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Subject: Submittal of the Interim Measures Progress Report for Soil-Vapor Extraction of Volatile Organic Compounds from Material Disposal Area L, Technical Area 54

Dear Mr. Kieling:

Enclosed please find two hard copies with electronic files of the Interim Measures Progress Report for Soil-Vapor Extraction of Volatile Organic Compounds from Material Disposal Area L, Technical Area 54. This report summarizes the results from the first 6 months of soil vapor extraction operation at two vapor-extraction wells at Material Disposal Area L, Technical Area 54, from January 9, 2015, to July 31, 2015.

If you have any questions, please contact Kent Rich at (505) 665-4272 (krich@lanl.gov) or Ramoncita Massey at (505) 665-7771 (ramoncita.massey@em.doe.gov).

Sincerely,

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Sincerely,

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Enclosure: Two hard copies with electronic files – Interim Measures Progress Report for Soil-Vapor Extraction of Volatile Organic Compounds from Material Disposal Area L, Technical Area 54 (EP2015-0164)

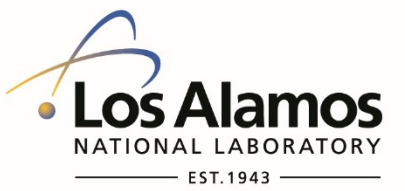
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Interim Measures Progress Report for Soil-Vapor Extraction of Volatile Organic Compounds from Material Disposal Area L, Technical Area 54



Prepared by the Environmental Programs Directorate

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EP2015-0164

Interim Measures Progress Report for Soil-Vapor Extraction of Volatile Organic Compounds from Material Disposal Area L, Technical Area 54

September 2015

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EXECUTIVE SUMMARY

This interim measures progress report summarizes the results from the first 6 mo of soil-vapor extraction (SVE) operation at two vapor-extraction wells at Material Disposal Area (MDA) L, Technical Area 54. The SVE-West system began operation on January 9, 2015, and the SVE-East system began operation on January 26, 2015. During the first 6 mo of operation, the two SVE units removed 424 kg (932 lb) of total organic vapor mass. The mass was primarily removed from within an approximately 150-ft radius surrounding the extraction boreholes.

Baseline pore-gas monitoring samples were collected from 185 pore-gas sampling ports in 28 boreholes within and surrounding MDA L during the fall of 2014. Quarterly pore-gas monitoring samples were collected in April 2015 from a subset of 79 ports in 14 boreholes located within a 150-ft radius from the SVE units. Pore-gas sampling results confirm SVE operation has reduced the concentrations at the majority of sampling ports to below their baseline values. Data collected during the interim measure will be analyzed further as part of ongoing efforts to support the selection and design of a final remedy for MDA L.

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1.0 INTRODUCTION

This interim measures (IM) progress report summarizes results from the first 6 mo of soil-vapor extraction (SVE) operation at two extraction wells at Material Disposal Area (MDA) L, Technical Area 54 (TA-54), within the boundaries of Los Alamos National Laboratory (LANL). These activities were conducted in accordance with the "Interim Measures Work Plan for Soil-Vapor Extraction of Volatile Organic Compounds from Material Disposal Area L, Technical Area 54, Revision 1 (hereafter, the IMWP) (LANL 2013, 241096). The IMWP was submitted to the New Mexico Environment Department (NMED) on September 15, 2014, in response to requirements in NMED's "Approval with Modifications, Interim Measures Work Plan for Soil-Vapor Extraction of Volatile Organic Compounds from Material Disposal, Area L," dated July 17, 2014 (NMED 2013, 522947). The data in this progress report were collected from August 2014 to the end of July 2015.

Remediation of the vapor plume by SVE is included as part of the recommended final remedy in the "Corrective Measures Evaluation Report for Material Disposal Area L, Solid Waste Management Unit 54-006, at Technical Area 54, Revision 2" (hereafter, the CME report) to meet the remedial action objective of preventing groundwater from being impacted above a regulatory standard by the transport of volatile organic compounds (VOCs) to groundwater through soil vapor (LANL 2011, 205756). The depth to regional groundwater beneath MDA L is on the order of 285 m (935 ft), whereas the vapor plume is predominantly within the Bandelier Tuff in the upper 90 m (300 ft) of the surface. The tuff units beneath the surface at MDA L are underlain by a thick (nearly 150 m [500 ft]) sequence of Cerros del Rio basalts. There is uncertainty regarding the long-term transport of vapors downward through the basalt toward the water table. Therefore, it is desirable to contain the plume above the basalt. The SVE interim measure (IM) is a proactive step to remove VOC mass, to decrease maximum VOC concentrations within the plume, to reduce the current extent of the vapor plume so it remains well contained within the upper tuff units, and to gather design information for a potential final SVE remedy.

The recommendations made in NMED's approval with modifications letter have been implemented, including collection of SUMMA data for plume and effluent analysis, inclusion of all accessible sampling ports for the baseline monitoring, inclusion of boreholes within 150 ft radius of the SVE units for quarterly monitoring, collection of differential pressure data from all subsurface sample ports, and sampling of borehole 54-24399 in both quarterly and baseline monitoring.

1.1 Background

MDA L operated from the early 1960s to 1986 as the designated disposal area for nonradiological liquid chemical wastes, including containerized and uncontainerized liquid wastes; bulk quantities of treated aqueous waste; batch-treated salt solutions and electroplating wastes, including precipitated heavy metals; and small-batch quantities of treated lithium hydride. Waste was disposed of in 1 pit, 3 impoundments, and 34 shafts.

Disposal Shafts 1 through 34 were dry-drilled directly into the Tshirege Member of the Bandelier Tuff. The shafts range from 3 ft to 8 ft in diameter and from 15 ft to 65 ft in depth. The 34 disposal shafts were used to dispose of containerized and uncontainerized liquid chemical wastes and precipitated solids from the treatment of aqueous waste. Before 1982, containerized liquids were disposed of without the addition of absorbents. Small containers were typically dropped into a shaft. Larger drums were lowered by crane and arranged in layers of one drum in a 3- or 4-ft-diameter shaft, 4 to 5 drums in a 6-ft-diameter shaft, or 6 drums in an 8-ft-diameter shaft. The space around the drums was filled with crushed tuff, and a 6-in. layer of crushed tuff was placed between each layer of drums. Uncontainerized liquid wastes were also disposed of in the shafts. Between 1982 and 1985, only containerized wastes (including organic and

inorganic liquids, precipitated heavy metals, and stabilized heavy metals) were disposed of in the shafts. These shafts are the primary source for the subsurface VOC vapor plume that is present beneath MDA L (LANL 2011, 205756).

Soil-vapor monitoring boreholes located within and around MDA L have been used to characterize the nature and extent of the subsurface vapor plume at the site since 1986. Figure 1.1-1 shows the pore-gas monitoring boreholes at MDA L. Concentrations in the subsurface VOC plume are generally highest within 150 ft below ground surface (bgs) and decrease significantly with depth to the top of the Cerros del Rio basalt. Concentrations measured in the basalt are quite low, with values less than 1 ppm.

The CME report used a screening approach, called Tier II screening, to identify the VOCs present at high enough concentrations within the vapor plume to potentially impact groundwater above a regulatory standard if they migrated to groundwater (LANL 2011, 205756). The analysis found vapor concentrations for 1,1,1-trichloroethane (1,1,1-TCA); trichloroethene (TCE); tetrachloroethene (PCE); methylene chloride; 1,2-dichloropropane (1,2-DCP); 1,1-dichloroethene (1,1-DCE); 1,2-dichloroethane (1,2-DCA); and 1,4-dioxane present within the tuff units at concentrations that exceed their Tier II screening levels (LANL 2011, 205756).

The hydrogeologic framework for the contaminated subsurface at MDA L is based on many years of data collection, including results from a 2006 pilot SVE test at the site (LANL 2006, 094152). The current IM uses the same two wells used during the pilot test, SVE-East and SVE-West (Figure 1.1-1). Data gathered in 2006 and subsequent analysis (Stauffer et al. 2007, 097871; Stauffer et al. 2011, 255584) provided IM estimates of expected total mass removal from the two SVE units.

2.0 OPERATION OF SVE UNITS

2.1 Description of SVE Units

The two SVE systems employed during the first 6 mo of SVE operation each have a main blower unit rated to 129 standard cubic feet per minute (scfm) at vacuum equal to 42.5 kPa (120 in. of water), a knock-out trap for liquid, various in-line flow and pressure-measurement instruments, and an off-gas stack to the atmosphere (Figures 2.1-1 and 2.1-2). The SVE blower systems are 11-ft-long × 3-ft-wide skid-mounted Model 4L SVE Blower Package systems provided by Catalytic Combustion Corp. of Bloomer, WI.

The SVE units pull subsurface gas from the open uncased part of the boreholes, 65 ft to 215 ft bgs. Condensed liquid (water) is removed in the SVE unit knock-out tank, and the effluent gas is filtered with a rough particulate filter to protect the blower from large particulate material that may be present. Untreated effluent gas from each SVE unit is then discharged through a stack located 21 ft above ground surface. Samples representative of the extracted gas are collected from a sample port (SP1) located between the blower and the exhaust stack.

The gas-flow rate is measured at each wellhead using a Dwyer Series PE Orifice Plate Flow Meter (Model PE-H-2) equipped with a Dwyer 0–25 in. of water Magnehelic Differential Pressure Gage. Flow rate is calculated using the measured differential pressure across the orifice plate, line pressure, and temperature using a formula provided by the manufacturer of the flow meter. This calculation is also corrected for a local atmospheric pressure of 80 kPa. Readings from the differential pressure gage, pipeline temperature and pressure are recorded by the operator and used to calculate the instantaneous flow rate per ER-DOP-20242, Soil Vapor Extraction System Setup, Operation, and Monitoring Procedure. During the first 3 wk of operation, each system was monitored 7 d/wk. Following the first 3 wk of operation, each system was inspected and monitored by the operator a minimum of 4 d (Mondays through Thursdays) each week.

2.2 Data Collection Methods and Results

SUMMA canisters were used for both SVE gas effluent and subsurface pore-gas sampling. All SUMMA samples were analyzed by an independent analytical laboratory, Eurofins Air Toxics, Inc., using U.S. Environmental Protection Agency (EPA) Method TO15. Eurofins Air Toxic is a National Environmental Laboratory Accreditation Program–certified laboratory. The data are entered into the Environmental Information Management (EIM) database and undergo a secondary validation. The EIM is the official database for environmental data collected by both LANL and NMED. Table 2.2-1 lists the organic compounds analyzed by EPA Method TO15 from samples collected from the effluent streams of the active SVE units and subsurface pore-gas sampling ports. Analytical results from samples collected during the first 6 mo of SVE operation are presented in Appendix A (on CD).

2.2.1 Effluent Gas from SVE Units

Effluent gas from each SVE system was sampled in accordance with the sampling plan outlined in the IMWP (LANL 2014, 261843). Section 12[2] of ER-DOP-20242 outlines the steps taken to collect the gas sample from sampling port SP1 on each unit (Figure 2.1-1). Samples were collected in SUMMA canisters more frequently early in the operation of the system. As operation of the system continued and the vapor concentrations of VOCs were observed to level out, the sampling frequency decreased. Section 2.3.1 of this report presents the SVE effluent sampling schedule.

2.2.2 Subsurface Pore-Gas Sampling

Subsurface pore-gas sampling was performed in accordance with the current version of Standard Operating Procedure (SOP) EP-ERSS-SOP-5074, Sampling Subsurface Vapor. Per the SOP, the static pressure of the formation at each sampling interval was documented. Baseline samples were collected from 185 pore-gas sampling ports in 28 boreholes. Quarterly samples were taken from a subset of 79 ports in 14 boreholes located within 150-ft radius from the SVE units.

2.3 Data Collection Schedule

2.3.1 Effluent Data from SVE Units

Gas samples were collected in SUMMA canisters from the two SVE systems effluent sample port (SP1) according to the following schedule:

1. Day 1 and Day 2 of operation: Four samples were collected each day.
2. Next 3 wk: One sample was collected each day (LANL closure prevented collection of one sample daily during this period).
3. Next 9 to 11 wk: One sample was collected weekly (generally on Wednesday of each week).
4. Beginning April 15, 2015, for SVE-West and May 6, 2015, for SVE-East: One sample was collected monthly on the first Wednesday of each month.
5. Monthly sampling of the SVE system effluent will continue until the SVE units are shut down for any extended period.

