarterly Operations and Monitoring Report, Fourth Quarter 2008* (MWH, 2009a) provides a more detailed description of the groundwater monitoring well installations. Section 2.3 of the 4Q08 report describes a dense nonaqueous-phase liquid (DNAPL) investigation and the installation of three new SVE wells and two new dual-screened soil vapor monitoring wells.

1.2 Report Organization

This report is organized as follows:

Section 1.0 provides a brief history of the Modesto Groundwater Superfund Site.

Section 2.0 describes the remedial systems.

Section 3.0 describes the sampling programs.

Section 4.0 provides performance evaluations for the GWT and SVE systems, including a groundwater capture zone analysis.

Section 5.0 summarizes results and provides recommendations for the GWT and SVE system O&M programs.

Section 6.0 provides an analytical data quality review.

The report is supported with the following appendices, provided on CD:

Appendix A is process and instrumentation diagrams (P&IDs) for the GWT and SVE systems.

Appendix B is laboratory analytical data tables.

Appendix C is a laboratory data validation report.

Appendix D is system uptime logs.

Appendix E is O&M process logs.

Appendix F provides operational history, including a brief discussion of the routine and nonroutine O&M performed on the GWT and SVE systems.

Appendix G provides historical data, as follows

G-1 Well Construction Details
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2.0 REMEDIAL SYSTEM DESCRIPTION

The Modesto Groundwater Superfund Site is located behind Halford's Cleaners and between an auto repair shop and the Season's Lodge (Figure 2-1). All SVE and GWT process equipment is contained within two metal storage containers in a fenced and locked compound in the parking lot behind the Season's Lodge.

2.1 Groundwater Treatment System

The GWT system includes a single extraction well (EW-1R), an equalization tank, particulate filters, an air stripper, two liquid-phase GAC vessels, one vapor-phase GAC vessel, and two ion exchange units, as well as piping and control systems. The GWT system P&ID is included in Appendix A.

The liquid-phase GAC vessels act as polishing vessels treating the water from the air stripper. The vapor-phase GAC vessel treats the air stream from the air stripper. The ion exchange units are installed in series after the polishing carbon vessels to remove low levels of naturally occurring uranium from the groundwater before discharge to the sewer. The design flow rate of the system is 50 gallons per minute (gpm).

The aboveground components of the system are contained in an 8.5- by 8.5- by 20-foot metal storage container. A secondary containment unit is located underneath the storage container. If a leak occurs, water from the sump is pumped to the equalization tank, and then treated before it is discharged to the sewer. Additional information can be found in the *Groundwater Treatment System and Soil Vapor Extraction System Operation and Maintenance Manual, Modesto Groundwater Superfund Site* (O&M Manual) (URS Group, Inc. [URS], 2010a), which describes the operating equipment (manufacturers, models, standard settings, inspection frequency, troubleshooting, etc.).

The groundwater monitoring network consists of 31 wells located throughout the site in residential and business communities (Figure 2-2). Well construction details are provided in Appendix G1.

2.2 Soil Vapor Extraction System

The SVE system includes three extraction wells, a blower, a condensate collection drum, filters, silencers, one 2,000-pound GAC vessel used for vapor treatment, piping, control systems, and an air conditioning unit. The SVE system P&ID is included in Appendix A.

The SVE system is operated by the local programmable logic controller on site. Its designed flow rate is 180 standard cubic feet per minute (scfm). Liquid that accumulates in the condensate collection drum is pumped to the equalization tank in the GWT system for treatment before discharge to the sewer.

The aboveground system components are contained in an 8- by 8.5- by 12.75-foot metal storage container, except the vapor GAC vessel. The vapor GAC vessel is located outside, next to the trailer within the fenced compound. Additional information can be found in the O&M Manual (URS, 2010a) which describes the operating equipment in the SVE trailer (manufacturers, models, standard settings, inspection frequency, troubleshooting, etc.).

The three extraction wells are located approximately 3 to 5 feet from the northwestern corner of Halford's Cleaners in the alley north of the building, within what is considered to be the source area. There are nine monitoring points surrounding the SVE wells. Figure 2-3 shows the location of the SVE wells, the vapor monitoring wells, and the conveyance piping configuration.

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3.0 SAMPLING AND MONITORING PROGRAM

Sampling and monitoring at the Modesto Groundwater Superfund Site is performed in accordance with the *Sampling and Analysis Plan, Modesto Groundwater Superfund Site* (SAP) (MWH, 2008c and URS, 2010b). Appendix B provides the schedule for samples collected during 1Q10, including sample locations and associated analytical test methods, phase (water, vapor, etc.), frequency, and date of sampling activity.

The quarterly sampling program consists of two types of sampling: site sampling and system sampling. Site sampling includes collecting groundwater samples from the network of 31 groundwater monitoring wells and one groundwater extraction well for EPA Method 524.2 analysis, and collecting vapor samples from the three SVE wells and nine vapor monitoring wells for Method TO15 analysis. System sampling provides data to evaluate the effectiveness of the treatment processes of both the SVE and GWT systems.

3.1 Site Sampling and Monitoring

Sampling of groundwater and vapor wells during 1Q10 is described below.

3.1.1 Groundwater Sampling and Monitoring

Depth-to-water measurements and groundwater samples were collected from all 31 groundwater monitoring wells during the quarter to delineate the GWT system's influence on the PCE plume. Depth to groundwater is measured from the top of casing using an electronic water level meter.

Based on historical data and previous quarterly data results, groundwater samples are collected starting with the least contaminated groundwater monitoring well and continuing in order to the most contaminated groundwater monitoring well to minimize the potential for cross-contamination of the groundwater monitoring well samples. Groundwater samples were collected using low-flow purge methods in 14 monitoring wells and using three-volume purge-and-sample methods in MW-3A and the 16 most recently installed groundwater wells. The samples from the extraction well is collected from a sample port. The samples were analyzed for volatile organic compounds (VOCs) using EPA Method 524.2.

At the end of each sampling event, water purged from the groundwater monitoring wells is transferred into the equalization tank located inside the GWT system. The SAP provides the detailed sampling procedure.

URS measured depths to groundwater on March 8, 2010, and collected groundwater samples from March 8 through 11, 2010.

3.1.2 Soil Vapor Sampling and Monitoring

Soil vapor samples were collected from SVE and vapor monitoring points on March 10, 2010, using Summa canisters. Samples were analyzed using Method TO15.

3.2 System Sampling and Monitoring

Sampling and monitoring of the GWT and SVE systems at the Modesto Groundwater Superfund Site are performed in accordance with the City Conditional and Revocable Groundwater Discharge Permit Number GW 98-3, (City of Modesto, 2009) and the SAP (URS, 2010b). Generally, two categories of samples are collected from the remedial systems: compliance monitoring and performance monitoring. Compliance monitoring samples are collected to satisfy regulatory requirements; performance monitoring samples are collected to assess the performance of the remedial systems.

Compliance monitoring samples for the GWT system, as identified by the City, are collected monthly from the extraction well and system effluent during periods when the system is operating. Performance monitoring samples are collected from the various process units to monitor the performance and efficiency of the individual units. The GWT system performance monitoring samples are collected from the carbon influent, carbon mid-bed, post-carbon/pre-ion exchange, and ion exchange mid-bed. System effluent samples are analyzed for VOCs monthly, total dissolved solids (TDS) monthly, and total uranium quarterly. Figures A-1 and A-2 in Appendix A illustrate the locations of the sampling ports for the GWT system.

The SVE system performance samples are collected at the pre-GAC and stack sample ports. Influent and effluent samples are collected monthly for analysis by Method TO15. Figure A-3 in Appendix A illustrates the locations of the sampling ports for the SVE system.

4.0 PERFORMANCE EVALUATION

This section provides a performance evaluation based on current and historical site sampling and system sampling results. The site sampling evaluation assesses sampling results from groundwater and vadose zone monitoring points. The system sampling evaluation summarizes the remedial progress of the GWT and SVE systems. Both of these evaluations are based on analytical laboratory results and subsequent data evaluations. A complete set of validated analytical data for groundwater and soil vapor samples collected during this reporting period is provided in Appendix B. Appendix C is the laboratory data validation report for this reporting period's analytical data.

4.1 Site Performance

This section provides results of the groundwater and soil vapor well sampling events for 1Q10 (Sections 4.1.1 and 4.1.2, respectively). A stratigraphic conceptual model is shown on Figure 4-1. A capture zone analysis is provided in Section 4.1.3, and an analysis of vertical gradients is presented in Section 4.1.4.

4.1.1 Groundwater Monitoring Sampling

Based on water levels measured on March 8, 2010, overall groundwater elevations ranged from 44.72 feet mean sea level (msl) (MW-03A) to 47.76 feet msl (MW-11A) in the A zone; 45.34 feet msl (MW-16B) to 46.73 feet msl (MW-9B) in the B zone; and 46.13 feet msl (MW-16C) to 48.1 feet msl (MW-04C) in the C zone. Comparing 1Q10 to 4Q09 water levels, water elevations in A zone wells increased at an average of about 1.5 feet across the site; water elevations in B zone wells increased an average of approximately 2.2 feet across the site; and water levels in C zone wells increased an average of approximately 3 feet across the site. A complete list of historical (starting in 2000) and current water level measurements is presented in Appendix G-2. Pumping histories from January 2000 through August 2009 for City supply wells surrounding the site are compiled in *Groundwater Remediation Optimization Methods* (MWH, 2010a, Appendix B).

Potentiometric surface data, groundwater flow directions, PCE plumes and concentrations in the A, B, and C zones are shown on Figures 4-2, 4-3, and 4-4, respectively. Groundwater contours indicate that groundwater in the A zone flows southeast, consistent with previous quarters (Figure 4-2). It also shows the induced cone of depression around EW-1R, which was operating at approximately 46 gpm during 1Q10. The average hydraulic gradient along the direction of regional groundwater flow for the A zone was approximately 0.0010, or approximately 5.5 feet per mile. Groundwater in the B zone flows southeast (Figure 4-3). The horizontal gradient is approximately 0.0014 (approximately 7.5 feet per mile). Groundwater in the C zone flows south-southeast (Figure 4-4) with a horizontal gradient of approximately 0.0013 or approximately 7.0 feet per mile.

Note that the flow direction in the C zone was southeast during 4Q08 and 1Q09, shifted to the west during 2Q09, southwest during 3Q09, and then returned to southeasterly in 4Q09 and 1Q10. As discussed in previous reports, the gradients in this deeper zone are strongly influenced by regional supply well pumping that increases during the spring and summer months (MWH, 2010b).

In 1Q10, the analytes PCE and benzene were detected at concentrations exceeding their MCLs. Data suggest that the source of the benzene concentrations is likely south of Halford's Cleaners; therefore, this analyte is discussed separately from the discussion on PCE concentrations in groundwater.

4.1.1.1 PCE

The distribution of PCE contamination in groundwater is illustrated with isoconcentration contour lines (lines of equal concentration) on Figures 4-2, 4-3, and 4-4 for the A, B, and C zones, respectively. Appendix G-3 includes historical and current quarterly groundwater monitoring well analytical results and pH levels from water samples. Figures G-4(a) through G-4(ae) (Appendix G-4) present historical time concentration plots for PCE for each monitoring well for the period from February 1992 through March 2010.

A Zone

As depicted in Figure 4-2, the PCE MCL (5.0 µg/L) plume boundary extends south-southeast in the general direction of the groundwater gradients. In general, the 1Q10 PCE detections in groundwater were consistent with previous quarters. PCE concentrations increased during the first quarter at MW-6A, MW-10A, MW-13A, and MW-14A resulting in an interpretation of the MCL boundary farther to the west. Figures G-4(q and r) show that concentrations have increased during the first quarter of the year since approximately 2005 in MW-13A and since 2007 at MW-14A. Prior to these years, PCE concentrations spiked less regularly. The graphs show an indirect correlation between groundwater elevations and concentrations. Concentrations spike as water levels increase, then decrease as water levels reach their peak and begin to decrease. This may be due to an area of high concentrations in the vadose zone above these wells that causes concentrations in groundwater to increase as the water table intersects the zone. It is currently unclear why concentrations decrease when the water levels peak at their highest, usually in the second quarter of the year. This correlation between increasing water levels and increasing PCE concentrations is not apparent at the other A zone wells.

