2011 Mound Site Groundwater Plume Rebound Exercise and Follow-Up - 13440

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ABSTRACT

The Mound Site facility near Miamisburg, Ohio, opened in 1948 to support early atomic weapons programs. It grew into a research, development, and production facility performing work in support of the U.S. Department of Energy (DOE) weapons and energy programs. The plant was in operation until 1995.

During the course of operation, an onsite landfill was created. The landfill was located over a finger of a buried valley aquifer, which is a sole drinking water source for much of the Miami Valley. In the 1980s, volatile organic compounds (VOCs) were discovered in groundwater at the Mound site. The site was placed on the National Priorities List on November 21, 1989. DOE signed a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Federal Facility Agreement with the U.S. Environmental Protection Agency (EPA) and the Ohio Environmental Protection Agency. The agreement became effective in October 1990.

The area that included the landfill was designated Operational Unit 1 (OU-1). In 1995, a Record of Decision was signed that called for the installation and operation of a pump and treatment (P&T) system in order to prevent the VOCs in OU-1 groundwater from being captured by the onsite water production wells. In addition to the P&T system, a soil vapor extraction (SVE) system was installed in 1997 to accelerate removal of VOCs from groundwater in the OU-1 area. The SVE system was successful in removing large amounts of VOCs and continued to operate until 2007, when the amount of VOCs removed became minimal.

A rebound study was started in February 2003 to determine how the groundwater system and contaminants would respond to shutting down the P&T system. The rebound test was stopped in February 2004 because predetermined VOC threshold concentrations were exceeded downgradient of the landfill. The P&T and SVE systems were restarted after the termination of the rebound test.

In 2006, the remediation of the Mound site was completed and the site was declared to be protective of human health and the environment, as long as the institutional controls are observed. The institutional controls that apply to the OU-1 area include provisions that no soil be allowed to leave the site, no wells be installed for drinking water, and the site may be approved only for industrial use. The onsite landfill with the operating CERCLA remedy remained. However, the Mound Development Corporation lobbied Congress for funds to remediate the remaining onsite landfill to allow for property reuse. In 2007 DOE received funding from Congress to perform

non-CERCLA removal actions at OU-1 to excavate the site sanitary landfill. In 2009, DOE received American Recovery and Reinvestment Act funding to complete the project. Excavation of the landfill occurred intermittently from 2006 through 2010 and the majority of the VOC source was removed; however, VOC levels near the P&T system remained greater than the EPA maximum contaminant levels (MCLs).

Presently, groundwater is contained using two extraction wells to create a hydraulic barrier to prevent downgradient migration of VOC-impacted groundwater. Since the primary contamination source has been removed, the feasibility of moving away from containment to a more passive remedy, namely monitored natural attenuation (MNA), is being considered.

A second rebound study was started in June 2011. If contaminant and groundwater behavior met specific conditions during the study, MNA would be evaluated and considered as a viable alternative for the groundwater in the OU-1 area.

From June through December 2011, the second rebound study evaluated the changes in VOC concentrations in groundwater when the P&T system was not in operation. As the study progressed, elevated concentrations of VOCs that exceeded predetermined trigger values were measured along the downgradient boundary of the study area, and so the P&T system was restarted. It was determined that a discrete area with VOC concentrations greater than the MCLs was present in groundwater downgradient of the extraction wells. The source was not identified, but the contamination was thought not to be caused by residually contaminated soil beneath the former landfill.

The data collected so far supports the consideration of MNA as a viable alternative to hydraulic containment. Additional investigations are being performed to identify possible sources or pathways of VOCs in groundwater that may be contributing to the elevated VOC levels measured downgradient of the extraction well system. Data from this additional investigation will be used to determine whether the VOCs detected downgradient of the hydraulic boundary are the result of residual soil contamination, a previously unknown contribution of VOC-contaminated water entering the groundwater outside the capture zone of the extraction wells, or a pulse of VOC-contaminated groundwater from the OU-1 landfill that occurred during the rebound study.