2.3.2 Subsurface Pore-Gas Data

Subsurface pore-gas samples were collected from a round of baseline sampling (referred to as Baseline 2014) in August and September 2014, and two quarters of sampling from boreholes located within a 150-ft radius of the SVE units in April and May 2015 and in July 2015 (designated as Q32015

and Q42015, respectively). Because of time requirements for analytical laboratory turnaround and data validation, only the results of Baseline 2014 and Q32015 sampling are presented in this report. Analytical results are included in Appendix A (on CD).

2.4 Summary of SVE System Operations

The SVE-West system operated from January 9, 2015, to July 30, 2015, at an average flow rate of 99.1 scfm. During this period, the system was operational 98.8% of the available time. The system shut down twice for an extended period: once on January 24, 2015, for about 18 h because of a sitewide power failure and again on February 23, 2015, for about 26 h because of ice buildup in the water knock-out tank. The SVE-West system was also shut down for very short periods for maintenance.

The SVE-East system operated from January 26, 2015, to July 30, 2015, at an average flow rate of 97.2 scfm. During this period, the system was operational 99.3% of the available time. The system shut down once for an extended period of time. On February 23, 2015, the system shut down for about 23 h because of ice buildup in the water knock-out tank. The SVE-East system was also shut down for very short periods for maintenance.

Water has condensed in the knock-out tank of both systems during periods of cold weather. Generally, water vapor in extracted pore gas condenses and is captured in the knock-out tank when the ambient air temperature drops below freezing for an extended period of time. More water was generated in the SVE-West unit probably because it is shaded in winter and never warms from exposure to the sun. Approximately 150 gal. of condensed water was generated through July 2015 from the operation of both SVE units. The condensed water is currently in the process of being characterized for disposal.

3.0 SUMMARY OF SUBSURFACE PORE-GAS BASELINE RESULTS

Baseline pore-gas samples were collected in August and September 2014. The baseline measurements entailed collecting subsurface pore-gas concentration data from 185 individual gas sampling ports in 28 boreholes within and surrounding MDA L. These data were used to create an estimate of total plume mass of two primary constituents, TCE and 1,1,1-TCA. These constituents were selected because they have historically constituted more than 60% of the estimated plume mass (Stauffer et al. 2005, 090537; Stauffer et al. 2007, 097871; LANL 2011, 205756; Stauffer et al. 2011, 255584). The mass of 1,1,1-TCA and TCE was calculated using three-dimensional data-interpolation techniques described more fully by Weston Solutions, Inc. (Weston 2015, 600886). Assumptions in this technique include fixed subsurface water saturation within each geological unit, fixed Henry's Law partitioning into subsurface pore water, fixed sorption parameters, and a small component (0.05%) of organic carbon within the subsurface. Given these assumptions, the baseline 1,1,1-TCA plume mass in September 2014 was estimated to be 740 kg (1628 lb), while the TCE plume mass was estimated to be 343 kg (755 lb). The baseline plume is discussed further in section 4, which compares pore-gas data collected after several months of SVE operations.

4.0 SUMMARY OF SVE RESULTS

4.1 Effluent Mass Removal

From January 9, 2015, to the end of July 2015, the combined VOC mass removal from the two SVE units is calculated to be 932 lb (424 kg). Cumulative mass removal versus time for both SVE units is shown in Figure 4.1-1, which also presents the cumulative volume of soil-gas pumped from the subsurface by both SVE units. The slopes of both the mass removal and volume pumped curves change when the SVE-East unit became active on January 26, 2015.

Figure 4.1-2 shows the rate of mass removal for the combined extraction from both SVE units in pounds per week. The activation of SVE-East on January 26, 2015, resulted in an increase in mass removal from 35 lb/wk to nearly 60 lb/wk. The mass-removal rate then decreases over time to a nearly steady 25 lb/wk. By July 2015, the rate decreased to about 22 lb/wk. The long tail in the mass removal curve shows that the SVE systems continue to be effective after 6 mo of operation.

Table 4.1-1 lists the mass removed for each detected organic compound during SVE operations. Of the total 932 lb removed, 1,1,1-TCA was the highest constituent at over 44% (419 lb); TCE comprised nearly 22% of the mass extracted (201 lb); Freon-113 (1,1,2-trichloro-1,2,2-trifluoroethane) was third at 9% (88 lb); and PCE was the fourth most prevalent component in the effluent at 8.7% (81 lb). Other significant mass removals include 1,2-DCA (36 lb); 1,1-DCE (25 lb); 1,2-DCP (21 lb); and chloroform (18 lb). Together these constituents comprised nearly 96% of the total extracted mass.

4.2 April 2015 Subsurface Plume Changes Relative to Baseline 2014

Samples for Q32015 were collected from April 20 to May 11, 2015, from 79 sampling ports in 14 wells that lie within approximately 150-ft (45.7-m) radius of each of the SVE units. Plate 1 presents color bars for the main constituents at each of the 2015 quarterly sampling locations compared with Baseline 2014 data at a range of depths. The sum of each color segment is the total parts per million by volume of a given sample. All the concentration plots have the same maximum scale (600 ppmv), allowing for comparison of relative plume concentrations. On the east side of the site, boreholes 54-02002, 54-24243, and 54-24241 show large decreases in measured total organics as a result of SVE operations. On the west side, boreholes 54-24240, 54-27641, and 54-02001 show the strongest impact from SVE operations.

Figure 4.2-1 plots concentrations for seven analytes from each of 79 ports in 14 boreholes around SVE-East and SVE-West that were sampled for both the Baseline 2014 and Q32015 (553 points in total). Data in this plot are for 1,1,1-TCA; TCE; PCE; 1,2-DCA; 1,1-DCE; 1,2-DCP; and methylene chloride. Baseline 2014 concentrations are plotted on the horizontal axis, while Q32015 concentrations are plotted on the vertical axis. Figure 4.2-1 shows the decreasing trend in concentrations that occurred during the first 3 mo of SVE operation. If the SVE system had no impact on subsurface concentrations, the data would plot on or close to the 1:1 line shown in red in the figure. However, most of the points fall below the 1:1 line, indicating the SVE system has reduced the concentrations at the majority of sample ports below their baseline values. Points are colored by borehole, indicating which boreholes are the most impacted.

4.2.1 Weston Data Interpolations

Figures 4.2-2 and 4.2-3 show 1,1,1-TCA plume images generated by data interpolation for the Baseline 2014 and Q32105 data, respectively (from Weston 2015, 600887). Data are shown with dots while the interpolation is shown on a contoured color scale with both color contour lines and contour shading. The contour intervals are based on multiples of Tier I screening values used in the CME report (LANL 2011, 205756). Tier I screening uses only Henry's Law partitioning to determine if a given vapor concentration would exceed groundwater standards, assuming the vapor is in contact with groundwater. The post-SVE image (Figure 4.2-3) shows a decrease in both the spatial extent of most individual concentration contours and the overall magnitude of the 1,1,1-TCA plume.

Figures 4.2-4 and 4.2-5 show the same kind of information for TCE (from Weston 2015, 600887). Again, the extent of a given contour is reduced, and maximum concentration contours are also reduced. For example, the highest concentration of TCE in Figure 4.2-4 on the west side of the site is well into the 250 times (red) color shading, while in Q32015 (Figure 4.2-5) the maximum concentration contour shading is reduced to 100 times (orange).

Using the data interpolation techniques, a comparison of the Q3FY15 data and corresponding models and mass estimates to those of the Baseline 2014 suggests substantial (~30%) SVE-induced mass reductions in both the 1,1,1-TCA and TCE plumes.

4.2.2 Effectiveness of SVE at Selected Boreholes

In Figures 4.2-6 through 4.2-9, data from a subset of nine boreholes are presented showing concentration versus depth for 1,1,1-TCA, TCE, and PCE compared with Baseline 2014 data. These figures are plotted with concentration on log scale to present a larger range in variation. In all of the depth-dependent plots, dashed lines show the Baseline 2014 data while solid lines are used for Q32015 data.

SVE-West

Figure 4.2-6 shows data from boreholes 54-27641 and 54-24240, both within a 30-ft radius of SVE-West, and both boreholes show similar concentration reductions within 150 ft bgs. Mass removal appears to be especially effective in the top 50 ft bgs, with drops of close to 2 orders of magnitude at this depth range. Borehole 54-27641 shows smaller concentration reductions in the 125- to 260-ft range and an increase in concentration at 340-ft depth. Borehole 54-02001, shown in Figure 4.2-7, is located 57 radial feet from SVE-West and exhibits a similar pattern of concentration reduction in the upper 75 ft bgs, while concentration reductions are accentuated at 100 ft and 175 ft bgs. The large drop at 100 ft could be coincident with the Qbt 1 v-u/Qbt 1 v-c geologic contact. However, the drop at 175 ft bgs occurs within the Qbt 1g geologic unit and could be impacted by fracture flow. Figure 4.2-8 shows concentration reductions for boreholes 54-02021 and 54-02022, both located more than 150 ft from SVE-West. These boreholes both show concentration decreases in the upper 50 ft bgs, while 54-02022 shows no impact of SVE below this depth. However, borehole 54-02021 shows a broad region of likely SVE impact between 100 ft and 150 ft bgs. This depth range includes two geologic contacts where permeability may be increased (Qbt 1 v-u/Qbt 1 v-c and Qbt 1 v-c/Qbt 1g). Figure 4.2-10 shows measured air permeability relative to the approximate geologic units mapped at MDA L. Of note are the changes in permeabilities at the geologic contacts between units Qbt 1g and Qbt 1v and between subunits Qbt 1v-c and 1v-u.

SVE-East

Figure 4.2-9 shows data for boreholes 54-24243 and 54-24241, located 54 ft and 83 ft radially, respectively, from SVE-East. Both show strong impacts from SVE, with concentration decreases between 3 times to 100 times in many ports. However, borehole 54-24243 shows the strongest impacts nearer to the surface, while 54-24241 shows the strongest impacts between 100 ft to 200 ft bgs. One explanation for these differences is that borehole 54-24243 is in an area with no asphalt where infiltration of atmospheric air through the surface can occur, while 54-24241 is near the center of the paved portion of MDA L. Boreholes 54-02002 and 54-27642 are both located about 130 radial feet from SVE-East but show differing concentration reductions (Figure 4.2-11). Borehole 54-27642 is located near the edge of the paved portion of the site and shows appreciable reductions only in the upper 75 ft bgs, with little impact observed at depth. However, 54-02002 shows impact to 125 ft bgs with stronger reductions in concentration at 140 ft and 180 ft bgs. The 140-ft-bgs horizon may exhibit the impacts of the Qbt 1 v-c/Qbt 1g geologic contact, while the 180 ft bgs level is likely well within the Qbt 1g. Both 54-02001 and 54-02002 show strong responses at 180 ft bgs.

4.3 Differential Pressure Measurements

Subsurface differential pressure measurements were made at pore-gas sampling ports in boreholes sampled during SVE operations. Measurements were made during the baseline sampling in August and September 2014, in April and May 2015 (Q32015), and in July 2015 (Q42015). For these measurements,

one input on a digital manometer is connected to a subsurface gas sampling port, while the other input is left open to the atmosphere. The manometer then records the difference in pressure between the subsurface port and the atmosphere. Table 4.3-1 shows the results of the pressure measurements for 189 ports in the 28 boreholes for the baseline and a subset of these for the April and May and July 2015 quarterly sampling events (Q32015 and Q42015).

To understand the potential usefulness of these data, it is helpful to first review measurements made at MDA L in the 1990s. Neeper (2002, 098639) presents atmospheric and differential subsurface pressure data from boreholes near MDA L. These data show that the atmosphere can change pressure by more than 1.5 kPa over the span of a few days (Neeper 2002, 098639, Figure 3). Subsurface pressure will change in response to atmospheric pressure; however, pressure changes in the subsurface are shifted in time and reduced in amplitude, based on their ability to connect to the atmosphere. The amplitude of subsurface pressures within the Bandelier Tuff decreases, and maximum deviations from average pressure are shifted to later times with increasing depth. Neeper (2002, 098639) presents data collected from a borehole located 100 m (328 ft) to the east of the site that show almost no pressure difference between the atmosphere and a port at 11 m depth (36 ft). However, at depths of 77 m and 103 m (250 ft and 338 ft), the amplitude of the pressure wave is depressed, and the phase is shifted such that maximum differential pressure between atmospheric pressure and downhole pressure varies between +0.6 kPa and −0.6 kPa, with the maximum downhole deviation from average pressure occurring up to 0.33 d after the maximum atmospheric deviation.