In previous reports, these concentration fluctuations at the western perimeter wells (MW-6A, MW-11A, MW-13A, and MW-14A) have been attributed to potential influences from pumping of municipal supply wells to the west or northwest, perhaps from Municipal Well 14 or 17 (Figure 1-2). However, Municipal Well 14 has been offline since September 2006 (MWH, 2010a). Municipal Well 17, which has remained in consistent operation, has a 4-foot-long perforated interval about 25 feet lower than the screened zones of MW-13 and MW-14, but is located more than 3,500 feet northwest of the monitoring wells (MWH, 2010b).

The PCE concentration at EW-1R increased from 160 µg/L in 4Q09 to 180 µg/L in 1Q10. Concentrations remained fairly similar (changes of approximately 0.1 µg/L) in upgradient wells to the north (MW-1A, MW-2A, MW-7A, and MW-11A). Concentrations decreased in cross and downgradient wells; therefore, the plume boundary was pulled inward at this location.

Notable observations in 1Q10 include the following:

- The PCE concentration at MW-4A was the lowest detected since the 3Q00.
- The 4Q09 PCE concentration in well MW-5A, which had increased sharply from 79 to 300 µg/L, decreased to 210 µg/L in 1Q10. The PCE concentration at MW-6A increased to 48 µg/L in 1Q10, which is the highest concentration since March 2005 when the concentration was 92 µg/L.
- In general, PCE concentrations are decreasing in the northern portions of the plume. There are no apparent concentration trends in downgradient wells MW-16A, MW-17A, MW-18A, MW-19A and MW-20A. Although the spikes in concentration at cross-gradient wells MW-6A, MW-10A, MW-13A, and MW-14A commonly occur during the first quarter of each year, the concentrations reported in

1Q10 indicate an increase in the overall trend of PCE at these wells (see Figures G-4(h), G-4(l), G-4(q), and G-4(r)). Therefore, PCE concentrations are not defined at the western boundary of the plume during the first quarters of each year.

B Zone

Figure 4-3 depicts the B zone PCE plume and potentiometric surface contours. Seven wells are screened in the B zone, which include well MW-9B and the six more recently installed B zone monitoring wells MW-04B, MW-10B, MW-16B, MW-17B, MW-19B, and MW-20B. PCE was detected above the MCL in all B zone wells except MW-9B, MW-16B, and MW-19B (Figure 4-3).

Notable observations in 1Q10 results include the following:

- PCE concentrations decreased at all wells screened in the B zone except at cross-gradient well MW-17B where it increased from 51 to 63 µg/L, which is the highest concentration detected at that well since it was installed in 2008. This could indicate a migration pathway toward this well possibly influenced by pumping from Municipal Well 7.

- It has been established that pumping from municipal supply wells can significantly alter and even reverse local groundwater flow directions. The presence of PCE at MW-17B is believed to be the result of pumping from downgradient Municipal Well 7, located 1,000 feet southwest. The City provided historical flow and water quality data for this municipal supply well through August 2009 (MWH, 2010a). The perforated interval for this well is from about 160 to 210 feet bgs (-70 to -120 feet msl); the well is screened across the lower portion of the B zone sands and through the B/C aquitard. This is an active well in continuous use by the City and has been sampled regularly since 1986 at intervals ranging from one to two years. The City's records show that PCE has never been detected in Municipal Well 7, and MWH confirmed with the City that there is not a carbon treatment unit on this well (MWH, 2010b). Water quality data from Municipal Well 7 should be closely monitored in the future and this well should be recommended for shutdown.

- The B zone MCL plume is undefined at the western, southwestern, and southern (cross-gradient) boundaries (Figure 4-3).

C Zone

Groundwater elevation contours for the C zone and PCE concentrations are shown on Figure 4-4. Data for 1Q10 indicate only two detections of PCE at wells screened in the C zone, both results less than the MCL.

Potentiometric data for the C zone provide direct and observable evidence that local pumping from supply wells affects horizontal and vertical gradients in relatively shallow portions of the saturated zone in the vicinity of the PCE plume. The groundwater flow direction in the C zone reversed from southeast to west-northwest from the 1Q09 to 2Q09, moved to the southwest during 3Q09 (MWH, 2010b), and returned back to the southeast during 4Q09 and 1Q10.

The changes in flow direction in the C Zone may be due to regional pumping from the municipal wells throughout the area.

4.1.1.2 Benzene

Concentrations of benzene were detected in 1Q10 groundwater samples, the first time since the wells have been sampled. The highest concentrations are 25 µg/L in the A zone at MW-16A; 26 µg/L in the B zone at

MW-19B; and 9.9 µg/L in the C zone at MW-16A (all of which exceed the MCL of 1 µg/L). The related components toluene, ethylbenzene, and xylenes were also detected; however, concentrations of these analytes are less than MCLs. The configuration of concentrations indicates that the source is located south of the site. Concentrations are highest south and southeast of the site and decrease in the A, B, and C zones further north/northwest. Because the groundwater gradient in the A zone has been consistently southeast, the source of the benzene concentrations is likely close to the downgradient edge of the plume in the A zone (near MW-16A). Fluctuating gradients in the B and C zones from southeast to west and northwest likely contributed to the migration northwards towards Halford's Cleaners in these zones.

Because this report is an evaluation of the contamination from Halford's Cleaners, further speculation about the source of benzene in the monitoring wells at this site is not included.

4.1.2 Soil Vapor Sampling

Samples from the three SVE wells were collected on March 10, 2010. Results are listed in Appendix G-5 and posted on Figure 4-5. Historically, concentrations have shown a decreasing trend in all three SVE wells since their installation, but this quarter concentrations in the shallowest wells (SVE-02 and SVE-03) increased slightly:

- SVE-02: PCE concentrations increased from 110 parts per billion by volume (ppbv) last quarter to 290 ppbv this quarter.
- SVE-03: PCE concentrations increased from 2.6 ppbv last quarter to 88 ppbv this quarter.
- SVE-04: PCE concentrations decreased from 90 ppbv last quarter to 57 ppbv this quarter.

If this pattern of concentrations increases in the shallow zones and decreases in the deeper zone continue, it may be useful to optimize flow rates to increase flow from the wells with highest concentrations in order to extract greater mass from the shallow zones.

4.1.3 Extraction Well EW-1R Capture Zone Analysis

Estimates of horizontal and vertical capture from extraction well EW-1R are shown on Figures 4-6 and 4-7, respectively. Two lines of evidence (groundwater elevation contours developed based on 1Q10 data and modeled particle tracking [MWH, 2010a]) were used to estimate the extent of capture presented on Figure 4-6 and projected onto Figure 4-7.

Groundwater elevations from water levels measured during 1Q10 were contoured using the contouring program Surfer and augmented with profession hydrogeologic judgment. Groundwater stagnation based on the potentiometric contours was identified, separating areas wherein groundwater flow is interpreted to be moving either toward or away from a pumping well. This "empirical" capture zone or groundwater stagnation line is illustrated in green on Figure 4-6. A new and expanded transient groundwater flow model for the site and surrounding region was developed to support of the *Groundwater Remediation Optimization Methods* report (MWH, 2010a, Appendix B). The modeled capture zone for EW-1R pumping at 50 gpm is shown on Figure 4-6, illustrated as the sweep of groundwater flow lines toward the well based on backward particle tracking (i.e., particles released at the well and modeled backwards to determine their starting points). The actual average flow rate at this well in 1Q10 was 46 gpm.

The horizontal estimates of capture for EW-1R, based on the two lines of evidence, are in good agreement. The downgradient extent of capture is interpreted to be near the location of MW-4A. These lines of evidence suggest that EW-1R is capturing only the upgradient portion of the PCE plume (approximately

25%) (Figure 4-6). The portions of the MCL plume (the volume of groundwater with PCE concentrations that exceed 5.0 µg/L) close to and downgradient from MW-4A are, apparently, not being captured by EW-1R.

An estimate of the vertical extent for capture of EW-1R is illustrated on Figure 4-7. The downgradient extent of capture depicted in profile view (just downgradient from MW-4A) is based on the empirical and modeled lines of evidence. The vertical capture zone below the base of EW-1R is an estimate based on modeling, water level data, and vertical gradients. The groundwater model suggests (1) there is an upward vertical gradient beneath the extraction well and (2) flow in the bottom portions of the screen may originate from the B zone sands (MWH, 2010b). The upward vertical gradients are confirmed by 1Q10 groundwater elevation data, as described in Section 4.1.4.

4.1.4 Analysis of Vertical Gradients

Vertical gradients were calculated using 1Q10 data at seven well pairs between the A and B zones and at five well pairs between the B and C zones and are listed on Table 4-1. In the A zone, the potential for an upward gradient exists at five of the seven well pairs. There was a potential for a downward gradient from MW-19A to MW-19B, and the gradient was flat (0.0000) between MW-16 A and MW-16B.

In the B zone, vertical gradients for all five well pairs were positive, all indicating the potential for an upward gradient from the C to the B zone.

4.2 System Performance

System compliance and performance samples were collected to evaluate the progress of the remedial systems. Water, vapor, and media samples were collected per the SAP (URS, 2010) and the City Conditional and Revocable Groundwater Discharge Permit (Permit Number GW98-3) (see Appendix B). Appendices G-6 and G-7 summarize the analytical results for samples collected from the GWT and SVE systems, respectively.

4.2.1 Groundwater Treatment System Results

During 1Q10, the GWT system operated for approximately 2,130 hours (of 2,160 hours possible during the quarter), which represents an uptime of approximately 98.6 percent. System uptime logs and graphical representation of the GWT system operation time are presented in Appendix D.

During this quarter, the system treated a total of approximately 5.24 million gallons of water and removed approximately 7.3 pounds of PCE. To date (since August 2001), the system has treated approximately 142.8 million gallons of water and removed approximately 464 pounds of PCE. Table 4-2 lists the influent and effluent PCE concentrations from monthly samples. Figure 4-8 illustrates the cumulative PCE mass removed.

Samples are also analyzed for uranium and TDS. A summary of all 1Q10 treatment system results are provided in Appendix G-6.

4.2.2 Soil Vapor Extraction System Results

SVE system samples were collected in January, February, and March 2010. All samples were collected in SUMMA canisters and sent to the U.S. EPA Region 9 Laboratory in Richmond, California, for VOC analysis. Results are presented in Appendix G-7; PCE results are summarized in Table 4-3.

From June 2001 until system shutdown on October 6, 2008, PCE detections in influent samples were decreasing. After the addition of the three new extraction wells in 4Q08, system influent concentrations increased sharply but have since declined.

The SVE system operated at an average flow rate of approximately 120 to 162 scfm for approximately 2,160 hours during 1Q10, an uptime of 100 percent. System uptime logs and graphical representation of the SVE system operation time are presented in Appendix D.

The SVE system removed approximately 5.11 pounds of VOC contamination during this quarter (Figure 4-9). The total cumulative VOC mass removed through 1Q10 is approximately 3,449 pounds.

5.0 RECOMMENDATIONS

A summary of observations and recommendations for the GWT and SVE systems are provided in this section.

5.1 GWT System – Summary Observations and Recommendations

The current GWT system (the single extraction well EW-1R) was designed as an interim measure with an objective of source control and mass removal within the northern portion of the center of mass of the groundwater plume where PCE concentrations in shallow zones have historically been the highest (MWH, 2010a). Concentrations of PCE in groundwater have migrated from the source horizontally and downward into the A, B, and C zones. Data collected in 1Q10 indicate that concentrations are defined in the A zone except to the west near MW-13A and MW-14A. Concentrations at these wells increased from less than the PCE MCL in 4Q09 to greater than the MCL in 1Q10. However, as stated in Section 4.0, time series plots suggest an indirect correlation between groundwater elevations and concentrations indicating a possible area of high concentrations in the vadose zone above these wells that causes concentrations in groundwater to increase as the water table rises into them (Appendix G-4, Figures G-4 a–ac). Because the concentrations at MW-13A and MW-14A generally decrease to less than the MCL in the second quarter, the plume may be considered partially defined to the south and southwest.