INTRODUCTION

At the Mound, Ohio, Site, groundwater in Operable Unit 1 (OU-1) has been impacted by volatile organic compound (VOC)-contaminated materials in the former solid waste landfill, and the groundwater is being contained using two extraction wells that create a hydraulic barrier. Since the source materials have been removed from the landfill, the feasibility of moving away from containment to a more passive remedy, namely monitored natural attenuation (MNA), is being considered as a viable alternative at the Mound site.

The present selected remedy for controlling contamination from residual soil and groundwater at OU-1 is the collection, treatment, and disposal of groundwater. MNA is being considered as a viable alternative to hydraulic containment for the following reasons:

- The majority of the source term has been removed from the former landfill.
- Concentrations of VOCs in groundwater have decreased since the removal the source.
- Attenuation mechanisms, such as dilution, dispersion, and trichloroethene (TCE) degradation, have been observed in OU-1 groundwater.

Since 2004 several studies have been performed and a large body of data has been collected to support the transition of the OU-1 groundwater remedy from an active remedy to MNA. Specifically, two rebound tests were performed to evaluate the behavior of contaminants in groundwater under unstressed conditions. The first test was performed prior to excavation of materials from the landfill and the second was performed after a significant volume of materials was excavated from the landfill. After excavation of the landfill was started, numerous rounds of in situ groundwater sampling were performed to monitor VOC migration as well as to better delineate the plume and it migration pathways. A recent investigation also included soil-gas and interval groundwater sampling.

Additional testing has been recommended to determine whether an area of VOC-impacted groundwater downgradient of the hydraulic barrier is (1) a remnant of a pulse of impacted groundwater that migrated at some point or (2) an actively sourced plume. Information from this testing as well as historical data will be evaluated to determine whether this site is a candidate for MNA.

BACKGROUND

The Mound Site is located in Miamisburg, Ohio, approximately 10 miles southwest of Dayton (Figure 1). In 1995, the U.S. Department of Energy (DOE) Mound Plant, named after the Miamisburg Indian Mound that is adjacent to the site, was comprised of 120 buildings on 306 acres. The Great Miami River located west of the site flows from northeast to southwest through Miamisburg and dominates the geography of the region surrounding the Mound site.

The Mound site was established by the U.S. Atomic Energy Commission, a predecessor to DOE, as an integrated research, development, and production facility that supported the nation’s weapons and energy programs. To reconfigure and consolidate the nuclear complex, DOE decided to phase out the defense mission at the Mound site. As a result, the Mound site was designated an environmental management site and the plant was converted into an industrial/commercial site.

After VOCs were discovered in the groundwater, the Mound Site was placed on the National Priorities List in 1989. DOE remediated the former DOE Mound site property to the U.S. Environmental Protection Agency’s risk-based standards for industrial/commercial use, and institutional controls are used to control land and groundwater use. The groundwater remedy for two other areas of the site is MNA for those contaminants that exceed maximum contaminant levels (MCLs). The OU-1 remedial action was designed to control groundwater contamination (primarily low-level volatile organic compounds) to prevent migration of contamination toward the plant production wells, and to minimize exposure to potential receptors.