Given the variability expected in subsurface differential pressure, it is difficult to attribute many of the measured values presented in Table 4.3-1 to the SVE systems. However, some ports at boreholes 54-24240, 54-24241, and 54-27641 show strong signals that are likely impacted by the SVE suction. Additionally, some of the shallower pressure measurements should be less impacted by shifts in magnitude and phase, allowing smaller pressure differences to be attributed to the SVE units. Further analysis using daily pressure variations at the time of the sampling could allow more refined estimates of the extent of pressure propagation from the SVE units and may reduce unexpected variability observed in data collected between Q32015 and Q42015. Such analysis would require the use of layered permeability models to separate out the effects of natural-phase shift and amplitude reduction from those caused by SVE at individual ports.

5.0 CONCLUSIONS

During the first 6 mo of SVE operation, the two SVE units removed 424 kg (932 lb) of total organic vapor mass. The mass was primarily removed from within approximately 150-ft radius surrounding the extraction boreholes. Mass removal was higher initially, and continued at a removal rate of nearly 100 lb/mo after 6 mo of operation. The long-term ability of the SVE system to remove significant quantities of organic vapor has been demonstrated, and data collected during the IM will be analyzed further as part of ongoing efforts to support the selection and design of a final remedy for MDA L.

6.0 RECOMMENDATIONS

The following recommendations are based on the initial 6 mo of SVE operation at MDA L.

- Continue SVE operation through the middle of November 2015. This timing is based on two primary considerations: (1) the mass-removal rate remains near 45 kg (100 lb) per month and (2) shutting the system down before winter 2015 to avoid problems with experienced during cold periods of operation.

- Evaluate data collected during the SVE IM to refine the assumptions in the MDA L CME.
- Modify the Tier II screening algorithm to include depth-dependent diffusion and update the assumptions for VOC transport to the regional aquifer.
- Reevaluate potential engineered solutions (e.g., passive SVE, active SVE), including pumping scenarios and number/placement of extraction wells, that were presented in the MDA L CME.
- Develop cleanup goals to support the corrective measures implementation phase of site closure.
- Provide data and modeling analyses of the physical and geochemical processes impacting VOC vapor transport beneath MDA L.

In addition, two key areas of additional data collection are proposed to begin in 2016 and are described below.

6.1 Rebound Analysis

To more fully evaluate SVE strategies for MDA L, LANL is proposing to collect and analyze data related to plume rebound after the SVE units are shut down in November 2015. Rebound data will allow LANL to better design a long-term strategy for using SVE as a vapor-plume control measure at MDA L. Rebound sampling will also help determine whether, and to what degree, ongoing VOC releases from the shafts are occurring.

6.2 Tracer Study

To further characterize subsurface rock properties in the Cerros del Rio basalt, LANL proposes to implement a gas tracer test in the summer of 2016 to determine diffusivity in the fractured basalt that makes up nearly half the thickness of the unsaturated rock column between the MDA L disposal area and the regional water table. Overall, the tracer tests will provide fundamental gas flow and transport information under field conditions that would be difficult to obtain otherwise.

Preliminary activities include planning, coordination with U.S. Department of Energy and NMED, permitting, and analysis of data. The tracer test will include one or more injections of gas tracer (e.g., SF_6) into borehole 54-24399 through a packer system and subsequent monitoring of concentration decay as the tracer spreads in the subsurface. Monitoring at basalt ports in boreholes 54-01015 and 54-01016 could also be useful in this test. Analysis of breakthrough data will be performed using both analytical solutions and three-dimensional numerical simulation.

7.0 REFERENCES

The following list includes all documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ER ID or ESH ID. This information is also included in text citations. ER IDs were assigned by the Environmental Programs Directorate's Records Processing Facility (IDs through 599999), and ESH IDs are assigned by the Environment, Safety, and Health (ESH) Directorate (IDs 600000 and above). IDs are used to locate documents in the Laboratory's Electronic Document Management System and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the ESH Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

LANL (Los Alamos National Laboratory), November 2006. "Summary Report: 2006 In Situ Soil Vapor Extraction Pilot Study at Material Disposal Area L, Technical Area 54, Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-06-7900, Los Alamos, New Mexico. (LANL 2006, 094152)

LANL (Los Alamos National Laboratory), September 2011. "Corrective Measures Evaluation Report for Material Disposal Area L, Solid Waste Management Unit 54-006, at Technical Area 54, Revision 2," Los Alamos National Laboratory document LA-UR-11-4798, Los Alamos, New Mexico. (LANL 2011, 205756)

LANL (Los Alamos National Laboratory), April 2013. "Interim Measures Work Plan for the Evaluation of Chromium Mass Removal," Los Alamos National Laboratory document LA-UR-13-22534, Los Alamos, New Mexico. (LANL 2013, 241096)

Neeper, D.A., 2002. "Investigation of the Vadose Zone Using Barometric Pressure Cycles," *Journal of Contaminant Hydrology,* Vol. 54, pp. 59-80. (Neeper 2002, 098639)

NMED (New Mexico Environment Department), June 26, 2013. "Approval with Modification, Interim Measures Work Plan for the Evaluation of Chromium Mass Removal," New Mexico Environment Department letter to P. Maggiore (DOE-LASO) and J.D. Mousseau (LANL) from J.E. Kieling (NMED-HWB), Santa Fe, New Mexico. (NMED 2013, 522947)

Stauffer, P., K. Birdsell, and W. Rice, March 7–11, 2011. "3-D Model Validation in Support of Site Closure, Material Disposal Area L, Los Alamos, NM," Paper 11545, Waste Management 2011 Conference, March 7–11, 2011, Phoenix, AZ. (Stauffer et al. 2011, 255584)

Stauffer, P.H., K.H. Birdsell, M.S. Witkowski, and J.K. Hopkins, 2005. "Vadose Zone Transport of 1,1,1-Trichloroethane: Conceptual Model Validation through Numerical Simulation," *Vadose Zone Journal,* Vol. 4, pp. 760–773. (Stauffer et al. 2005, 090537)

Stauffer, P.H., J.K. Hopkins, T. Anderson, and J. Vrugt, July 11, 2007. "Soil Vapor Extraction Pilot Test at Technical Area 54, Material Disposal Area L: Numerical Modeling in Support of Decision Analysis," Los Alamos National Laboratory document LA-UR-07-4890, Los Alamos, New Mexico. (Stauffer et al. 2007, 097871)

Weston (Weston Solutions, Inc.), May 2015. "Final Baseline Data Evaluation for Soil Vapor Extraction at Material Disposal Area L, Solid Waste Management Unit 54-006, at Technical Area 54," report prepared for Los Alamos National Laboratory, Los Alamos, New Mexico. (Weston 2015, 600886)

Weston (Weston Solutions, Inc.), September 2015. "Draft Final Evaluation of Data from the First Quarter of Soil Vapor Extraction at Material Disposal Area L, Solid Waste Management Unit 54-006, at Technical Area 54," report prepared for Los Alamos National Laboratory, Los Alamos, New Mexico. (Weston 2015, 600887)

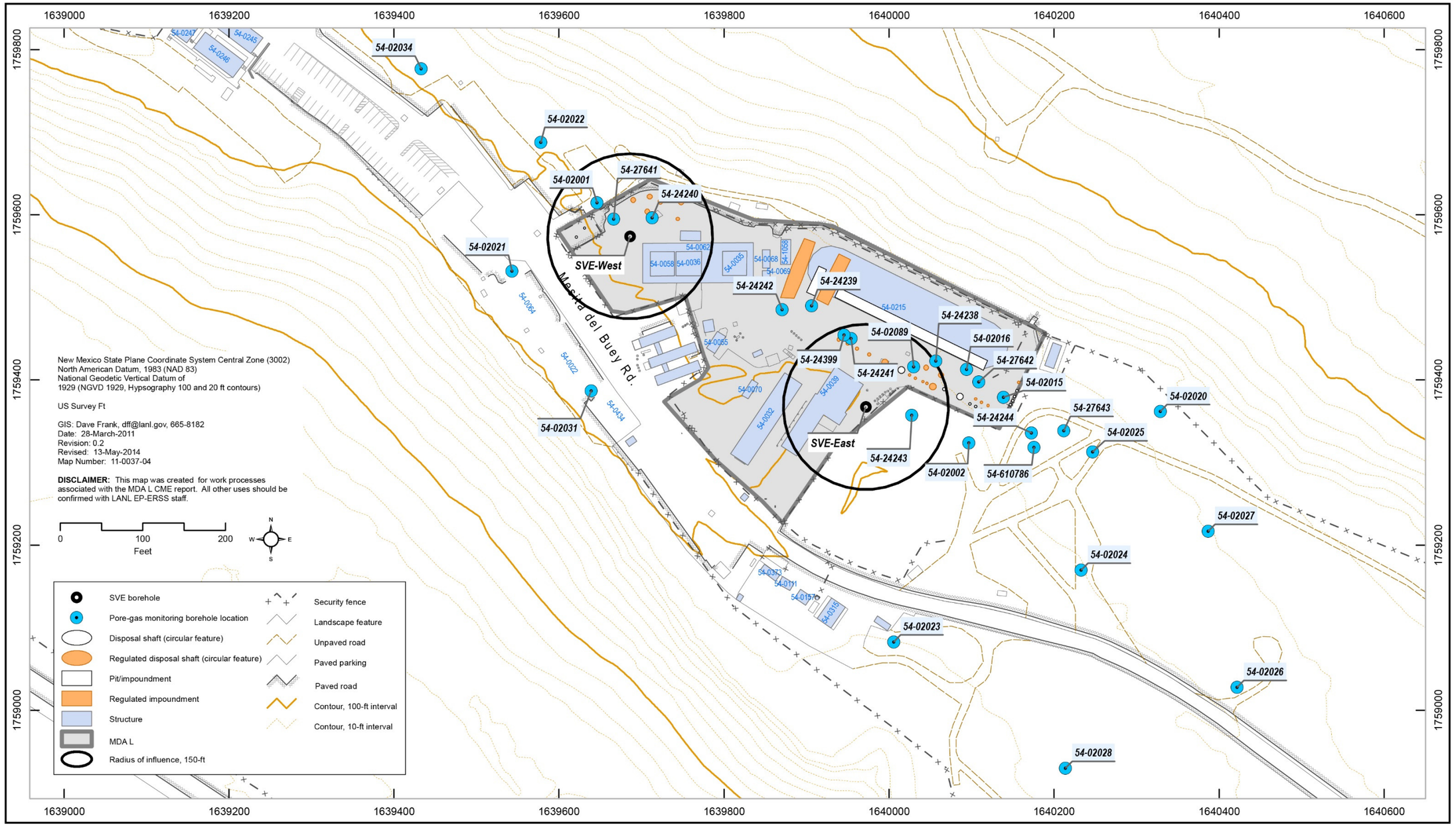


Figure 1.1-1 View of MDA L with disposal units, surface structures, pore-gas monitoring boreholes, SVE boreholes, and 150-ft radius of influence of extraction wells