Concentrations in the B zone are undefined to the south, southwest, and west. PCE concentrations at MW-17B, located to the southwest, have been increasing since 1Q09. Concentrations of PCE at every other B zone well decreased during 1Q10. The 1Q10 results from B zone well MW-17B (63 µg/L) are notable in that under current groundwater gradients (Figure 4-3), the well is located cross-gradient from the center of mass of the plume. This may indicate some preferential pathway possibly influenced by pumping from municipal supply wells, most likely Municipal Well 7.

PCE concentrations decreased at every well screened in the C zone in 1Q10. Concentrations have been less than the MCL since 1Q09.

Figures 4-6 and 4-7 show that the PCE plume is only partially captured in the A and B zones. Based on 1Q10 data, the plume is approximately 1,600 feet wide and 1,850 feet long in the A zone (Figure 4-2).

Current recommendations for groundwater were developed based on current and historical data from the site and on two additional studies described in the *Groundwater Remediation Optimization Methods* (MWH, 2010a). Both studies were designed to support or be incorporated into a feasibility study. The studies are (1) development of a groundwater flow model to support optimization of the interim remedy and provide the framework to model the fate and transport of PCE and (2) preparation of a groundwater optimization study that will incorporate the results of the groundwater modeling, present methods to optimize the current interim remedy, and discuss potential alternative discharge scenarios (MWH, 2010a).

Recommendations provided in *Groundwater Remediation Optimization Methods* (MWH, 2010a) included potentially installing new wells to fill data gaps and monitor progress of the optimized interim and final groundwater remedies for the site. All recommendations from the report are transcribed here (MWH, 2010a):

> **Remaining Data Gaps.** Areas in which new monitoring wells might be installed for elimination of data gaps have been identified. (Figures showing data gaps have been identified are provided in the Groundwater Remediation Optimization Methods report [Figures 2-4 and 2-5] [MWH, 2010a]):

- The A zone south of MW-20A and between MW-16A and MW-17A, near McHenry Avenue and south of the drainage canal. This area is along the southern margin of the plume in the uppermost hydrogeologic zone, in an area with an undefined MCL boundary. This area is also just north of Elwood's Dry Cleaning Service, another PCE source; improved monitoring in this area will allow differentiation between contamination from Halford's and Elwood's.
- The B zone between wells MW-16B and MW-17B. The B zone MCL boundary is undefined in this area, and improved monitoring in this area will allow differentiation between contamination from Halford's and Elwood's.
- The B zone to the southwest of MW-17B. B zone PCE contamination appears to extend to the southwest of MW-17B toward Municipal Well 7, but the extent is unknown because PCE has not been detected in Municipal Well 7.
- The B zone in the area to the west of MW-09, MW-04, and MW-10 and north of MW-17. The B zone MCL volume boundary is currently unknown in this area. No shallow wells are recommended in this general area because the A zone monitoring well network is sufficient, and the MCL volume boundary west of Halford's is defined in the A zone.

These wells are not critical for the early stages of an upcoming FS. As such, the number of wells and specific well locations are not identified in this report. However, information provided from data gap wells may allow more accurate evaluation of potential approaches that will completely address PCE-impacted groundwater, should that be required under the final remedy, and their associated life cycle costs. New wells would also be useful for monitoring the progress of the optimized interim and final groundwater remedies for the Site.

In addition to the dissolved PCE data gaps identified above, residual DNAPL or presence of significant TCE in the capillary fringe is potentially present at the Site upgradient of MW-4A as indicated by recent PCE concentrations exceeding 1,500 µg/L in groundwater samples from this well. The likelihood that DNAPL is present and the significance of TCE that has accumulated in the capillary fringe should be further evaluated based on available information, and if deemed necessary, a focused field screening investigation using direct push methods with membrane interface probe detection could be implemented.

Monitor Additional Groundwater Parameters. As recommended by GeoTrans (2001), additional monitoring parameters should be measured to determine the potential for reductive dechlorination of PCE in groundwater. The key parameters that should be measured during groundwater sampling events are DO and ORP. These parameters are relatively inexpensive to determine in the field and will be useful during upcoming FS to evaluate the potential effectiveness of natural attenuation or in situ bioremediation.

Install Additional Extraction Wells and Conveyance Piping. Three new extraction wells are recommended for installation at two locations. New extraction wells are recommended in the A zone near MW-4A (proposed well EW-2A_P) and MW-20A (proposed well EW-3A_P) and in the B zone near MW-20B (proposed well EW-3B_P). The locations are shown on Figures 2-4 and 2-5. With these three new extraction wells, the total extraction rate will increase from 50 gpm to 150 gpm, thereby improving hydraulic control of the plume and increasing the mass extraction rate. Phased implementation of these extraction wells could be considered, although this may complicate other required system modifications. Approximately 1,600 feet of new conveyance piping would be required for pumping of extracted groundwater to the treatment system.

Expand the Groundwater Treatment Plant. As discussed in Section 4.3, the current treatment plant has a design capacity of 50 gpm. To provide adequate treatment for a higher flow rate with a higher influent concentration, the major components of the treatment system must be modified or upgraded, and the storage unit that houses the GWT system must be reconfigured. The air stripper will require expansion by addition of two additional trays; the liquid-phase GAC units and ion exchange vessels will likely require replacement with higher capacity treatment vessels; an additional bag filter would need to be added to the system; and various fittings, valves, and piping would require replacement. Additionally, the treatment building will require modifications to provide sufficient space for expanded treatment units. Operation of the expanded system will incur higher O&M costs due to additional maintenance and requirements for media changeout.

Evaluate Requirement for Off-Gas Treatment. The existing vapor-phase GAC unit that treats air stripper off gas will be sufficient to treat the expanded flow, although the frequency of GAC replacement will increase with higher PCE mass loading. Requirements for vapor-phase GAC to treat air stripper off-gas should be fully evaluated as part of the upcoming FS. Federal, state, and local regulations that apply specifically to vapor-phase emissions from the Site treatment systems should be carefully reviewed before eliminating this treatment system, and decision logic should be developed for determining when or if vapor-phase treatment could be suspended.

Implement an Alternative Discharge Method. To reduce costs for disposal of treated groundwater, an alternative discharge method should be implemented. Based on the preliminary analysis presented in Section 4.4, discharge of treated groundwater to surface water via the City stormwater drainage system is recommended. Permitting and compliance issues as well as requirements for treatment and possible prohibitions on discharge to the sanitary sewer during storm events must be further evaluated during the detailed design phase.

In addition to the recommendations from the *Groundwater Remediation Optimization Methods* (MWH, 2010a), the following recommendation is made based on data collected during 1Q10. The benzene concentrations reported at down and cross-gradient wells should be investigated (MW-16A, MW-16B, and MW-16C, MW-19A and MW-19B, MW-20A, MW-20B, and MW-20C, MW-17B and MW-17C, MW-10B and MW-10C, and MW-4B and MW-4C). The source is most likely located close to the edge of the A zone plume near MW-16A.

5.2 Soil Vapor Extraction – Summary Observations and Recommendations

Results from a site investigation conducted in 2007 and from a soil vapor rebound test conducted from late November 2006 through January 2007 identified significant vapor mass at the northwestern corner of the Halford's Cleaners building and possibly extending underneath the building (see *Soil Vapor Extraction System Optimization and Enhancement Methods* [MWH, 2008b] for summary results). Initial sub-slab vapor sampling in buildings at and near the source area in February 2008 confirmed that high concentrations of PCE in vapor (up to 20,000 ppbv) were present under the concrete slab foundation of the Halford's Cleaners building (MWH, 2010b). An SVE optimization plan was implemented in November 2008, which included using SVE-01 as a monitoring point and installing three new SVE wells (SVE-02, SVE-03, and SVE-04).

In 1Q10, samples collected from the three newer SVE wells showed increased concentrations at the shallow wells (SVE-02 and SVE-03). PCE concentrations in vapor samples collected from within Halford's Cleaners at sample locations OSVE-10 and OSVE-11 decreased from 450 and 27,000 ppbv in 1Q09 to 130 and 530 ppbv in 1Q10. These changes suggest that operation of the SVE system is mitigating

shallow vapor concentrations in the residual source area and reducing the potential for vapor intrusion into the buildings.

PCE concentrations in deeper extraction well SVE-04, however, continued to decrease in 1Q10. If this pattern of concentrations increases in the shallow zones and decreases in the deeper zone continue, it may be useful to optimize flow rates to extract greater mass from the shallow zones. Extraction well flow measurements on March 25, 2010, show that most vapor flow is coming from the deeper well SVE-04 at 54 scfm. SVE-02 and SVE-03 flow rates are 31 and 29 cfm, respectively. If flow from SVE-04 can be decreased without adversely affecting the regenerative blower on the treatment system, then flow may be able to be increased from the more shallow wells to increase the system mass extraction rate.

6.0 QUALITY CONTROL SUMMARY REPORT

6.1 Introduction

This section summarizes quality assurance and quality control results for the samples collected and data generated during the period of January 2010 through March 2010 at the Modesto Groundwater Superfund Site, Modesto, California. Sampling activity protocols are provided in the SAP (MWH, 2008c and URS, 2010b).

Between January 27, 2010, and March 23, 2010, 41 groundwater samples, 24 air samples, 9 field duplicates, 5 matrix spike and matrix spike duplicate (MS/MSD) pairs, 6 trip blanks, and 5 field blanks were collected. Water samples were collected from the GWT system and existing monitoring wells. Air samples were collected from the GWT and SVE systems. Contaminants of concern at the Modesto Groundwater Superfund Site are indicated in Table B1 of Appendix B. Samples were submitted for chemical analyses as presented in Table B2 of Appendix B. Analyses performed include the following:

- TDS by Standard Method 2540C
- VOCs in water by EPA Method 524.2
- Total uranium by American Society for Testing and Materials (ASTM) D5174
- VOCs in air by EPA Method TO-15

Analytical chemistry services for groundwater and air samples were provided by the EPA Region 9 Laboratory in Richmond, California. Analytical chemistry services for uranium analysis were provided by GEL Laboratories, LLC, in South Carolina. All laboratories are certified by the California Department of Health Services through the Environmental Laboratory Accreditation Program to perform hazardous waste analyses. Sample results are summarized in Appendix B, Table B3.

The URS project chemist reviewed ASTM Method D5174. Laboratory Data Consultants (LDC) performed data validation of all other sample results using the criteria established in the SAP (URS, 2010b), analytical methods, and EPA Region 9 Laboratory Standard Operating Procedures. The January and February analytical data were collected by the previous contractor, so LDC did not validate that data. Therefore, the discussions in this section apply only to data collected in March 2010. The samples validated by LDC were validated electronically. Data validation reports and qualified data tables are provided in Appendix C. Several data validation flags were used in the validation process. The definitions of these qualifier flags are as follows:

U	Indicates the compound or analyte was analyzed for but not detected at or above the reported quantitation limit.
UJ	Indicates the compound or analyte was analyzed for but not detected at or above the stated limit. The sample detection limit is an estimated value.
J	Indicates the analyte was positively identified; the associated numerical value is an approximate concentration of the analyte in the sample.

6.2 Data Quality Objectives

Data quality objectives (DQOs) are qualitative and quantitative statements that specify the quality of the data required to meet the goals of site investigations and support decisions made in remedial response activities. Data quality was assessed in terms of its precision, accuracy, representativeness, completeness, and comparability (PARCC). These criteria are briefly defined in the following sections. The results of the field and laboratory QC checks are evaluated against the DQOs, and the quality of the data is assessed according to the PARCC parameters. QC sample results that fall outside of these criteria serve to signal the production of unacceptable or biased data that could result in the implementation of corrective action or the qualification of data.

6.2.1 Precision

Precision is a measurement of mutual agreement among individual measurements of the same property, usually under prescribed conditions. Data evaluated to assess precision consist of results from the analysis of field duplicate pairs and MS/MSD samples. The precision measurement is established using the relative percent difference (RPD) between the duplicate sample results, and is expressed as follows:

$$\text{RPD} = \frac{\left[X_1 - X_2\right]}{\left[\left(X_1 + X_2 / 2\right)\right]} \times 100$$

where:

X_1 and X_2 represent the individual concentrations of the target analyte in the two replicate analyses.