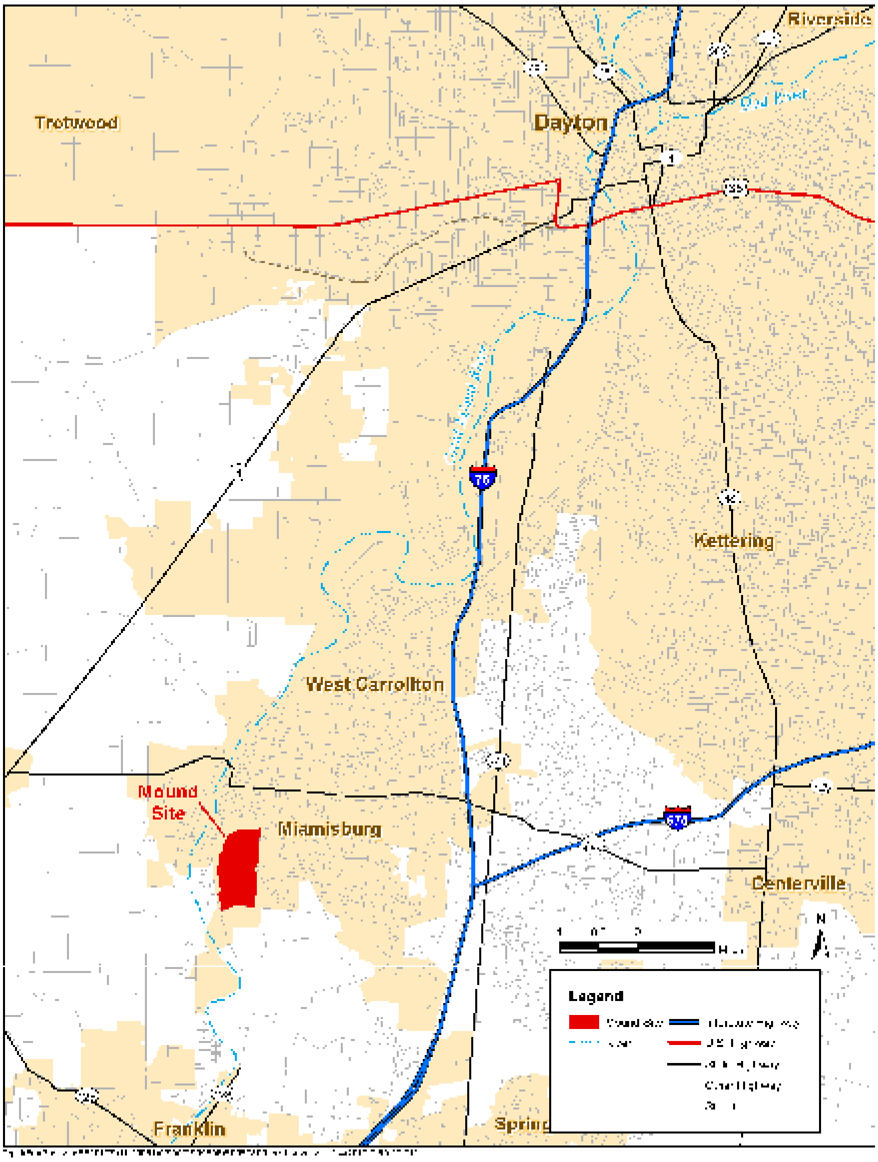

Figure 1. Location of Mound, Ohio Site.

VOC contamination in the buried valley aquifer (BVA) (a sole-source aquifer) originates from the site's former solid waste landfill and is addressed under OU-1. OU-1 occupies approximately 1.6 hectares (4 acres) in the southwestern portion of the Mound Plant (Figure 2) and includes a former landfill site that was used from 1948 to 1974 for the disposal of general trash and liquid waste. Much of the waste was later relocated and encapsulated in the site's sanitary landfill constructed in 1977. There were known releases of VOCs from OU-1 into the adjacent BVA. The pathway of concern consists of leaching of contaminants from site soils or disposed wastes; entrainment in the groundwater flow; and withdrawal by the Mound Plant production wells or by other future wells. The plant production wells were abandoned in October 2005, when the facility was connected to the municipal water supply.