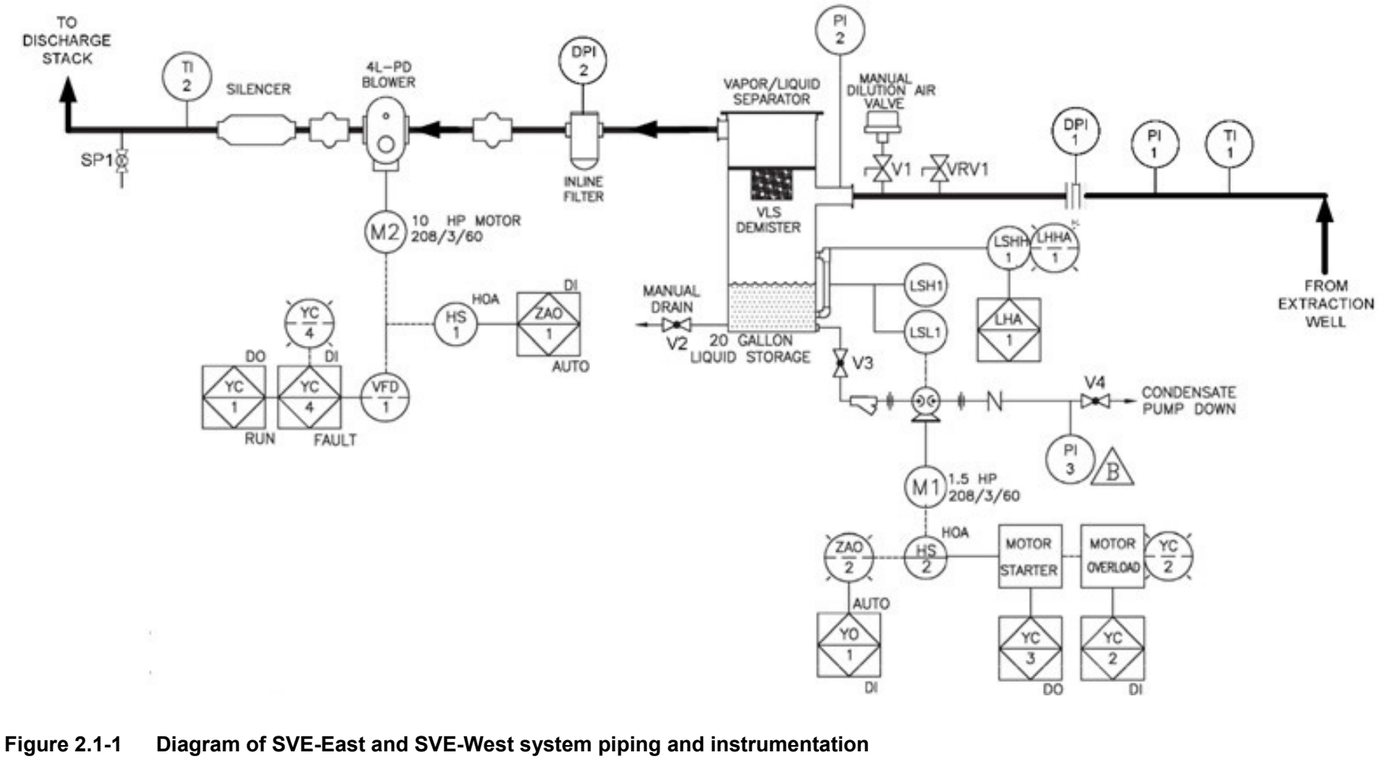


Figure 2.1-1 Diagram of SVE-East and SVE-West system piping and instrumentation



Figure 2.1-2 SVE-East SVE unit

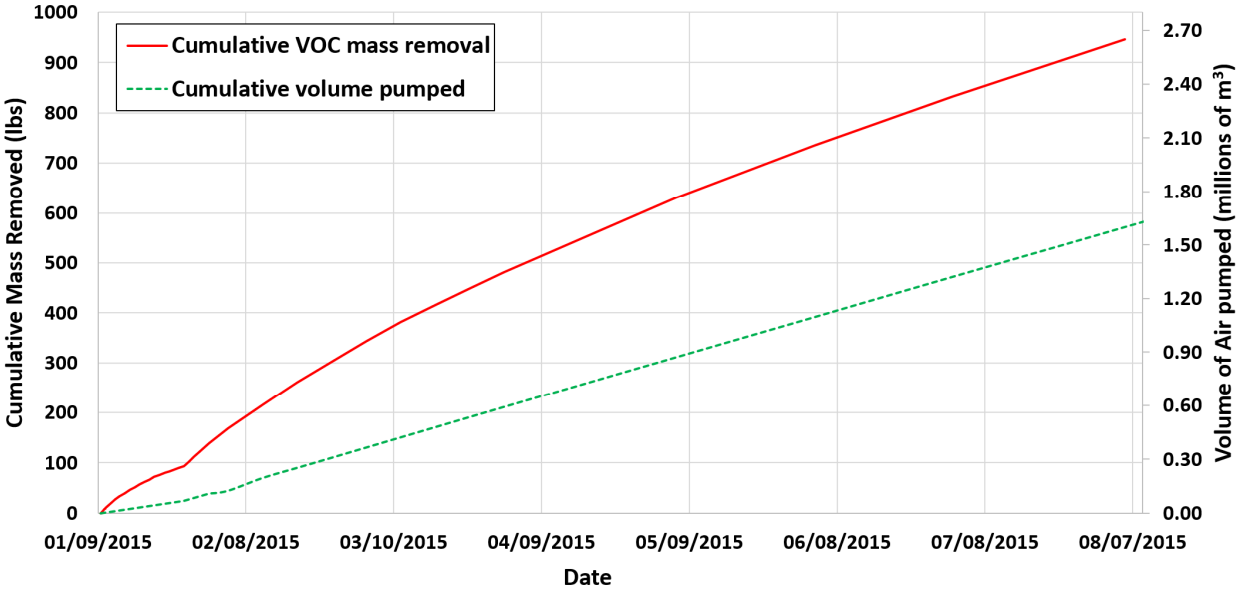


Figure 4.1-1 Cumulative mass removal from both SVE units as a function of time and cumulative volume of pore-gas pumped from the subsurface

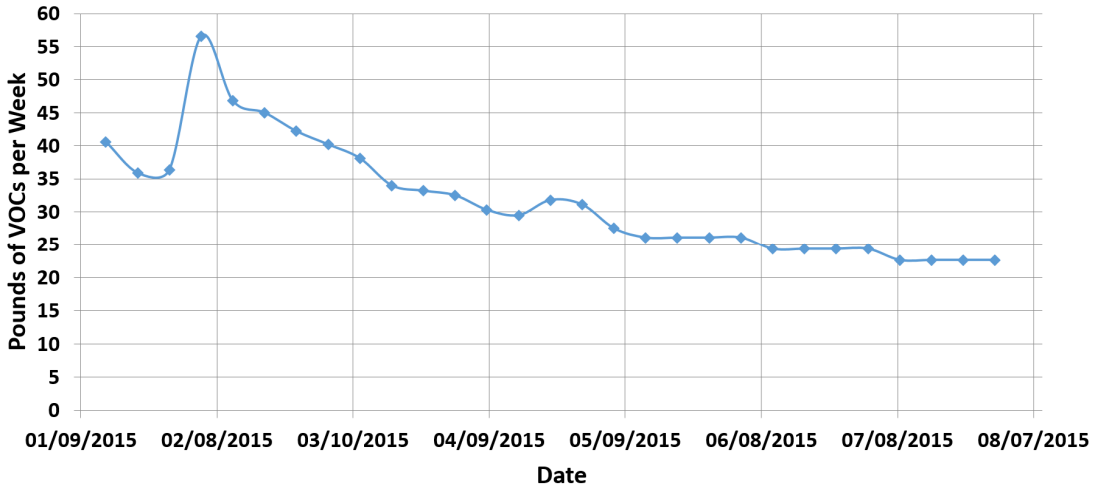


Figure 4.1-2 Weekly mass removal rate from both SVE units as a function of time

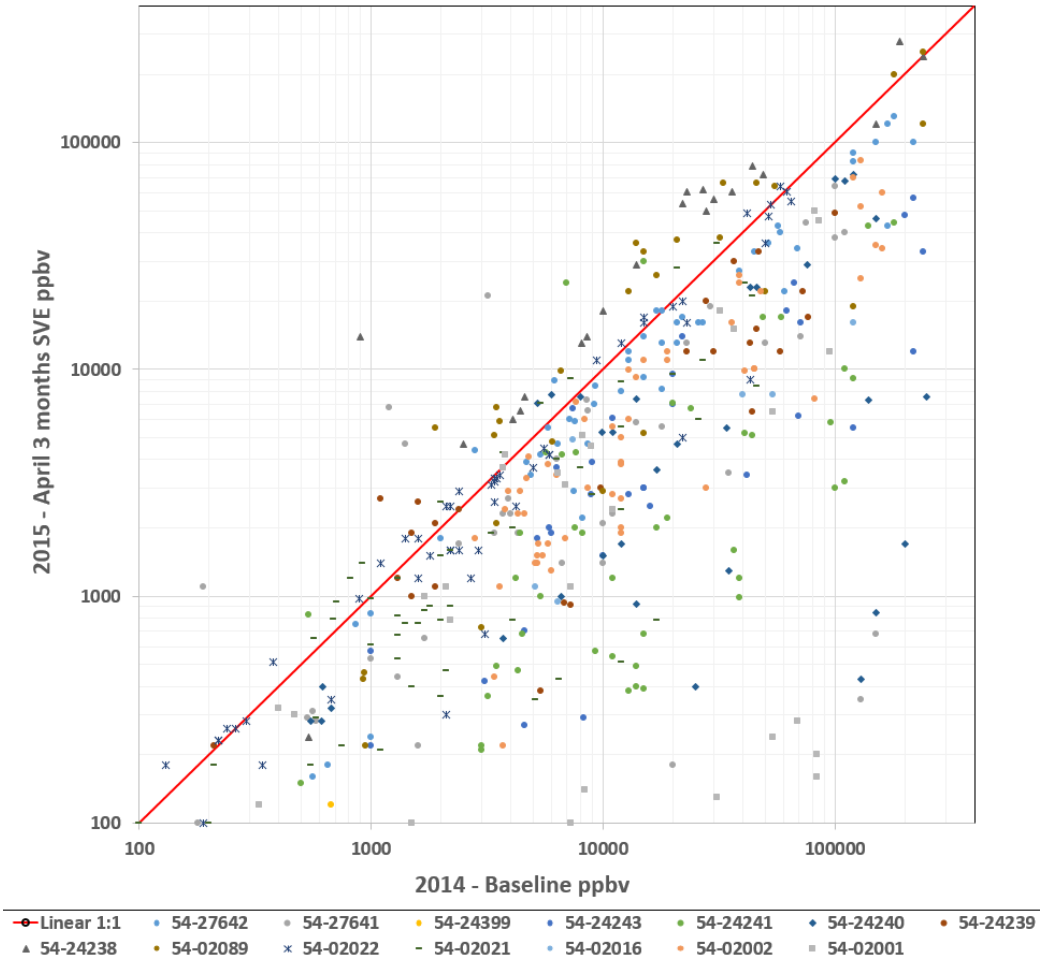


Figure 4.2-1 Comparison of subsurface VOC concentrations before SVE (Baseline 2014) and after 3 mo of SVE (Q32015). Data in this plot are for the seven analytes: 1,1,1-TCA, TCE, PCE, 1,2-DCA, 1,1-DCE, 1,2-DCP, and methylene chloride