6.2.2 Accuracy

Accuracy is defined as the proximity of the mean of a set of results to the true value. Accuracy is assessed through the evaluation of initial and continuing calibration data, as well as laboratory control sample (LCS) recoveries, surrogate standard recoveries, and MS recoveries, which are expressed as a percent recovery according to the following equation:

$$\text{percent recovery} = \frac{\left(\text{spiked sample conc.} - \text{sample conc.}\right)}{\text{known conc. of spike}} \times 100$$

6.2.3 Representativeness

Representativeness is defined as the degree to which sample data accurately and precisely represent the characteristics of the site, parameter variations at a sampling point, or environmental conditions. Representativeness, in terms of sample integrity for this investigation, was qualitatively evaluated based on the analysis of trip blanks, field blanks, and method blank samples. In addition, sample collection and handling methods and the cooler receipt forms were reviewed to confirm that samples were received under proper storage conditions.

6.2.4 Completeness

Two types of completeness have been evaluated for this project. Analytical completeness is the number of unqualified results related to the total number of results reported, expressed as a percentage. The analytical

completeness goal is 90 percent. Technical completeness is the number of valid results related to the total number of results reported, expressed as a percentage. The technical completeness goal for this project is 95 percent.

6.2.5 Comparability

Data comparability is achieved by using standard analytical methods and reporting limits, and by using standard units of measurements, as specified in the methods. Comparability is a qualitative parameter.

6.3 Quality Control Results

The following sections summarize the data review process and results in terms of PARCC criteria, as defined in Section 2.2.5 of the SAP (URS, 2010b). Qualified data based on this review process are provided in Appendix C.

6.3.1 Precision and Accuracy

Precision and accuracy were evaluated based on the results of QC samples collected by the field team and QC samples that originated in the laboratory. The calculated RPD for MS/MSDs and field duplicate pairs provided information on the precision of sampling and analytical procedures. MS/MSD analyses were associated with all samples for this sampling event. All data were reviewed for accuracy based on the surrogate spike, MS/MSD, and LCS percent recoveries. In addition, initial and continuing calibration data were reviewed for analytical accuracy. The criteria used for the evaluation are provided in the quality assurance project plan in the SAP (URS, 2010b). Data validation findings are provided in Appendix C. Field duplicate results are included in the results summary table (Table B3 in Appendix B), LCS recovery outliers are summarized in Table B4, and MS/MSD recovery outliers are summarized in Table B5.

6.3.2 Representativeness

Representativeness was evaluated through the analysis of field blank, trip blank, and method blank samples. Additionally, sample collection and handling methods and the cooler receipt forms were reviewed. All sample bottles were received in good condition and the chain-of-custody documents agreed with the sample labels.

Trip blanks are required to accompany each cooler of aqueous samples sent to the laboratory for analysis of VOCs. One trip blank accompanied each cooler for each of the sampling dates. Trip blank detections can be found in Table B3 (Appendix B).

Field blanks are used to determine if potential sample contamination has occurred during the sample collection process. Field blank samples were collected at monitoring wells MW-7A (identified as MW-401-1Q10), MW-8A (identified as MW-402-1Q10), MW-18A (identified as MW-403-1Q10), and MW-19B (identified as MW-404-1Q10), and at the groundwater treatment system (identified as MW-405-1Q10). Field blanks are analyzed using the same analytical procedures as the associated samples. Field blank detections are provided in Table B3 (Appendix B).

Method blanks are processed through the same analytical procedures as the associated samples. Method blanks are analyzed with each batch of samples to provide information on contamination originating in the analytical process. Method blank detections are indicated in the data validation reports in Appendix C.

6.3.3 Completeness

Completeness of data was evaluated by assuring that all analytical requests were met, samples were received in proper condition, and all analyses were performed within the appropriate holding times. Overall analytical completeness (93.5%) exceeded the project goal of 90 percent. Overall technical completeness for this data set (100%) exceeded the project goal of 95 percent. Refer to Appendix C for a breakdown of completeness by method and analyte for all methods except ASTM D5714. Table B6 (Appendix B) provides a breakdown of completeness for ASTM D5714.

6.3.4 Comparability

Comparability was evaluated for this sampling event by analyzing all samples according to the specified EPA analytical methods, which use standard units of measurement. Necessary sample dilutions, due to the presence of elevated target compound concentrations, did not affect data usability and comparability. Results for some analytes are reported below the practical quantitation limit (PQL) but above the method detection limit (MDL). The "J" flag has been applied to results reported between the MDL and the PQL.

6.4 Summary of Data Reliability

Based on this evaluation, all data collected during this period are of known and acceptable quality in relation to the DQOs of this project. All data are considered usable as qualified for the intended purposes.

7.0 REFERENCES

City of Modesto, 2009. City of Modesto Conditional and Revocable Groundwater Discharge Permit Number GW 98-3. December.

MWH, 2008a. *Addendum to Work Plan for Supplemental Site Investigation and Remedial Optimization: Well Installation, Modesto Groundwater Superfund Site*. June.

MWH, 2008b. *Soil Vapor Extraction System Optimization and Enhancement Methods, Modesto Groundwater Superfund Site*. June.

MWH, 2008c. *Sampling and Analysis Plan, Modesto Groundwater Superfund Site.* June.

MWH, 2009a. *Quarterly Operations and Monitoring Report, Fourth Quarter 2008, Modesto Groundwater Superfund Site*. March.

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URS Group, Inc. (URS), 2010a. *Groundwater Treatment System and Soil Vapor Extraction System Operation and Maintenance Manual, Modesto Groundwater Superfund Site.* Final. March.

URS, 2010b. *Sampling and Analysis Plan, Modesto Groundwater Superfund Site.* March.

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Tables

Table 4-1. Vertical Gradients, First Quarter 2010

Well Number	Monitoring Zone	Groundwater Elevation (feet msl)	Vertical Gradient
MW-4A	A	45.74	0.0102
MW-4B	B	46.41	
MW-8A	A	46.05	0.0092
MW-9B	B	46.73	
MW-10A	A	45.80	0.0048
MW-10B	B	46.20	
MW-16A	A	45.34	0.0000
MW-16B	B	45.34	
MW-17A	A	45.28	0.0039
MW-17B	B	45.48	
MW-19A	A	45.79	-0.0056
MW-19B	B	45.53	
MW-20A	A	45.42	0.0005
MW-20B	B	45.46	
MW-4B	B	46.41	0.0204
MW-4C	C	48.10	
MW-10B	B	46.20	0.0214
MW-10C	C	47.63	
MW-16B	B	45.34	0.0081
MW-16C	C	46.13	
MW-17B	B	45.48	0.0131
MW-17C	C	46.70	
MW-20B	B	45.46	0.0204
MW-20C	C	46.95	

msl = mean sea level
positive gradient = upward
negative gradient = downward

Table 4-2. GWT System Sample Results: January – March 2010

Sample Identification	Date	PCE (µg/L)
EW-1-012710 (Influent)	1/27/2010	**160**
EW-1-022510 (Influent)	2/25/2010	**160**
EW-1-0302 (Influent)	3/11/2010	**180**
EFF-012710 (Effluent)	1/27/2010	<0.5
EFF-022510 (Effluent)	2/25/2010	<0.5
EFF-0302 (Effluent)	3/11/2010	<0.5

Note: Values in **bold** type are greater than the PCE MCL of 5.0 µg/L.

GWT = groundwater treatment
MCL = maximum contaminant level
PCE = tetrachloroethene
µg/L = micrograms per liter
< = less than

Table 4-3. SVE System Sample Results: January – March 2010

Sample Identification	Date	PCE (ppbv)
SVE PrGAC-012710 (Influent)	1/27/2010	700
SVE PreGAC-022510 (Influent)	2/25/2010	470
SVE PreGAC-0302 (Influent)	3/11/2010	12
SVE Stack-012710 (Effluent)	1/27/2010	6
SVE Stack-022510 (Effluent)	2/25/2010	38
SVE Stack-0302 (Effluent)	3/11/2010	51

GAC = granular activated carbon
PCE = tetrachloroethene
ppbv = parts per billion by volume
SVE = soil vapor extraction

Figures

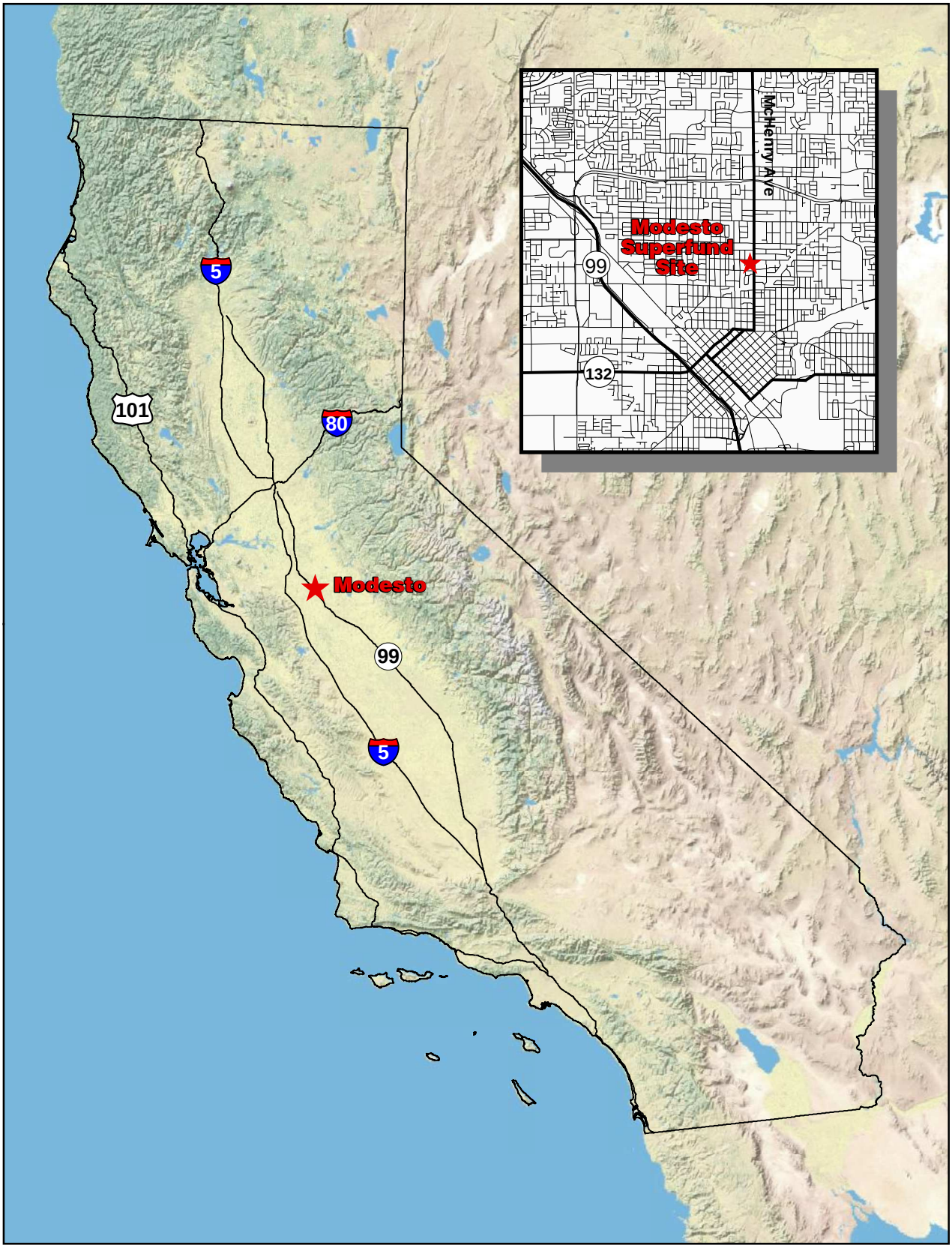

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Figure 1-1. Site Location, Modesto Groundwater Superfund Site, Modesto, California