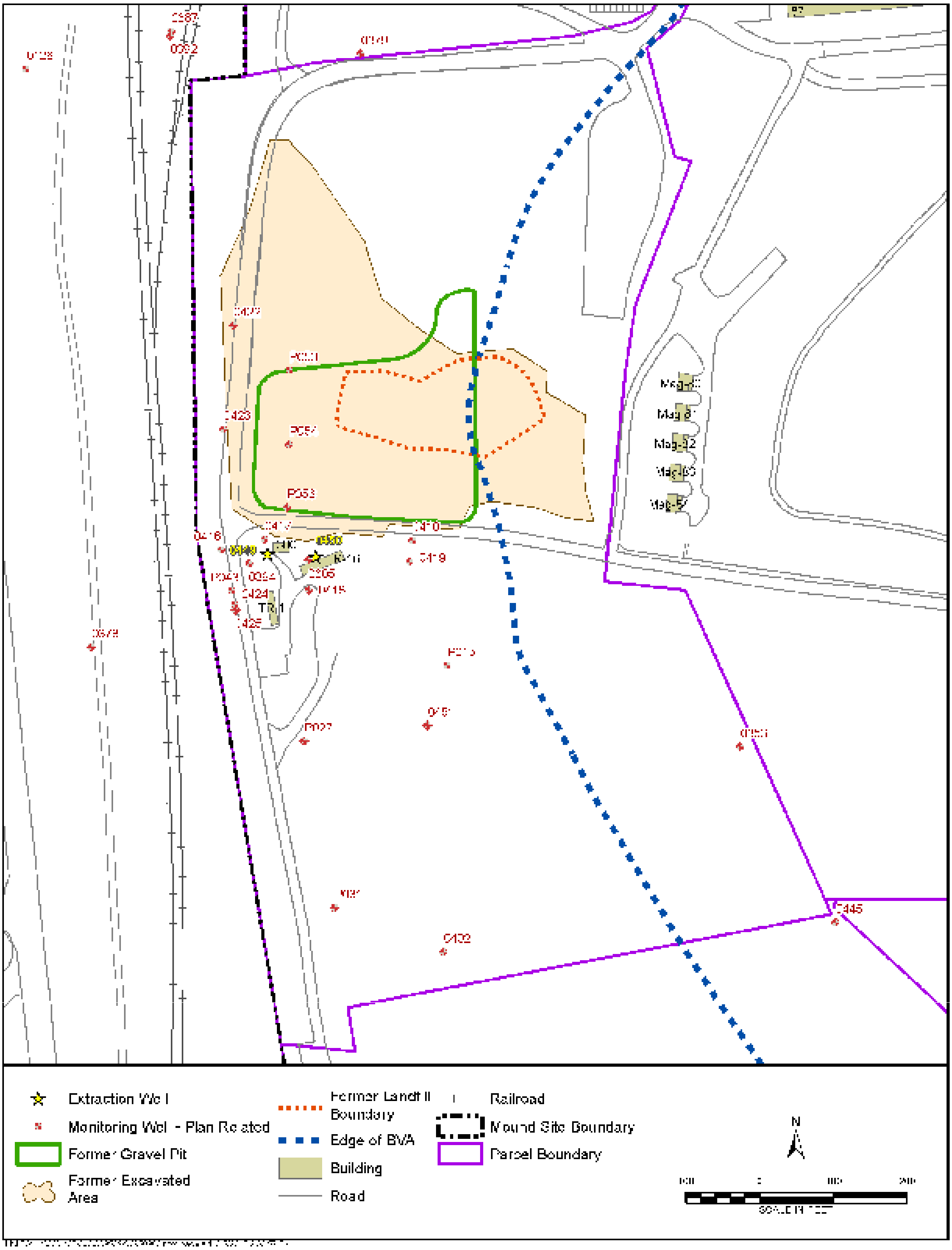

Figure 2. OU-1 Site Map.

The Record of Decision (ROD) for OU-1, signed in 1993, described the use of extraction wells to create a hydraulic barrier to prevent the migration of VOC-impacted groundwater from the landfill area. A technical evaluation of conditions within OU-1 was performed in 2003 to address concerns about data collected after the ROD. Among these concerns were uncertainties in site conditions, technology performance, and regulatory requirements. This evaluation included several areas of contamination that were not originally evaluated during the OU-1 ROD because either the sites had not been identified at the time of the ROD or they were located outside the OU-1 compliance boundary. These additional areas were evaluated to determine whether they could potentially impact groundwater and therefore the current OU-1 remedy.

Based on this technical evaluation, field investigations were performed to assess possible sources to groundwater. Results indicated no additional sources of VOCs to groundwater in the vicinity of the landfill. An area of polonium- and thorium-contaminated soil and waste within the landfill footprint was further characterized, and a determination was made to remove it. Excavation of approximately 11,468 m^3 (15,000 cubic yards) of contaminated soil and debris was completed in 2005. Groundwater impact south of the OU-1 landfill was identified earlier; it was considered an extension of the OU-1 groundwater plume and would be addressed through the implementation of the OU-1 remedy.