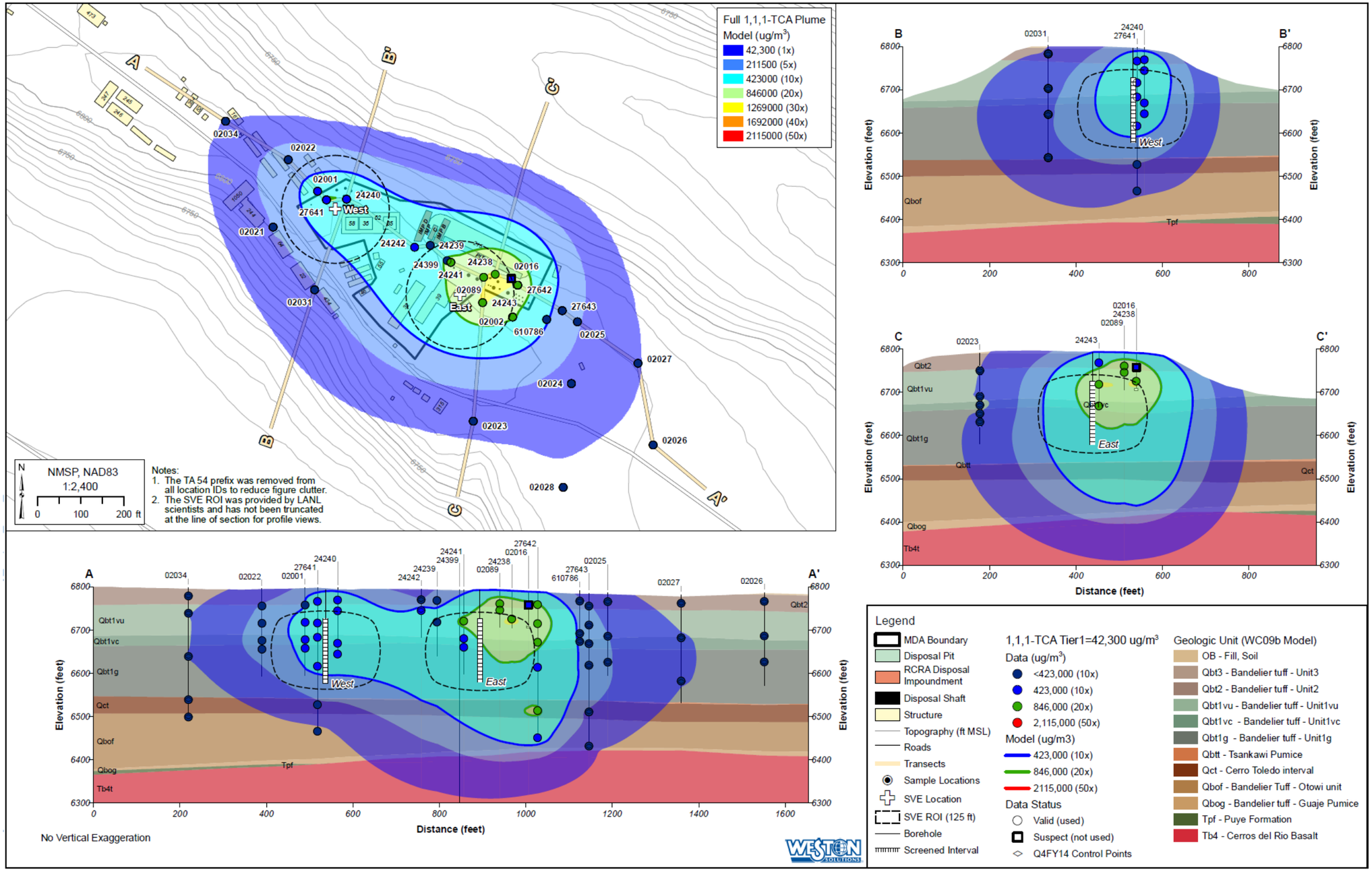


Figure 4.2-2 Baseline 2014 1,1,1-TCA plume data interpolated from borehole data

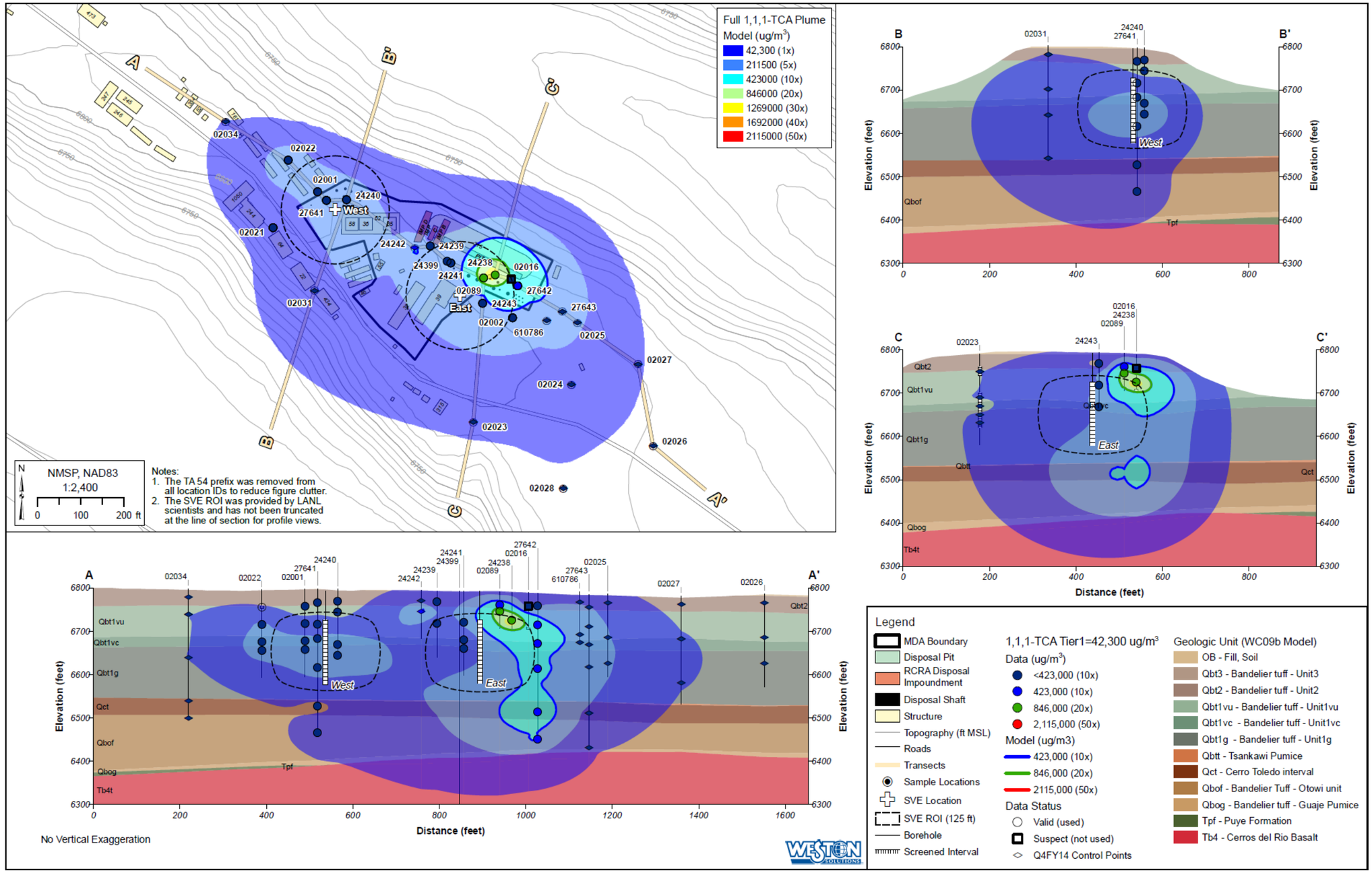


Figure 4.2-3 Q32015 1,1,1-TCA plume data interpolated from borehole data

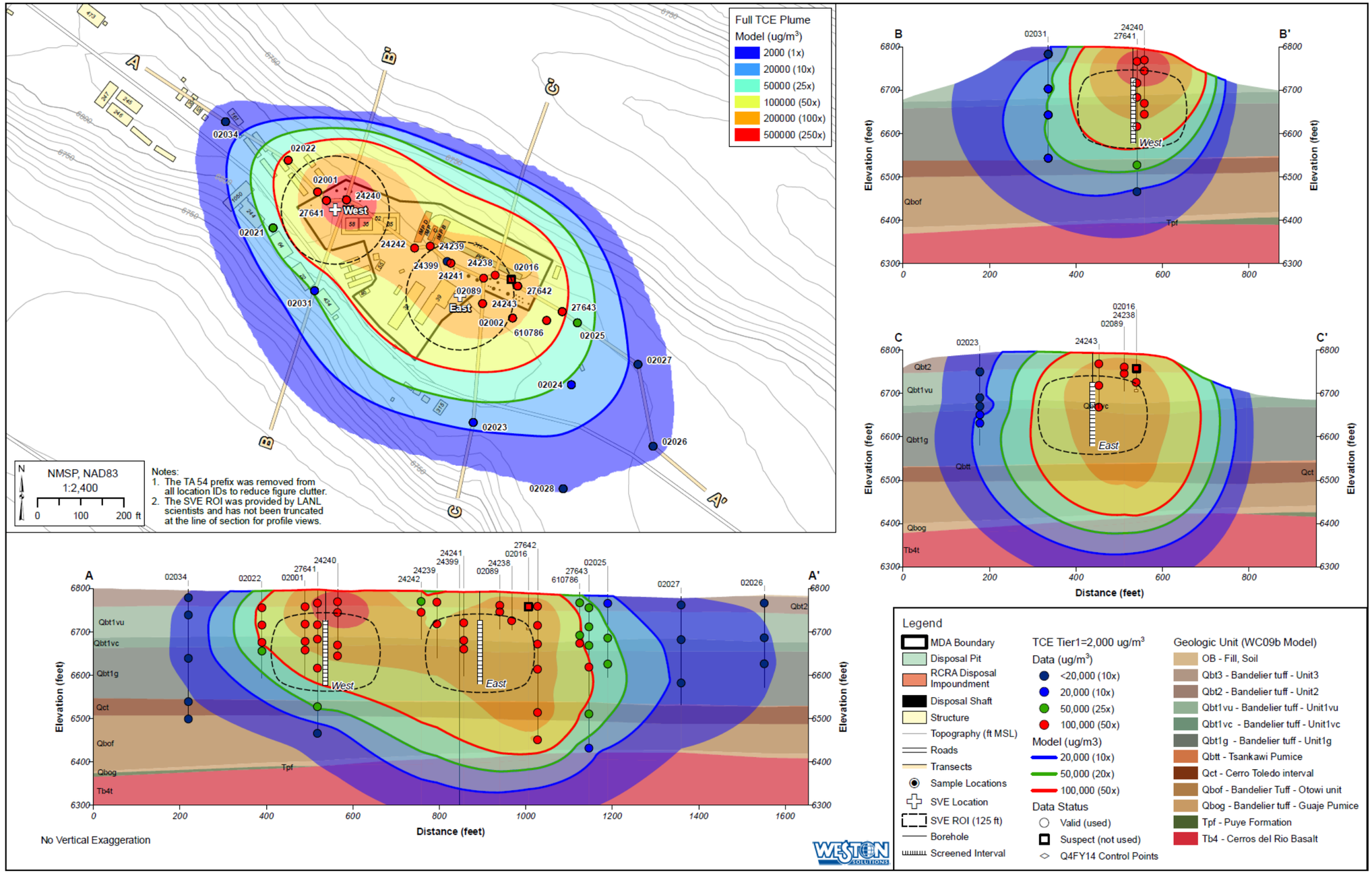


Figure 4.2-4 Baseline 2014 TCE plume data interpolated from borehole data

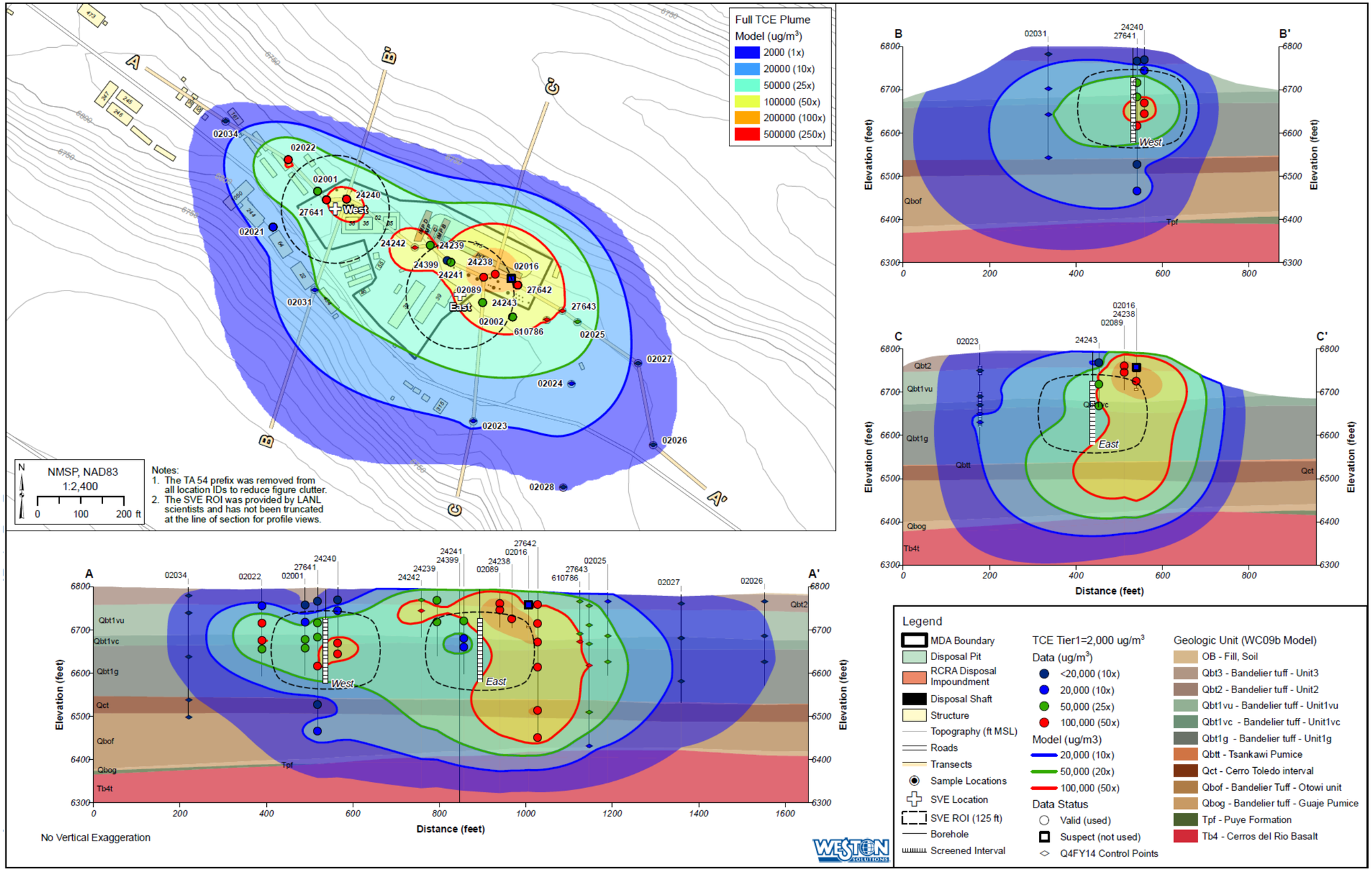


Figure 4.2-5 Q32015 TCE plume data interpolated from borehole data