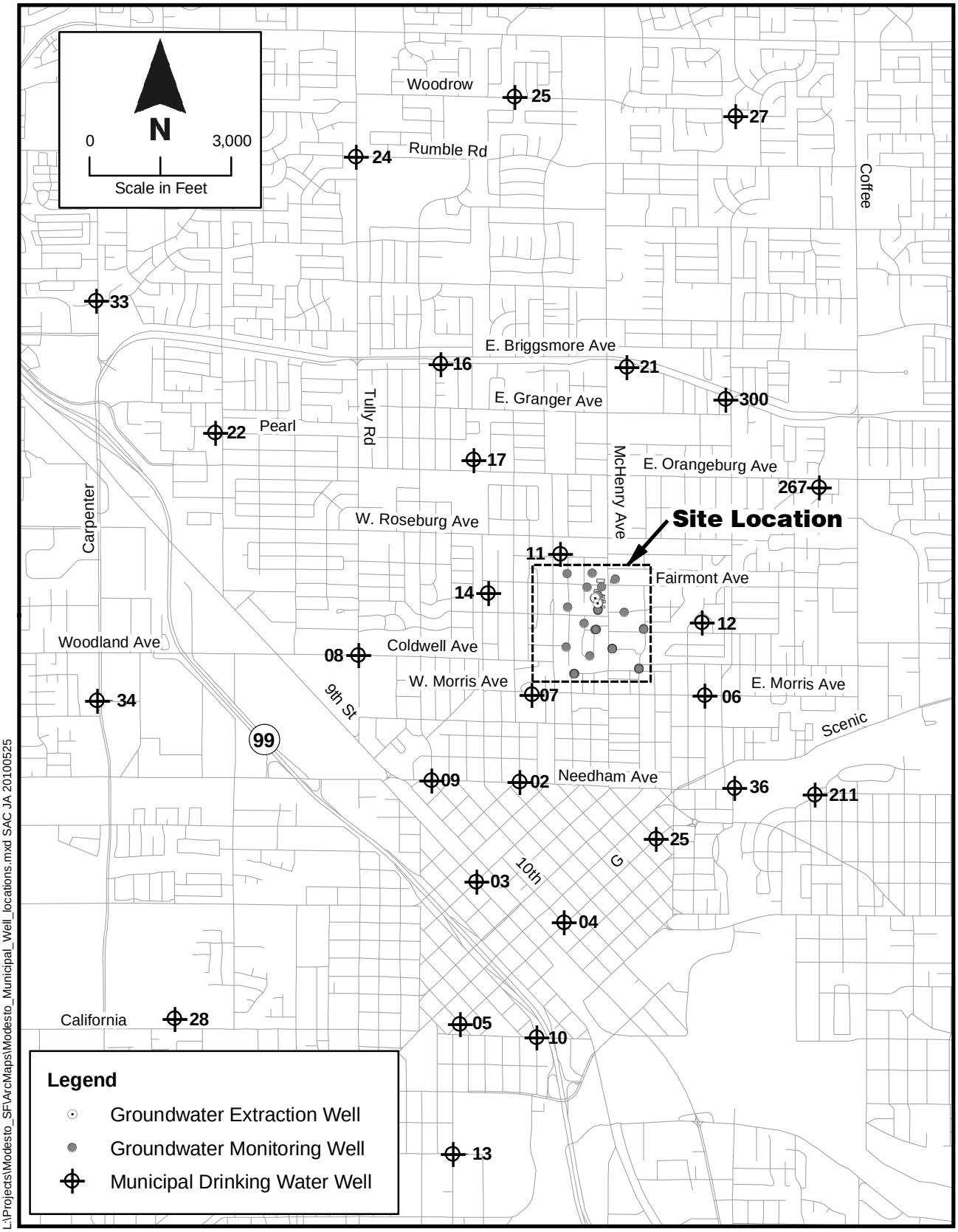

Figure 1-2. Municipal Well Locations, Modesto Groundwater Superfund Site

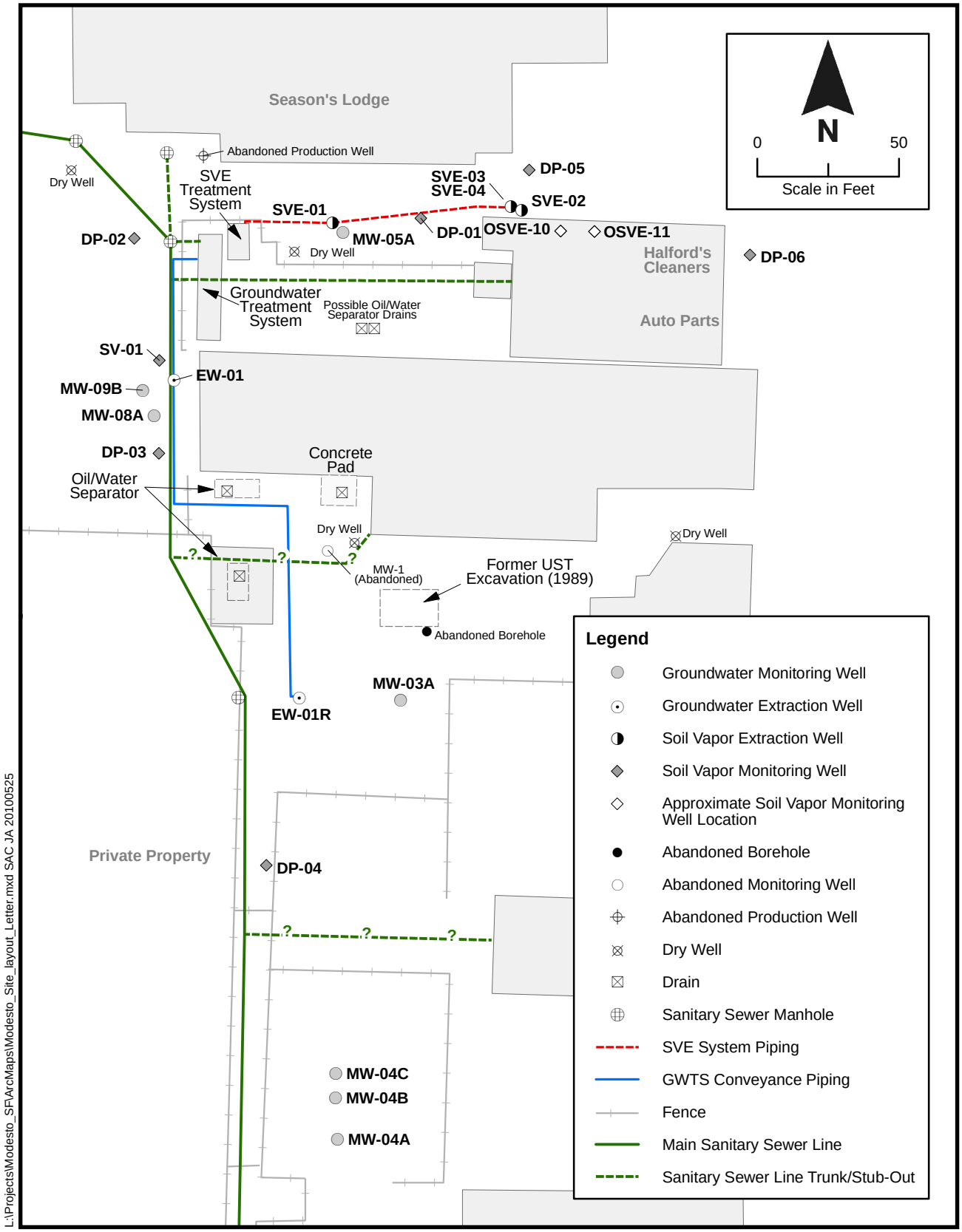

Figure 2-1. Site Layout
Modesto Groundwater Superfund Site

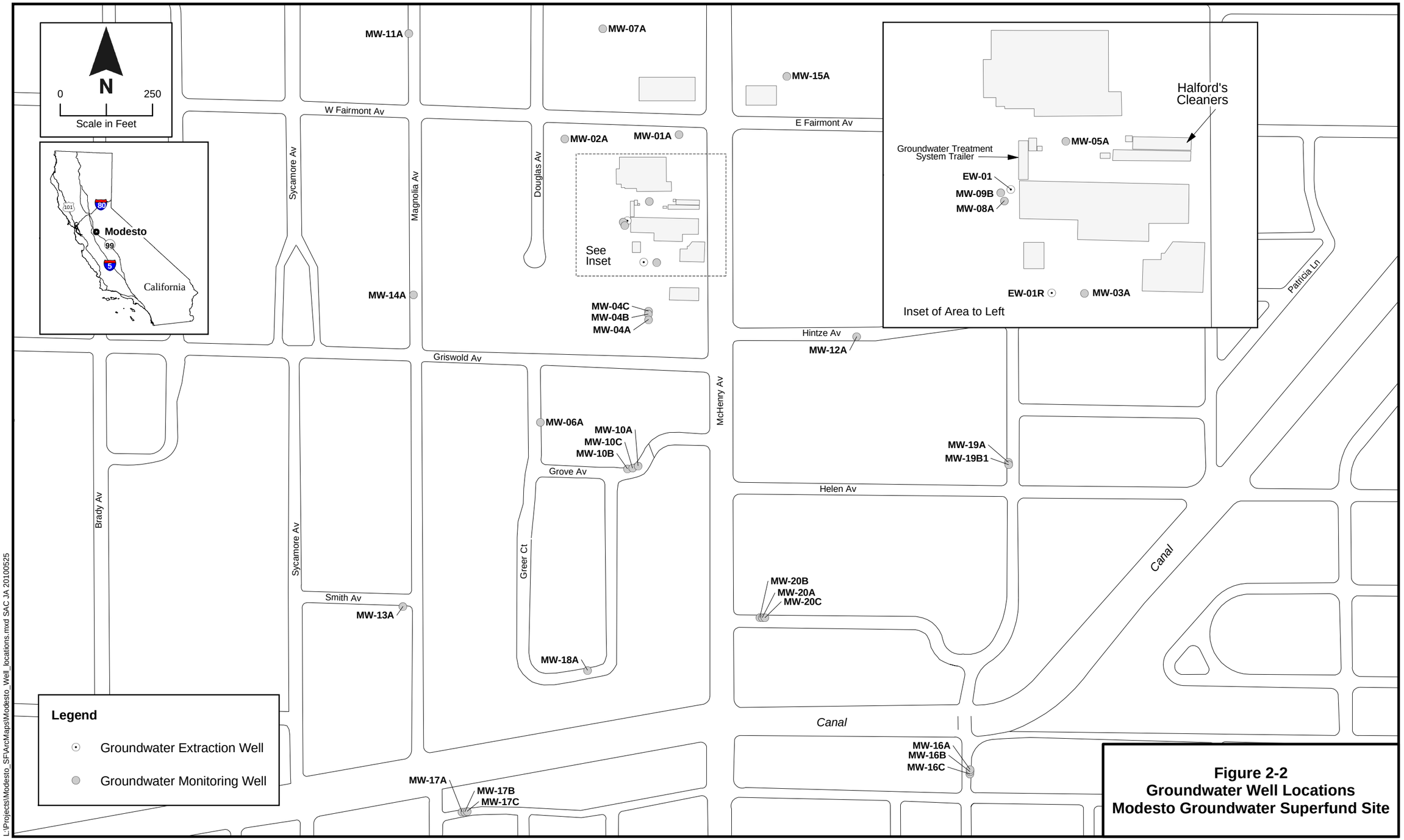

Figure 2-2
Groundwater Well Locations
Modesto Groundwater Superfund Site

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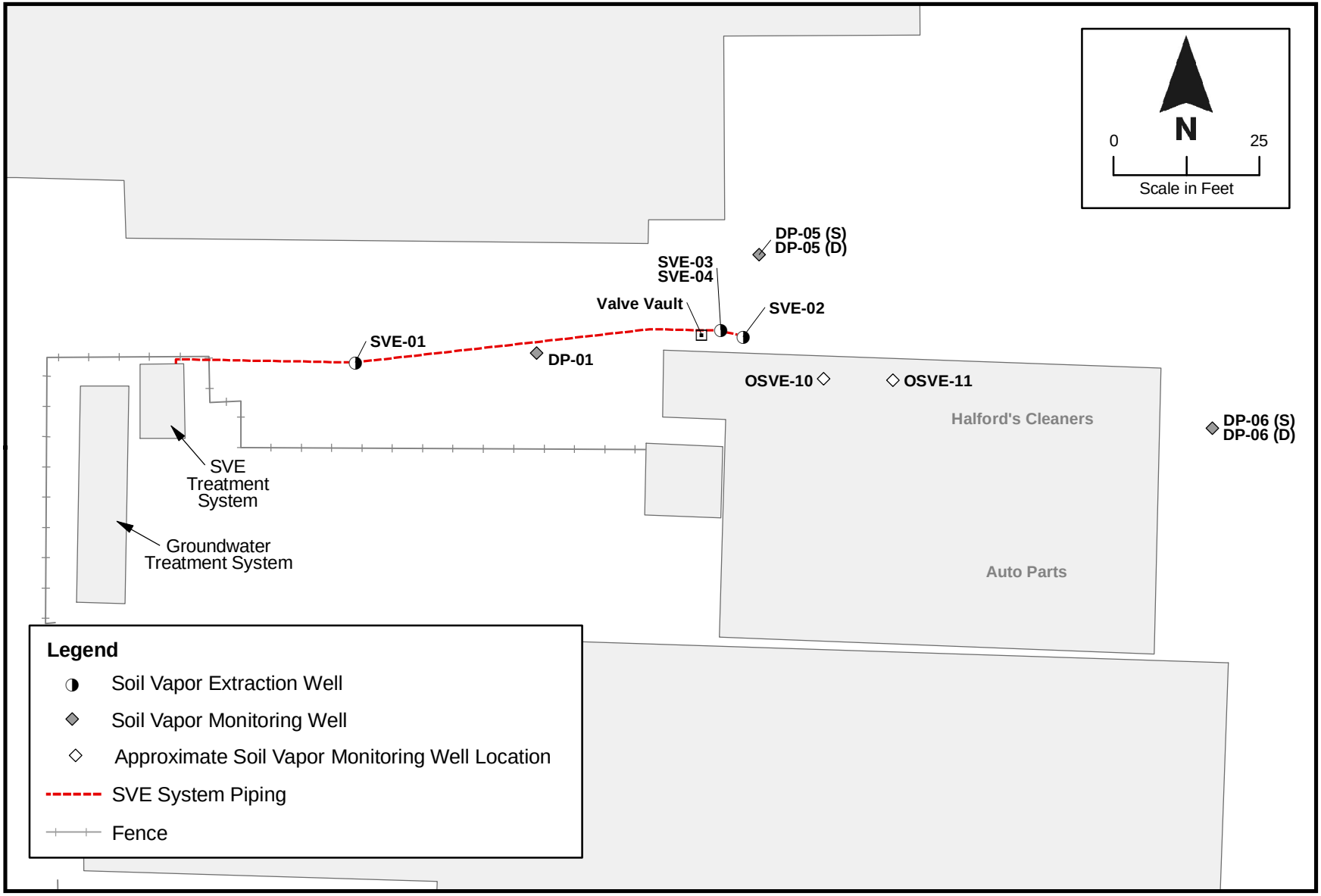
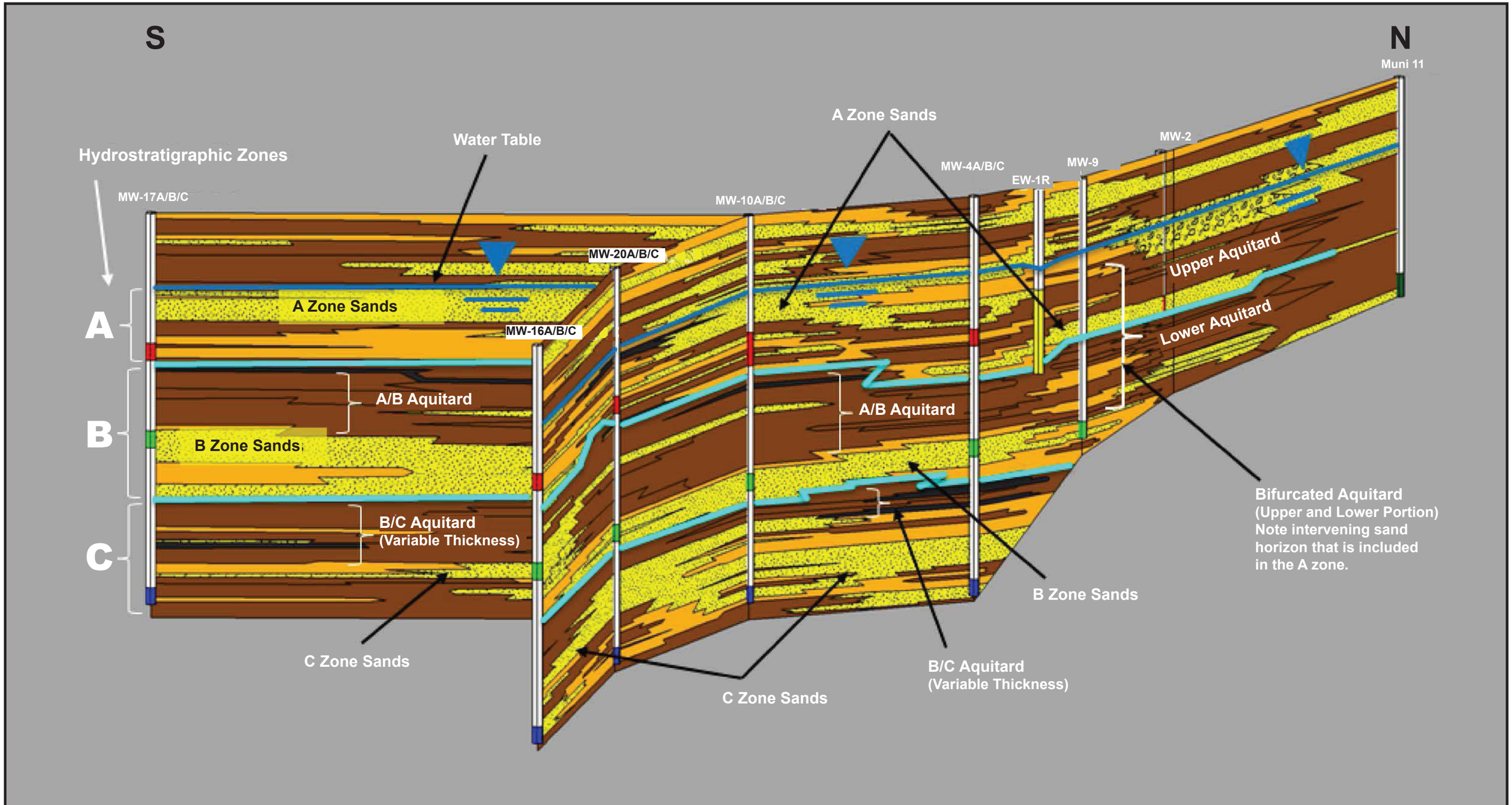
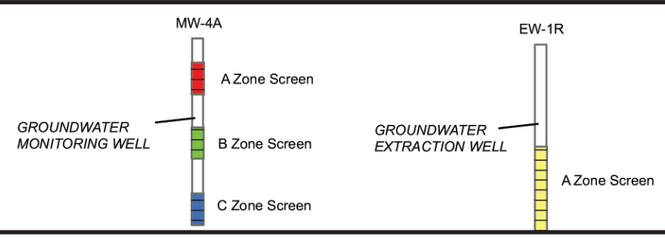