The OU-1 landfill was excavated in two phases from 2007 through 2010 to support future redevelopment of the property by the Mound Development Corporation. This non-CERCLA work resulted in the removal of approximately 12,233 m^3 (16,000 cubic yards) of material from the landfill and approximately 37,081 m^3 (48,500 cubic yards) of cover and berm material. The area was backfilled and restored after each excavation event.

Geology and Hydrogeology

The aquifer system at the Mound site consists of two different hydrogeologic environments: groundwater flow through limestone and interbedded shale layers beneath the hills, and groundwater flow within the unconsolidated glacial deposits and alluvium associated within the BVA in the Great Miami River valley. The bedrock flow system is dominated by fracture flow and is not considered a highly productive aquifer. No evidence of solution cavities or cavern development has been observed in any borings or outcrops in the area. The BVA is dominated by porous flow, with interbedded gravel deposits providing the major pathway for water movement. The unconsolidated deposits are Quaternary Age sediments consisting of both glacial and fluvial deposits ranging from fine silts to gravel. The BVA is a highly productive aquifer capable of yielding a significant quantity of water and is designated a sole-source aquifer.

Groundwater flow in the bedrock typically mimics the topography, with groundwater discharging to the BVA or discharge from the upper bedrock occurring at seeps (Figure 3). Groundwater flow in the BVA near the Mound site is to the southeast, following the downstream course of the Great Miami River. OU-1 is situated along the eastern edge of the BVA where the outwash and alluvial materials truncate along the bedrock to the west.