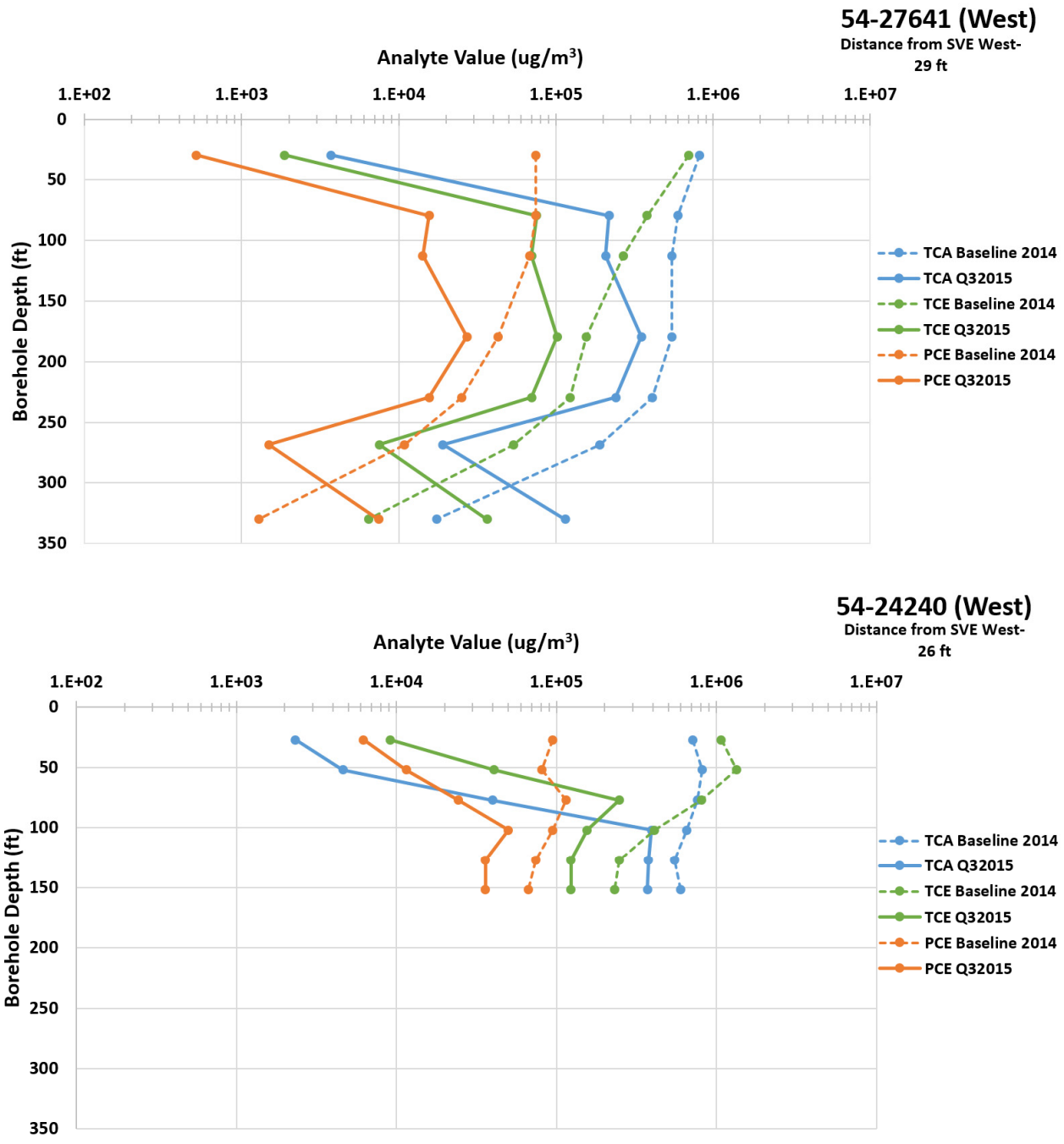


Figure 4.2-6 **1,1,1-TCA, TCE, and PCE concentration data for Q32015 versus Baseline 2014 for boreholes 54-27641 and 54-24240**

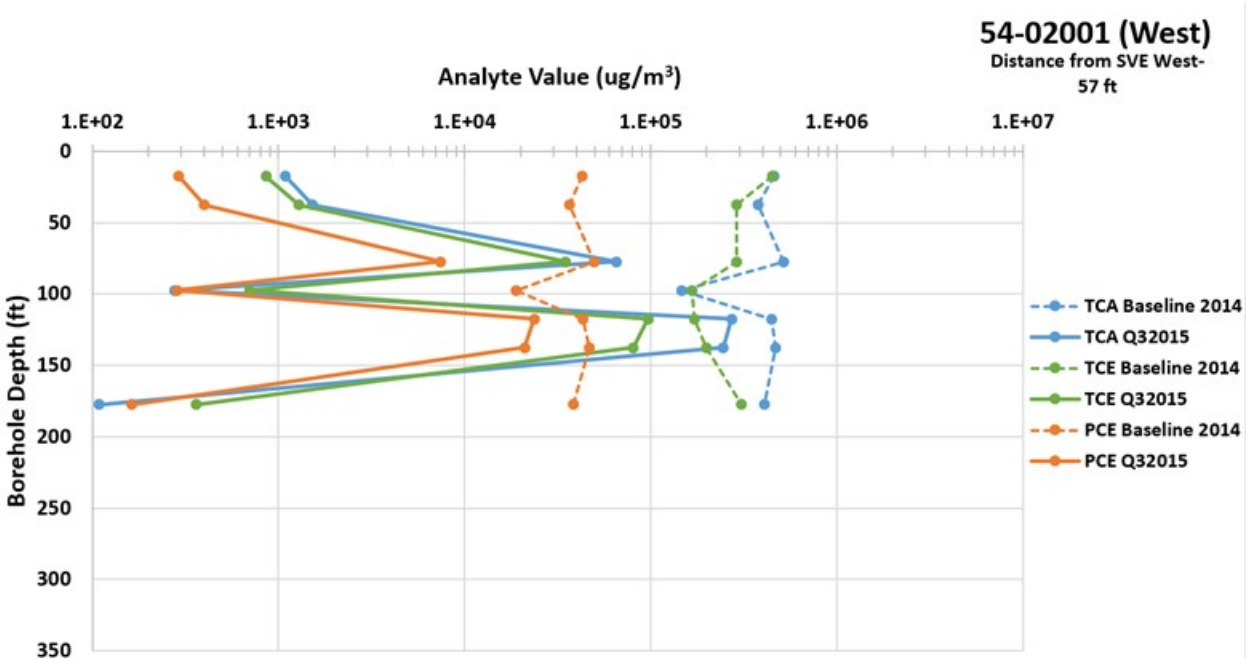


Figure 4.2-7 1,1,1-TCA, TCE, and PCE concentration data Q32015 versus Baseline 2014 for borehole 54-02001

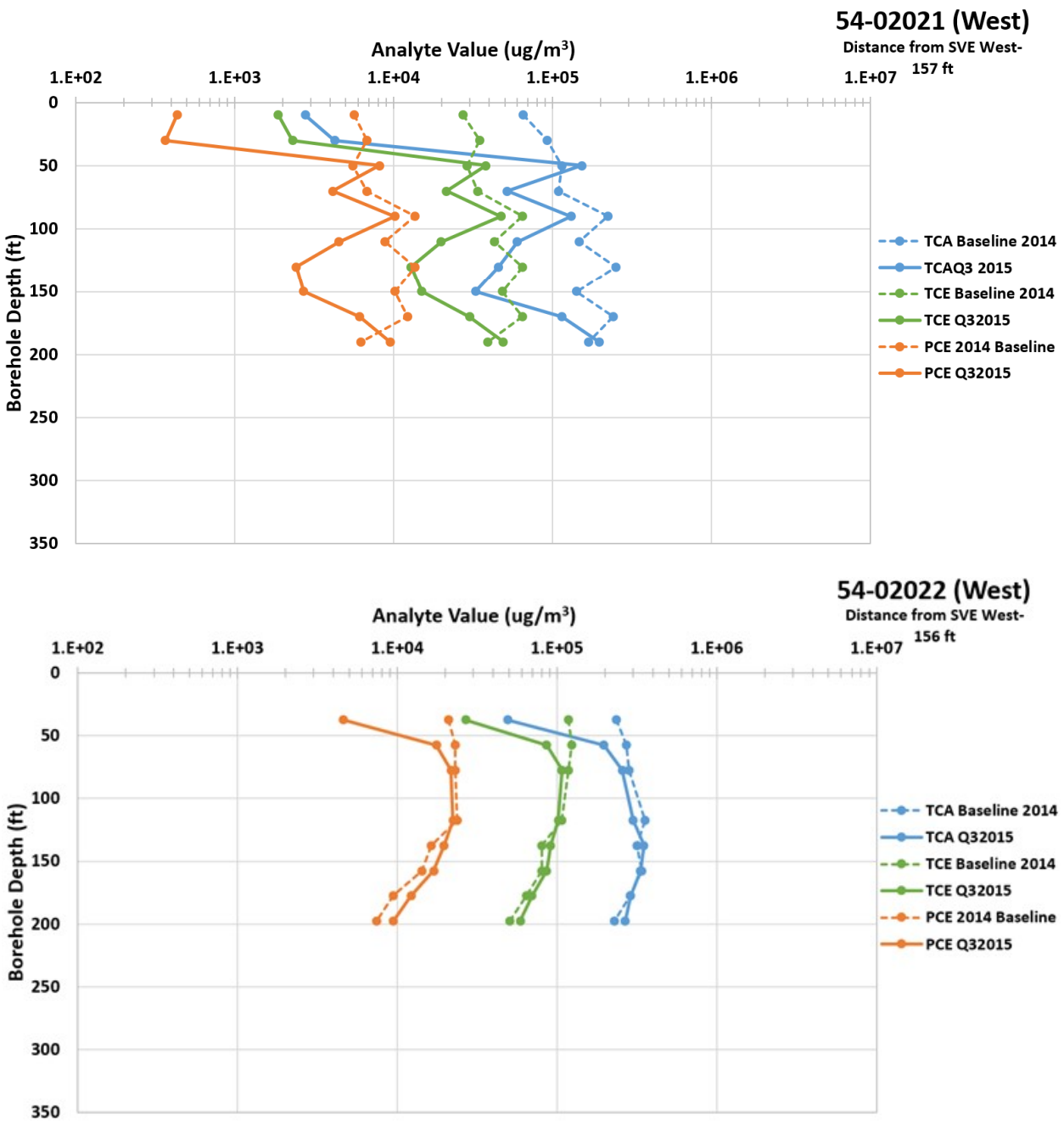


Figure 4.2-8 **1,1,1-TCA, TCE, and PCE concentration data Q32015 versus Baseline 2014 for boreholes 54-02021 and 54-02022**