Figure 2-3. Soil Vapor Well Locations, Halford's Cleaners Area, Modesto Groundwater Superfund Site



LEGEND:

- SAND
- SILTY SAND
- SILT
- CLAY
- WATER TABLE SURFACE (A Zone)



URS

Adapted from:
MWH source file

Figure 4-1
Stratigraphic Conceptual Model
Modesto Groundwater Superfund Site

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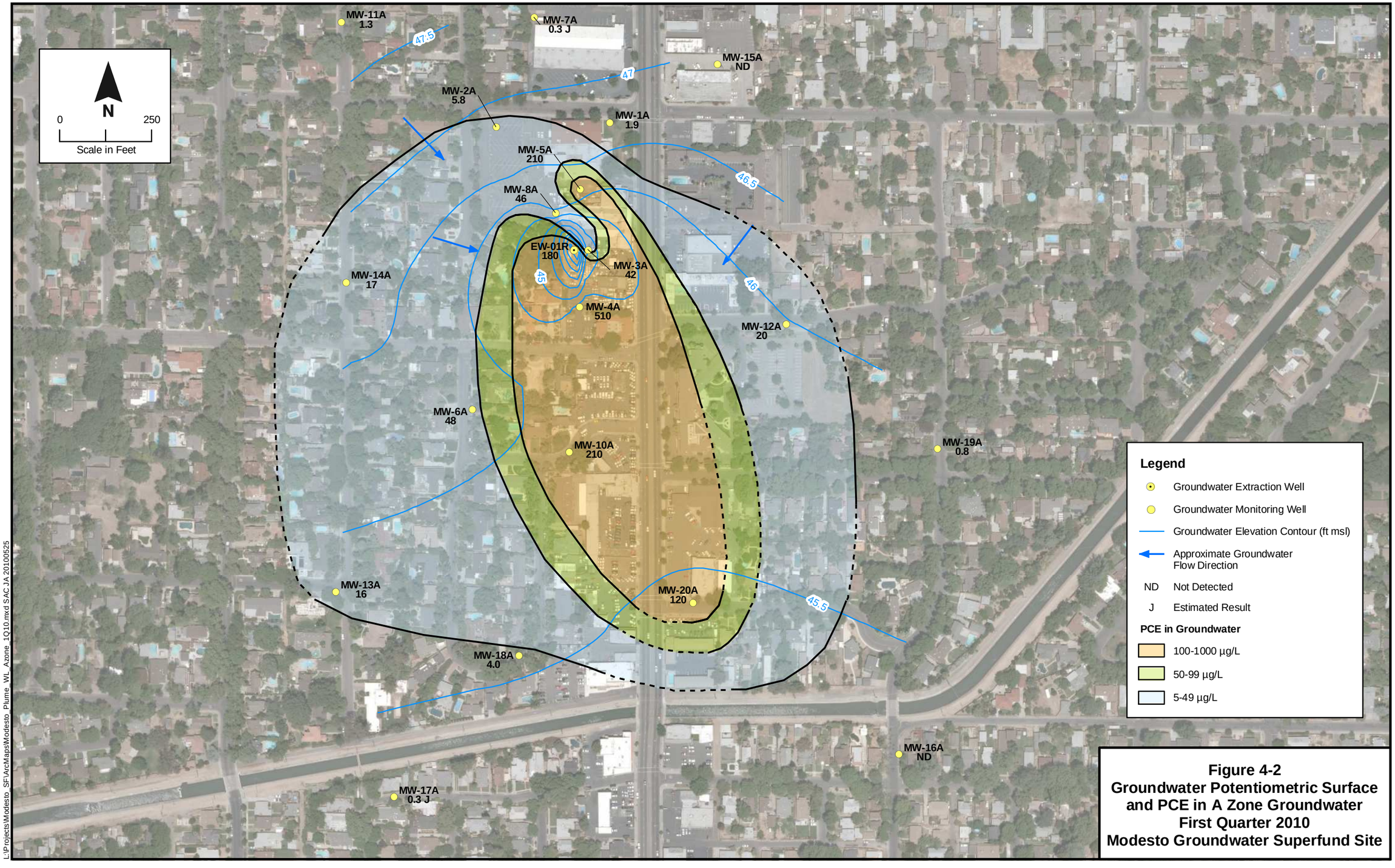


Figure 4-2
Groundwater Potentiometric Surface and PCE in A Zone Groundwater
First Quarter 2010
Modesto Groundwater Superfund Site