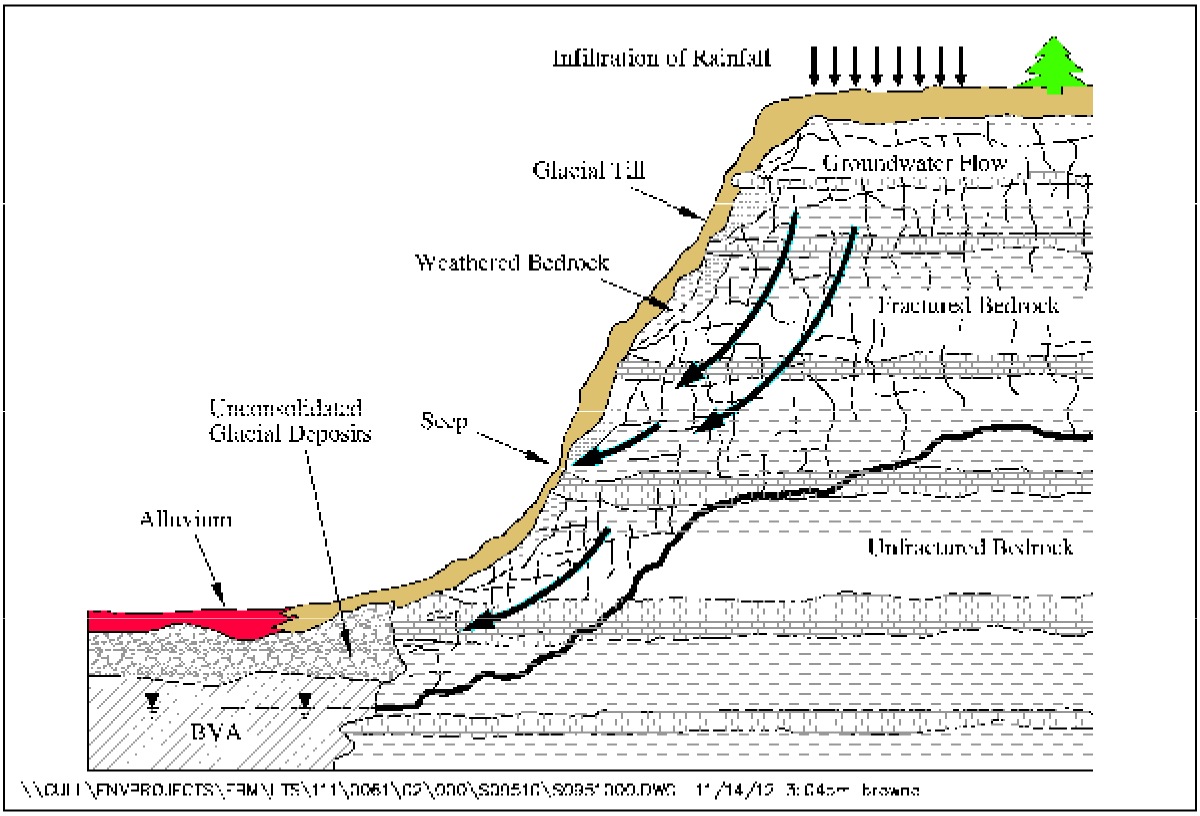

Figure 3. Generalized Cross-Section of Geology and Groundwater Flow at the Mound Site.

A map of the water table in OU-1 shows the depression of the groundwater surface around the extraction wells (Figure 4). It should be noted that the change in groundwater elevations across OU-1 is approximately 30.5 cm (1 foot), resulting in low hydraulic gradients and groundwater flow velocities on the order of less than 1 meter per day. Using site-specific data, the total width of the capture zone along the axis of the extraction wells is 261 m (856 feet) using the combined pumping rate of 106 liters per minute (Lpm) (28 gallons per minute [gpm]). The maximum total width of the capture zone range is 522 m (1,712 feet). The distance to the point where capture ends downgradient of the extraction wells (i.e., the stagnation point) is 83 m (272 feet). When the P&T system is operating, a zone of stagnation is created downgradient of wells P015 and P027. As a result, the groundwater in this area has limited movement and recharge.