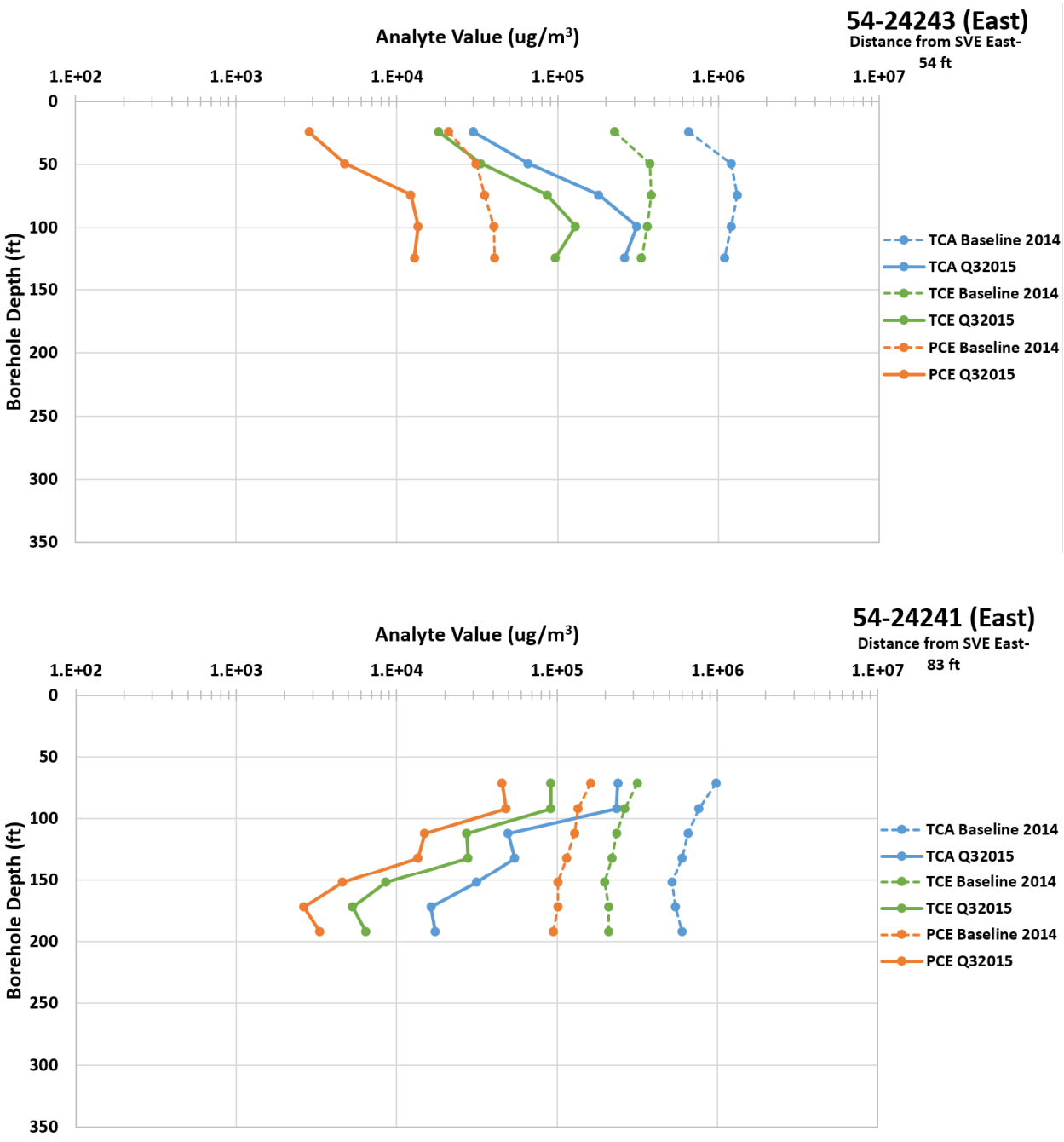


Figure 4.2-9 **1,1,1-TCA, TCE, and PCE concentration data for Q32015 versus Baseline 2014 boreholes 54-24243 and 54-24241**

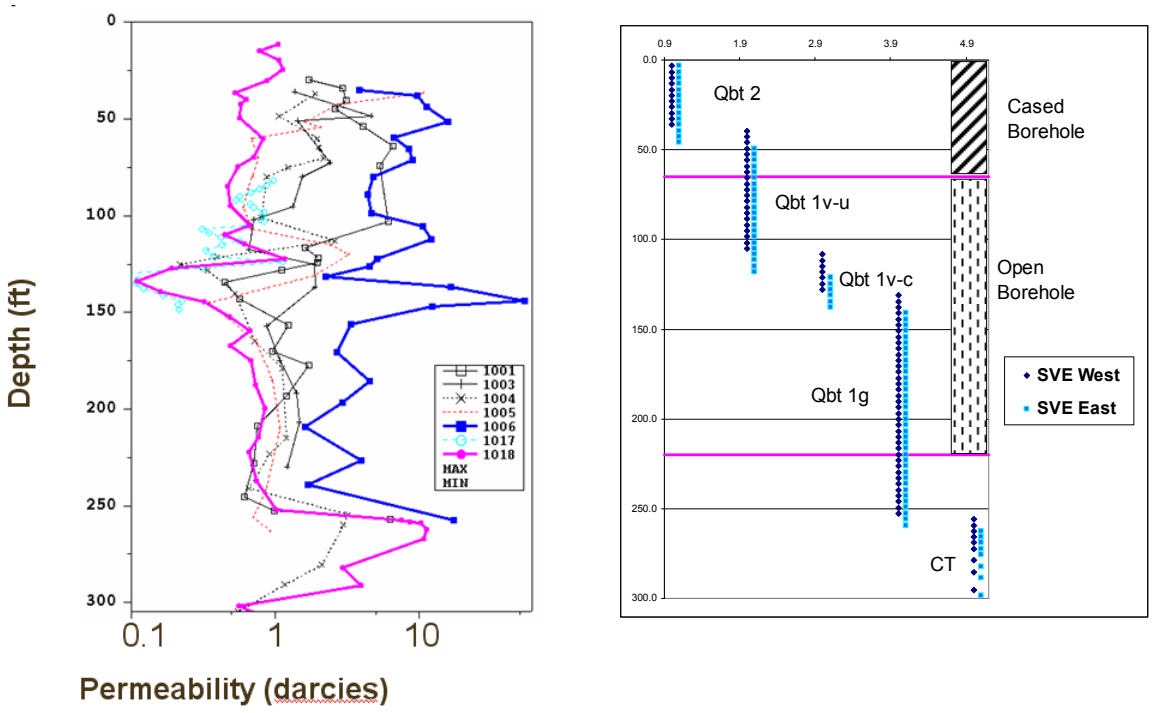


Figure 4.2-10 Straddle packer permeability data related to geologic units and the SVE borehole design

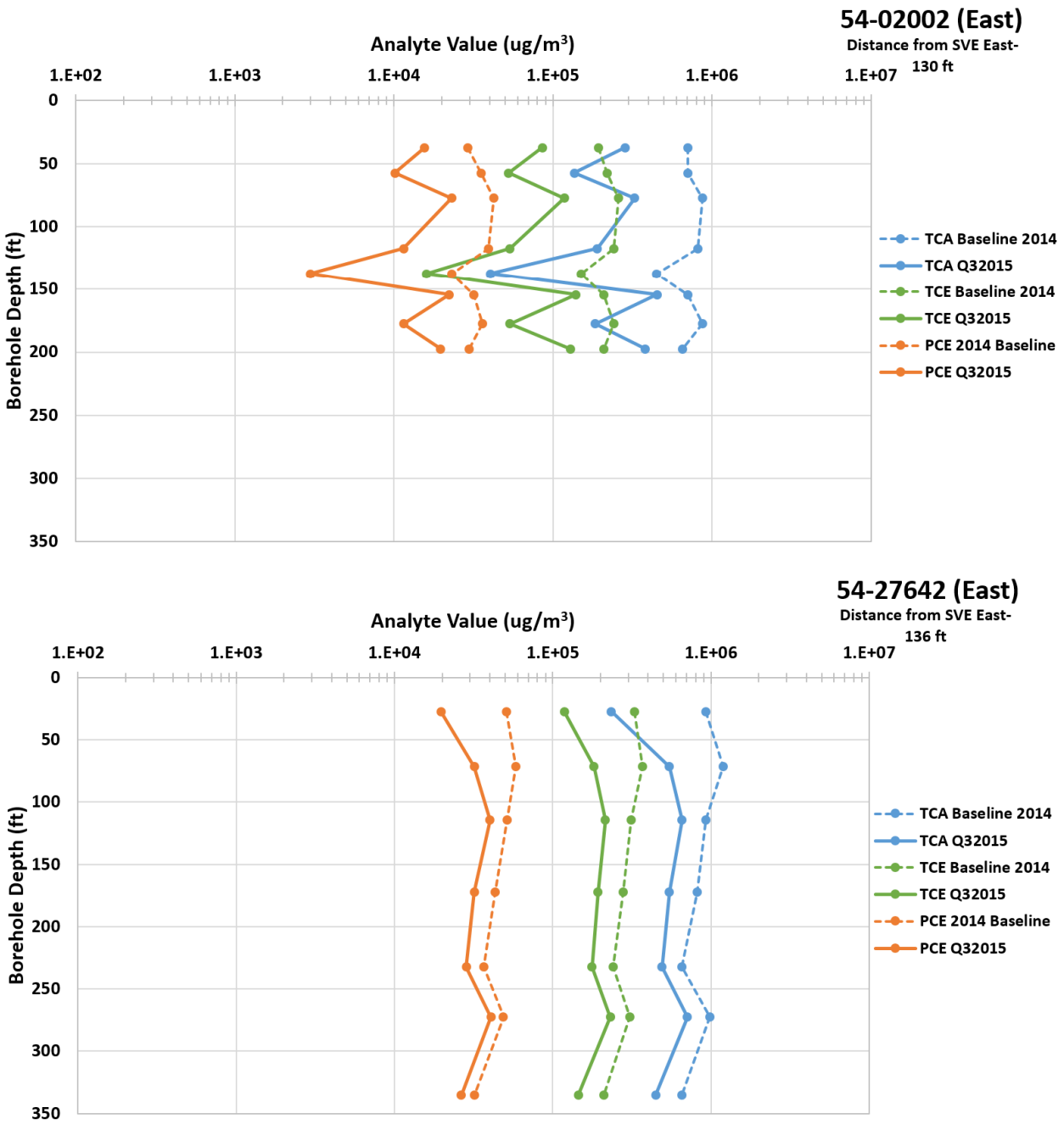


Figure 4.2-11 1,1,1-TCA, TCE, and PCE concentration data Q32015 versus Baseline 2014 for boreholes 54-02002 and 54-27642

Table 2.2-1
List of 62 Organic Compounds Analyzed
by EPA Method TO15 during SVE Operations