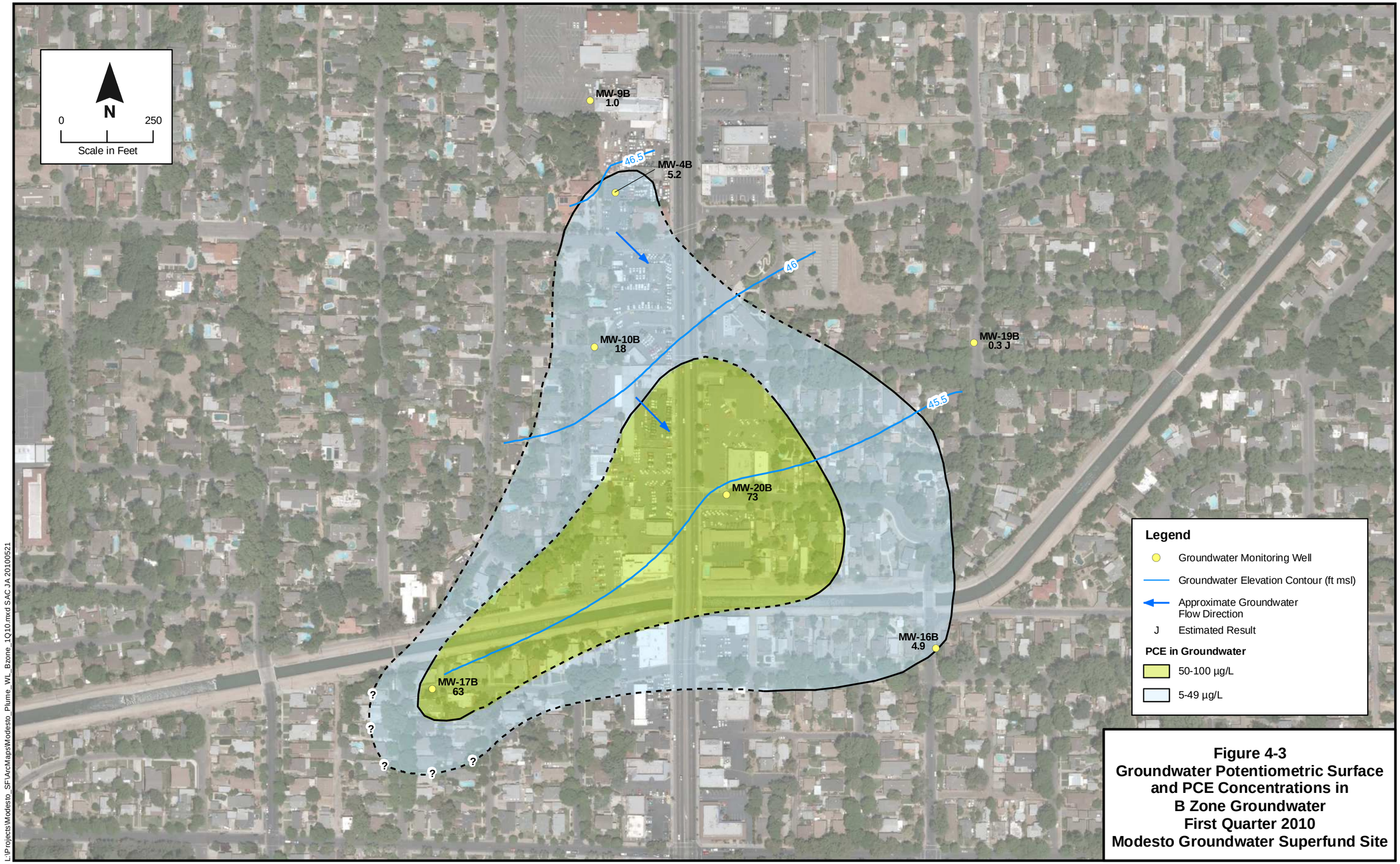


Figure 4-3
Groundwater Potentiometric Surface and PCE Concentrations in B Zone Groundwater
First Quarter 2010
Modesto Groundwater Superfund Site

L:\Projects\Modesto_SF\ArcMaps\Modesto_Plume_WL_Bzone_1Q10.mxd SACJA 20100521

Figure 4-4
Groundwater Potentiometric Surface and PCE Concentrations in C Zone Groundwater
First Quarter 2010
Modesto Groundwater Superfund Site

L:\Projects\Modesto_SF\ArcMaps\Modesto_WL_Czone_1Q10.mxd SAC JA 20100525

L:\Projects\Modesto_SF\ArcMaps\Modesto_Soil_Vapor_results_1Q09_1Q10.mxd SAC JA 20100525

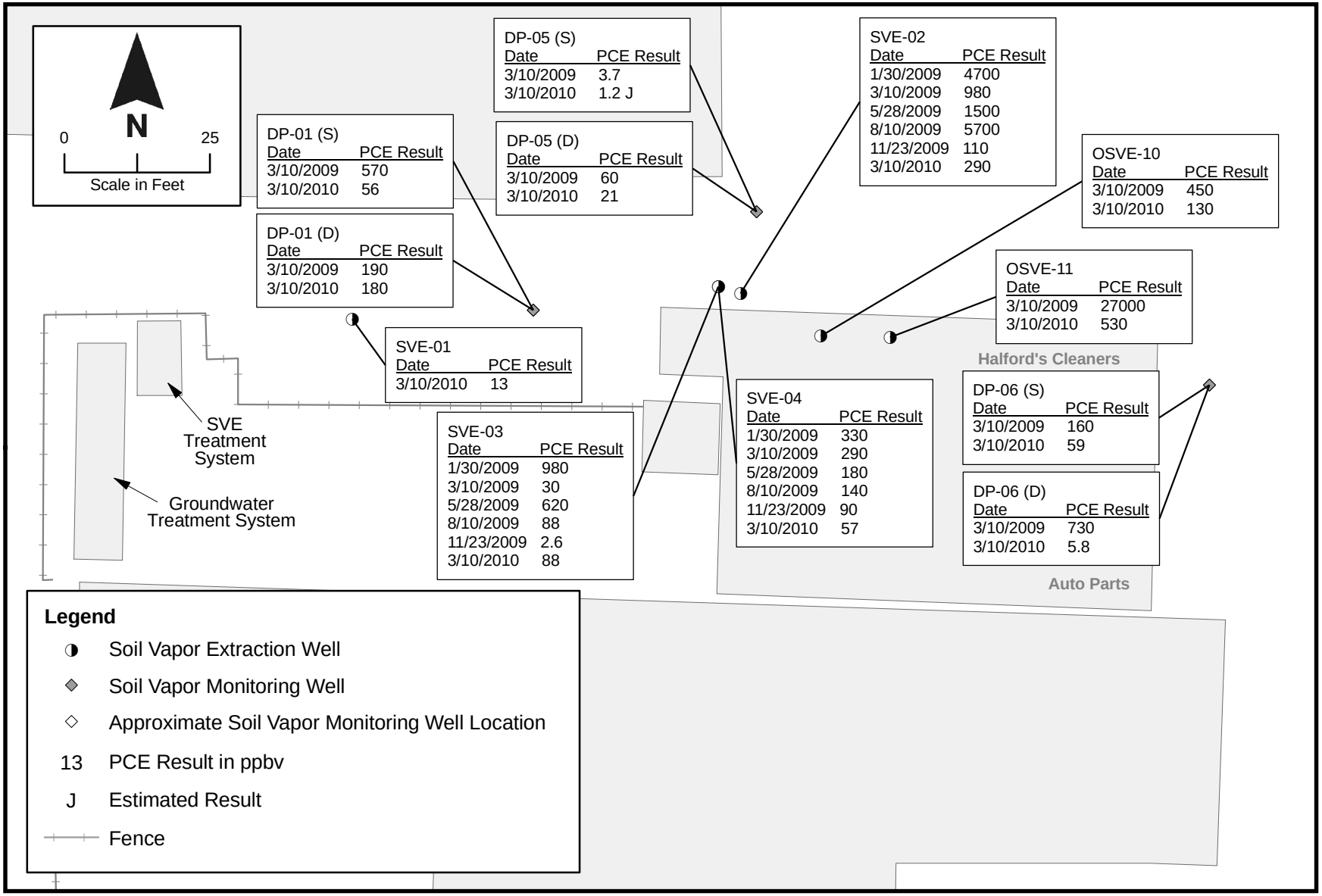


Figure 4-5. Soil Vapor Analytical Results, First Quarter 2009 through First Quarter 2010 Modesto Groundwater Superfund Site

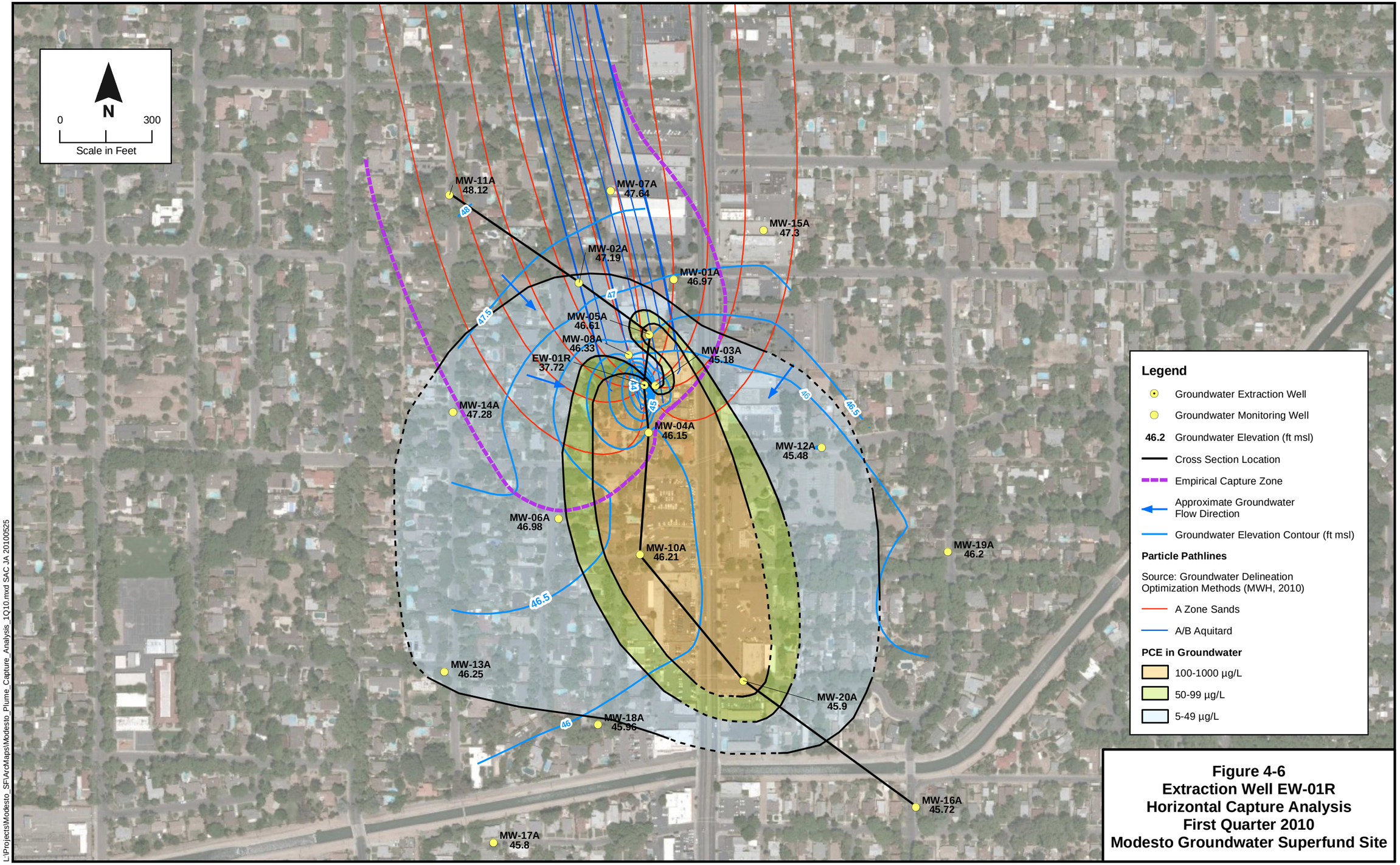
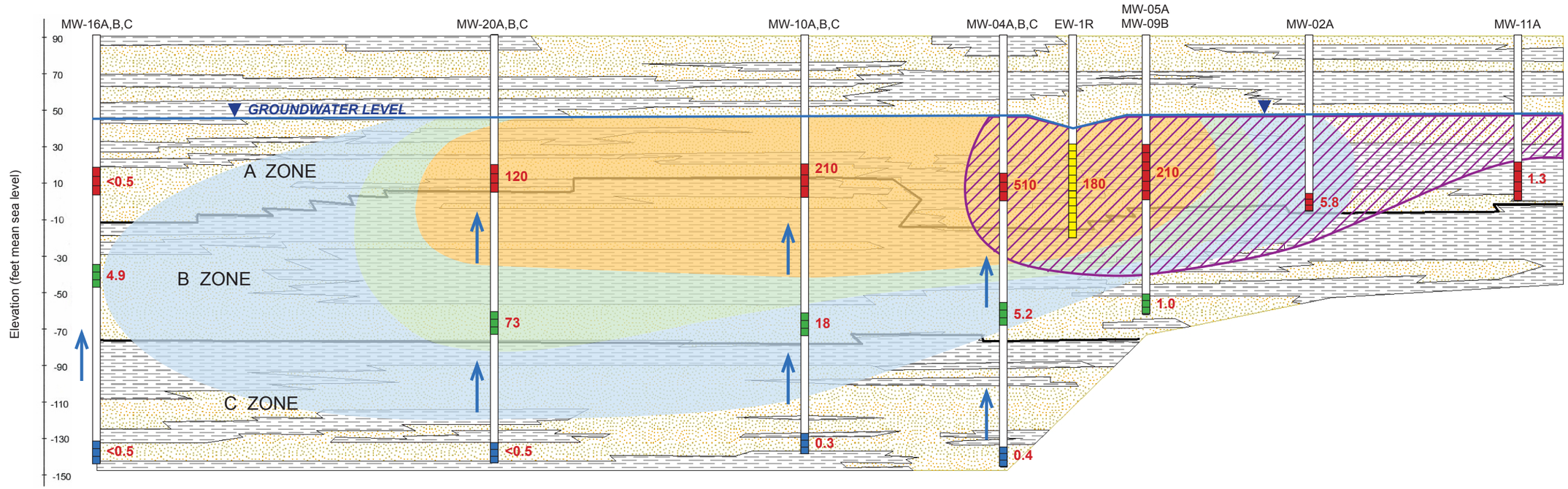