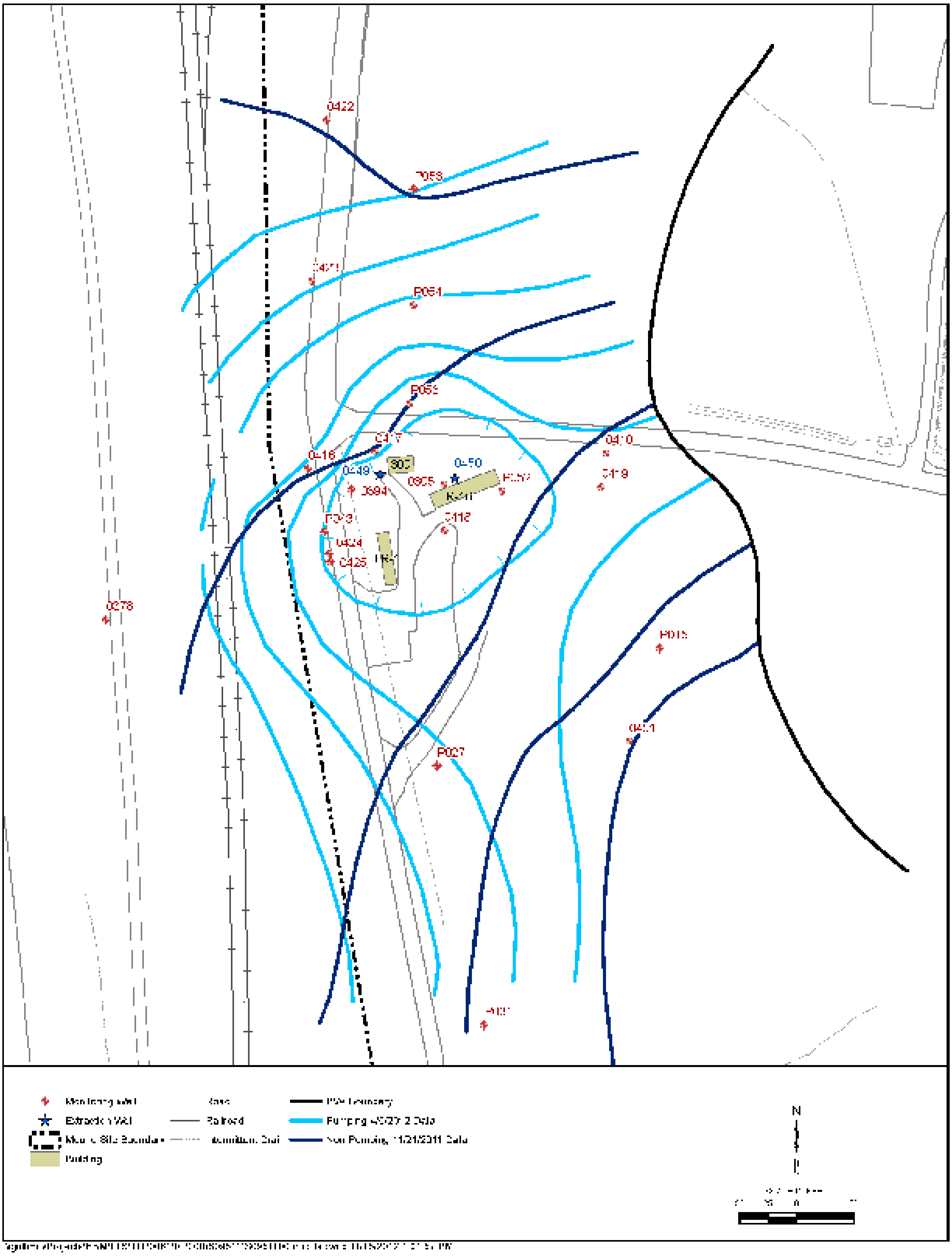

Figure 4. Groundwater Surface – Pumping and Non-pumping Conditions

As part of the P&T system evaluation, the system was shut down and restarted to determine unstressed groundwater flow and determine the area of influence of the extraction wells. A review of drawdown curves indicated that the drawdown resulting from the operation of the extraction wells at a combined rate of 91 Lpm (24 gpm) was small, ranging from 9.1 to 16.8 mm (0.030 to 0.055 foot). The small drawdowns are the result of low pumping rates in an aquifer with relatively high conductivity. It took between 350 and 400 minutes for the drawdowns to stabilize. Distance-drawdown plots were used to evaluate the radius of influence of the extraction wells operating at a combined rate of 91 Lpm (24 gpm). The distance-drawdown plot indicates that drawdown created by the extraction wells extended approximately 305 m (1,000 feet) after 400 minutes.

An aquifer test was performed prior to the 2011 rebound study to determine the effective downgradient extent of the capture zone created by the current extraction rates of the P&T system. Also, several external effects on the local water levels affecting the capture zone calculations were evaluated. The results of the aquifer test indicated that a capture zone that includes wells P015 and P027 was created with the wells operating at a combined pumping rate of approximately 138 Lpm (36.5 gpm).

Historical Monitoring and Testing

Starting in 1997, sampling of selected groundwater monitoring wells for VOCs was performed quarterly as specified in the operations and maintenance plan for OU-1. Data were analyzed to look for sustained downward trends as proof of successful capture of the plume. Hydrologic data were also collected to verify that hydraulic containment of the impacted groundwater was maintained.

A rebound test was performed from May 2003 through February 2004, and the system was restarted because predetermined VOC threshold concentrations were measured in a nearby downgradient well. The 2003 test was performed prior to the removal of the landfill; therefore, materials were present that provided a VOC source to groundwater. It was concluded from this initial rebound test that increases and decreases in the VOC concentrations in groundwater may have been linked to rises in the groundwater table, rather than being caused by a classical rebound of concentrations over time. During the test period, high groundwater levels were measured and were due to exceptionally high river stages. Increases in VOCs were observed in the wells coincident with the high groundwater levels and resulted from groundwater coming in contact with impacted material in the landfill.