Acetone	Dioxane[1,4-]
Benzene	Ethanol
Benzyl Chloride	Ethylbenzene
Bromodichloromethane	Ethyltoluene[4-]
Bromoform	Hexachlorobutadiene
Bromomethane	Hexane
Butadiene[1,3-]	Hexanone[2-]
Butanone[2-]	Isooctane
Carbon Disulfide	Isopropylbenzene
Carbon Tetrachloride	Methyl tert-Butyl Ether
Chloro-1-propene[3-]	Methyl-2-pentanone[4-]
Chlorobenzene	Methylene Chloride
Chlorodibromomethane	n-Heptane
Chloroethane	Propanol[2-]
Chloroform	Propylbenzene[1-]
Chloromethane	Styrene
Cyclohexane	Tetrachloroethane[1,1,2,2-]
Dibromoethane[1,2-]	Tetrachloroethene
Dichloro-1,1,2,2-tetrafluoroethane[1,2-]	Tetrahydrofuran
Dichlorobenzene[1,2-]	Toluene
Dichlorobenzene[1,3-]	Trichloro-1,2,2-trifluoroethane[1,1,2-]
Dichlorobenzene[1,4-]	Trichlorobenzene[1,2,4-]
Dichlorodifluoromethane	Trichloroethane[1,1,1-]
Dichloroethane[1,1-]	Trichloroethane[1,1,2-]
Dichloroethane[1,2-]	Trichloroethene
Dichloroethene[1,1-]	Trichlorofluoromethane
Dichloroethene[cis-1,2-]	Trimethylbenzene[1,2,4-]
Dichloroethene[trans-1,2-]	Trimethylbenzene[1,3,5-]
Dichloropropane[1,2-]	Vinyl Chloride
Dichloropropene[cis-1,3-]	Xylene[1,2-]
Dichloropropene[trans-1,3-]	Xylene[1,3-]+Xylene[1,4-]

Table 4.1-1
Mass Removed for Detected Organic Compounds during SVE Operation

Parameter Name	Cumulative Total Pounds through 2/1/2015	Cumulative Total Pounds through 3/1/2015	Cumulative Total Pounds through 4/1/2015	Cumulative Total Pounds through 5/1/2015	Cumulative Total Pounds through 6/1/2015	Cumulative Total Pounds through 7/1/2015	Cumulative Total Pounds through 8/1/2015
Acetone	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Benzene	0.029	0.157	0.271	0.345	0.429	0.509	0.593
Carbon Tetrachloride	0.319	0.719	1.052	1.345	1.597	1.803	2.003
Chlorobenzene	0	0	0.004	0.004	0.010	0.024	0.038
Chloroform	3.004	6.645	9.757	12.226	14.488	16.475	18.452
Dichlorodifluoromethane	0.270	0.586	0.846	1.046	1.236	1.403	1.580
Dichloroethane[1,1-]	2.364	5.062	7.253	9.029	10.673	12.034	13.297
Dichloroethane[1,2-]	8.164	14.285	19.745	24.514	28.893	32.584	36.269
Dichloroethene[1,1-]	2.682	7.405	11.398	14.669	17.888	21.224	24.567
Dichloropropane[1,2-]	1.328	5.669	9.611	12.857	15.948	18.595	21.081
Dioxane[1,4-]	0.101	0.362	0.828	1.377	2.014	2.669	3.332
Ethanol	0	0.007	0.007	0.043	0.050	0.050	0.050
Hexane	0	0.046	0.046	0.046	0.046	0.046	0.067
Isooctane	0	0.017	0.133	0.133	0.157	0.186	0.187
Methylene Chloride	1.027	3.360	5.509	7.451	9.317	10.939	12.518
n-Heptane	0	0.022	0.022	0.022	0.022	0.022	0.051
Tetrachloroethene	11.458	25.278	38.761	50.621	62.046	72.143	81.226
Tetrahydrofuran	0.042	0.160	0.290	0.391	0.532	0.667	0.795
Toluene	0.057	0.289	0.529	0.752	0.987	1.193	1.357
Trichloro-1,2,2-trifluoroethane[1,1,2-]	8.632	27.928	43.379	56.045	67.476	77.943	88.062
Trichloroethane[1,1,1-]	61.384	144.991	216.436	274.935	327.874	373.927	419.184
Trichloroethene	41.498	78.909	110.710	136.868	161.136	182.615	201.825
Trichlorofluoromethane	0.539	1.604	2.501	3.263	3.931	4.520	5.123
Xylene[1,3-]+Xylene[1,4-]	0.009	0.024	0.040	0.051	0.061	0.079	0.134
Total VOCs (lb)	142.917	323.536	479.138	608.045	726.822	831.660	931.801

Table 4.3-1
Differential Pressure Data at
Sampling Ports Monitored during SVE Operations

Well	Port Depth	Static Pressure (kPa)		
		Baseline 2014	Q32015	Q42015
54-02031	20	0.000	—[a]	—
54-02031	60	0.041	—	—
54-02031	100	0.101	—	—
54-02031	160	0.106	—	—
54-02031	200	0.207	—	—
54-02031	220	0.145	—	—
54-02031	260	0.235	—	—
54-02034	20	-0.029	—	—
54-02034	60	-0.063	—	—
54-02034	100	-0.041	—	—
54-02034	160	0.210	—	—
54-02034	200	0.243	—	—
54-02034	220	0.247	—	—
54-02034	260	0.272	—	—
54-02034	300	0.318	—	—
54-02022	20	-0.041	-0.140	-0.140
54-02022	40	-0.055	-0.177	-0.173
54-02022	60	-0.070	-0.200	-0.192
54-02022	80	-0.101	-0.207	-0.243
54-02022	100	-0.142	-0.245	-0.265
54-02022	120	-0.126	-0.247	-0.259
54-02022	140	-0.085	-0.239	-0.200
54-02022	160	-0.041	-0.229	-0.185
54-02022	180	0.000	-0.212	-0.146
54-02022	200	0.020	-0.200	-0.127
54-02021	20	-0.044	-0.070	-0.098
54-02021	40	-0.053	-0.075	-0.112
54-02021	60	-0.250	-0.082	-0.306
54-02021	80	-0.128	-0.075	-0.155
54-02021	100	-0.216	-0.093	-0.253
54-02021	120	0.000	-0.056	-0.227
54-02021	140	-0.239	-0.120	-0.303
54-02021	160	-0.103	-0.079	-0.110
54-02021	180	-0.269	-0.127	-0.282

Table 4.3-1 (continued)

Well	Port Depth	Static Pressure (kPa)		
		Baseline 2014	Q32015	Q42015
54-02021	198	-0.271	0.042	-0.173
54-24240	28	0.000	-0.244	-0.227
54-24240	53	-0.013	-0.897	-0.838
54-24240	78	-0.060	-2.053	-1.983
54-24240	103	-0.116	-1.652	-1.488
54-24240	128	-0.143	-1.187	-0.988
54-24240	153	-0.167	-0.654	-0.435
54-27641	32	-0.035	-0.283	-0.300
54-27641	82	-0.059	-3.844	-3.919
54-27641	115	-0.169	-1.169	-1.319
54-27641	182	-0.178	-0.067	-0.420
54-27641	232	-0.164	0.053	-0.320
54-27641	271	-0.164	0.141	-0.227
54-27641	332.5	-0.175	0.151	-0.195
54-24242	25	-0.048	—	—
54-24242	50	-0.203	—	—
54-24242	75	-0.112	—	—
54-24242	100	-0.053	—	—
54-24242	110.5	-0.213	—	—
54-24241	73	-0.127	-0.802	-0.394
54-24241	93	-0.150	-1.035	-0.565
54-24241	113	-0.180	-1.283	-0.695
54-24241	133	-0.233	-1.320	-0.659
54-24241	153	-0.278	-1.409	-0.124
54-24241	173	-0.282	-1.398	-0.566
54-24241	193	-0.288	-1.292	-0.585
54-24239	25	-0.024	0.033	-1.509
54-24239	50	-0.029	0.047	0.010
54-24239	75	0.064	0.028	-0.029
54-24239	99.5	0.103	-0.233	-0.022
54-02016	18	0.000	0.014	nc
54-02016	31	0.041	-0.057	-0.061
54-02016	82	-0.010	0.028	0.023
54-02089	13	-0.017	-0.049	-0.107
54-02089	31	-0.015	-0.047	-0.107
54-02089	46	-0.024	-0.047	-0.121
54-02089	86	-0.044	-0.192	-0.291

Table 4.3-1 (continued)

Well	Port Depth	Static Pressure (kPa)		
		Baseline 2014	Q32015	Q42015
54-24238	44	-0.020	-1.728	-0.150
54-24238	64	-0.024	-0.258	-0.278
54-24238	84	0.011	0.105	0.000
54-27642	30	-0.028	-0.094	-0.050
54-27642	75	-0.035	-0.667	-0.264
54-27642	116	0.000	-0.761	-0.480
54-27642	175	0.049	-0.985	-0.285
54-27642	235	0.038	-0.793	-0.154
54-27642	275	0.000	-0.722	-0.236
54-27642	338	-0.028	-0.526	-0.088
54-01016	30.8	-0.056	—	—
54-01016	162.2	0.021	—	—
54-01016	274.7	0.020	—	—
54-01016	336.3	0.016	—	—
54-02002	157	0.000	nc[b]	0.495
54-02002	180	0.100	0.016	0.000
54-02002	200	0.000	-1.092	0.440
54-24243	25	0.073	-0.115	-0.129
54-24243	50	0.075	-0.145	-0.180
54-24243	75	0.109	-0.330	-0.395
54-24243	100	0.176	-0.888	-0.961
54-24243	125	0.179	-1.064	-1.253
54-27643	30	0.018	—	—
54-27643	74	0.050	—	—
54-27643	117	0.129	—	—
54-27643	167	0.251	—	—
54-27643	235	0.279	—	—
54-27643	275	0.276	—	—
54-27643	354	0.133	—	—
54-610786	25	0.000	—	—
54-610786	50	0.000	—	—
54-610786	75	-0.020	—	—
54-610786	100	-0.044	—	—
54-610786	118.5	-0.053	—	—
54-02025	20	-23.000	—	—
54-02025	60	0.110	—	—
54-02025	100	-0.151	—	—

Table 4.3-1 (continued)

Well	Port Depth	Static Pressure (kPa)		
		Baseline 2014	Q32015	Q42015
54-02025	160	-0.174	—	—
54-02025	190	-0.185	—	—
54-02027	20	0.010	—	—
54-02027	60	-0.017	—	—
54-02027	100	-0.112	—	—
54-02027	160	-0.162	—	—
54-02027	200	-0.170	—	—
54-02027	220	-0.173	—	—
54-02027	250	-0.166	—	—
54-02020	20	-0.041	—	—
54-02020	40	-0.068	—	—
54-02020	60	-0.100	—	—
54-02020	80	-0.129	—	—
54-02020	95	-0.146	—	—
54-02020	120	-0.147	—	—
54-02020	140	-0.154	—	—
54-02020	160	-0.157	—	—
54-02020	180	-0.159	—	—
54-02020	200	0.012	—	—
54-02026	20	0.000	—	—
54-02026	60	-0.017	—	—
54-02026	100	-0.100	—	—
54-02026	160	-0.217	—	—
54-02026	200	-0.258	—	—
54-02026	215	-0.277	—	—
54-02028	20	0.000	—	—
54-02028	60	0.000	—	—
54-02028	100	0.010	—	—
54-02028	160	0.068	—	—
54-02028	200	0.086	—	—
54-02028	220	0.085	—	—
54-02028	250	0.076	—	—
54-24399	568-608	n/a[c]	n/a	n/a
54-24399	568-569	n/a	n/a	n/a
54-02024	20	-0.035	—	—
54-02024	40	-0.034	—	—
54-02024	60	-0.047	—	—

Table 4.3-1 (continued)

Well	Port Depth	Static Pressure (kPa)		
		Baseline 2014	Q32015	Q42015
54-02024	80	-0.092	—	—
54-02024	100	-0.132	—	—
54-02024	120	-0.146	—	—
54-02024	140	-0.164	—	—
54-02024	160	-0.182	—	—
54-02024	180	-0.193	—	—
54-02024	200	-0.203	—	—
54-02023	20	0.011	—	—
54-02023	40	0.017	—	—
54-02023	60	0.178	—	—
54-02023	80	0.051	—	—
54-02023	100	0.072	—	—
54-02023	120	0.018	—	—
54-02023	140	0.079	—	—
54-02023	159	0.151	—	—
54-02023	180	0.033	—	—
54-02023	200	0.204	—	—
54-01015	45	-0.106	—	—
54-01015	187	-0.180	—	—
54-01015	350	0.011	—	—
54-01015	385	-0.119	—	—
54-01015	435	-0.126	—	—
54-01015	485	-0.122	—	—
54-01015	525	0.000	—	—
54-02001	20	-0.063	-0.314	-0.206

[a] — = Not measured as part of quarterly sampling.

[b] nc = Not collected.

[c] n/a = Not applicable for packer system.

Appendix A

Analytical Suites and Results
(on CD included with this document)