Figure 4-6
Extraction Well EW-01R
Horizontal Capture Analysis
First Quarter 2010
Modesto Groundwater Superfund Site

L:\Projects\Modesto_SF\ArcMaps\Modesto_Plume_Capture_Analysis_1Q10.mxd SAC JA 20100525



Legend

EW-1R Interpreted Capture Zone

Water Table Surface

PCE Plume

≥1000 µg/L

100-999 µg/L

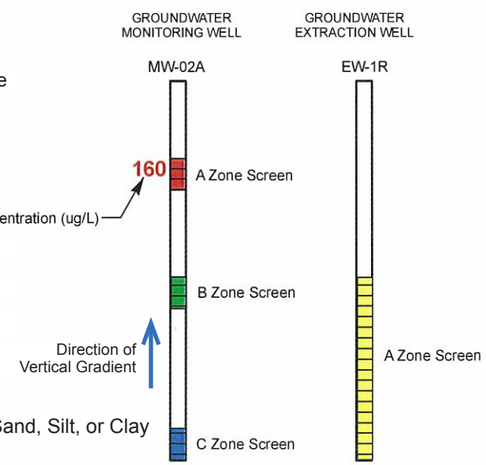
50-99 µg/L

5.0-49 µg/L

µ/L Micrograms per Liter

Sand and Silty Sand

Cemented Very Fine Grained Sand, Silt, or Clay



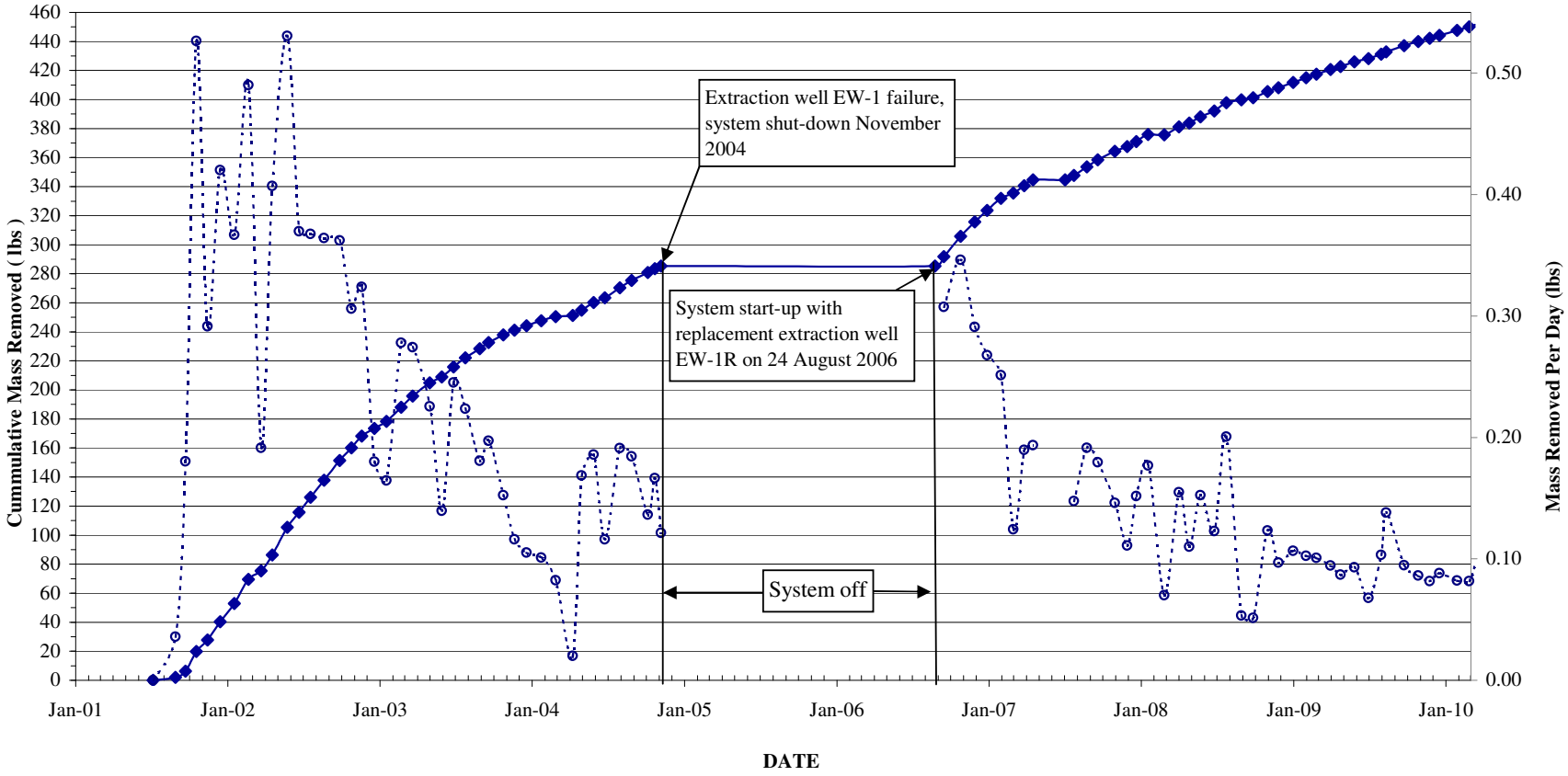
0 200
SCALE IN FEET

URS

Adapted from:
MWH source file

Figure 4-7
Extraction Well EW-1R
Estimated Capture Zone
First Quarter 2010
Modesto Groundwater Superfund Site

H:\Graphics\Modesto GW\04-10-Modesto-GW-1Q10-Capture-Zone-Xsec.indd - VMG 05/25/10 SAC



Notes:

The graph displays the cumulative pounds of PCE removed and the rate of PCE removal in pounds per day from groundwater extraction since startup of the groundwater treatment system in June 2001.

FIGURE 4-8
CUMULATIVE PCE MASS REMOVED BY GROUNDWATER TREATMENT SYSTEM
MODESTO GROUNDWATER SUPERFUND SITE

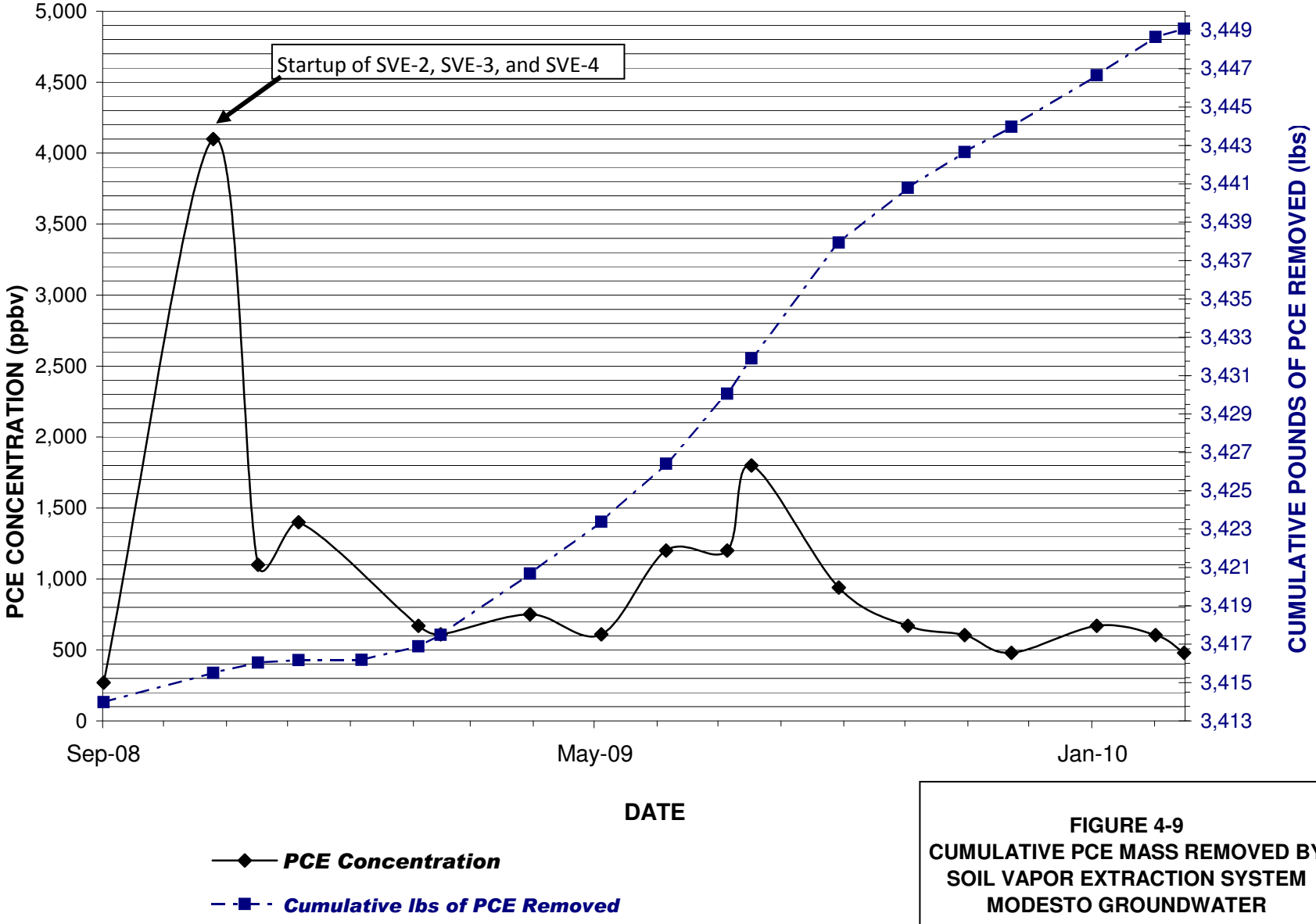


FIGURE 4-9
CUMULATIVE PCE MASS REMOVED BY SOIL VAPOR EXTRACTION SYSTEM MODESTO GROUNDWATER SUPERFUND SITE

Appendices

(provided on CD)