In 2007, a more frequent groundwater monitoring program was implemented to support excavation of the landfill. Some original extraction wells were removed to accommodate additional source removal (i.e., the excavation of contaminated soil and debris from the landfill area). Sampling was performed in wells downgradient of the landfill to assess the groundwater quality in the BVA and the distribution of TCE closer to the landfill area and extraction wells. The sampling program changed over time (i.e., frequencies and locations) to address changing conditions as excavation activities progressed. Later, two extraction wells were installed south of the landfill to reestablish hydraulic containment of the impacted groundwater. The OU-1 landfill was backfilled to allow for future reuse.

After completion of the landfill excavation, a second rebound study was performed from June to December 2011. Data were collected to evaluate the changes in VOC concentrations in the monitoring network and changes in groundwater flow when the P&T system was not operating. Samples were collected at locations and frequencies that allowed for adequate time to prevent unacceptable migration of VOC in groundwater. Water level measurements were made to determine groundwater flow directions and changes caused by seasonal events. These data were to be used to determine if the existing monitoring network was adequate to detect migration of the VOC impacted groundwater. Trigger values were set for locations downgradient of the extraction system and were used to determine whether additional sampling was necessary, if new wells should be installed, or if the P&T System needed to be turned back on to prevent unacceptable migration of VOC impacted groundwater. Triggers were set at levels that would allow the test to run for as long a period as possible without negatively impacting the groundwater quality.

The study was designed so data from the rebound study could be used to determine the feasibility of implementing MNA to address the residual VOCs in groundwater and the adequacy of the existing monitoring network to support a MNA remedy. If contaminant and groundwater behavior monitored during a rebound test met the following conditions, MNA would be evaluated as a viable alternative for the groundwater in the OU-1 area:

- Decreasing trends in source area wells
- Stable concentrations that do not exceed the trigger values in the capture zone wells
- Concentrations less than the trigger values in the downgradient wells
- Existence of a network deemed adequate for monitoring or that would be adequate with the installation of additional well locations identified from monitoring data (from wells and/or Geoprobe samples)

The rebound test was stopped in December 2011 when VOC concentrations in two downgradient boundary locations exceeded the MCL (i.e., the pre-determined threshold). The results from this most recent study indicated that impact greater than the MCL is present downgradient of the hydraulic barrier created by the extraction well system. Concentrations of VOCs in wells near the landfill increased gradually, but did not reach threshold values that would have prompted restarting the P&T system.

Additional VOC Investigation

Before the P&T system was restarted in December 2011, a large-scale Geoprobe campaign was performed to determine the areal extent of VOC impact in the OU-1 area. Geoprobe sampling had been performed periodically to evaluate the movement of VOC impacted groundwater south of the extraction well system during the rebound study. The December sampling event included an additional 12 sample locations downgradient of well 0451.

Data from the wells and Geoprobe locations collected in December 2011 were used to provide the distribution of TCE in the groundwater at the end of the study (Figure 5). The distribution indicated that the areas of higher impact continued to be present beneath the former landfill and in the vicinity of wells 0410 and 0419. Elevated concentrations of TCE were measured in two Geoprobe locations and extended to well 0451. Well 0451, which was installed in response to VOC concentrations that exceeded rebound study triggers, has maintained a TCE concentration of 9 to 12 μg/L since installation. Another isolated area of impact greater than the MCL was measured downgradient of well 0451. The source of TCE impact near well 0451 does not appear to be the residually impacted soil located in the southwestern corner of the landfill.

Available information and data regarding VOC occurrence in the OU-1 area and areas to the north and east that may have a hydraulic connection to the OU-1 area were reviewed to prepare a recommendation regarding the elevated VOCs discovered as a result of the rebound study. The historical investigation and verification data did not indicate any known areas of VOC impact that had a large areal extent or concentrations that could constitute a significant source to groundwater in the OU-1 area. However, three areas (Figure 6) were evaluated with the objective of determining possible sources of or migration pathways for VOC impacted groundwater. The three areas included in this investigation were:

- A utility trench immediately upgradient of well 0451
- The buried excavation face of the historical gravel pit along the eastern boundary of the OU-1 landfill
- A wet area observed between well 0451 and GP-116

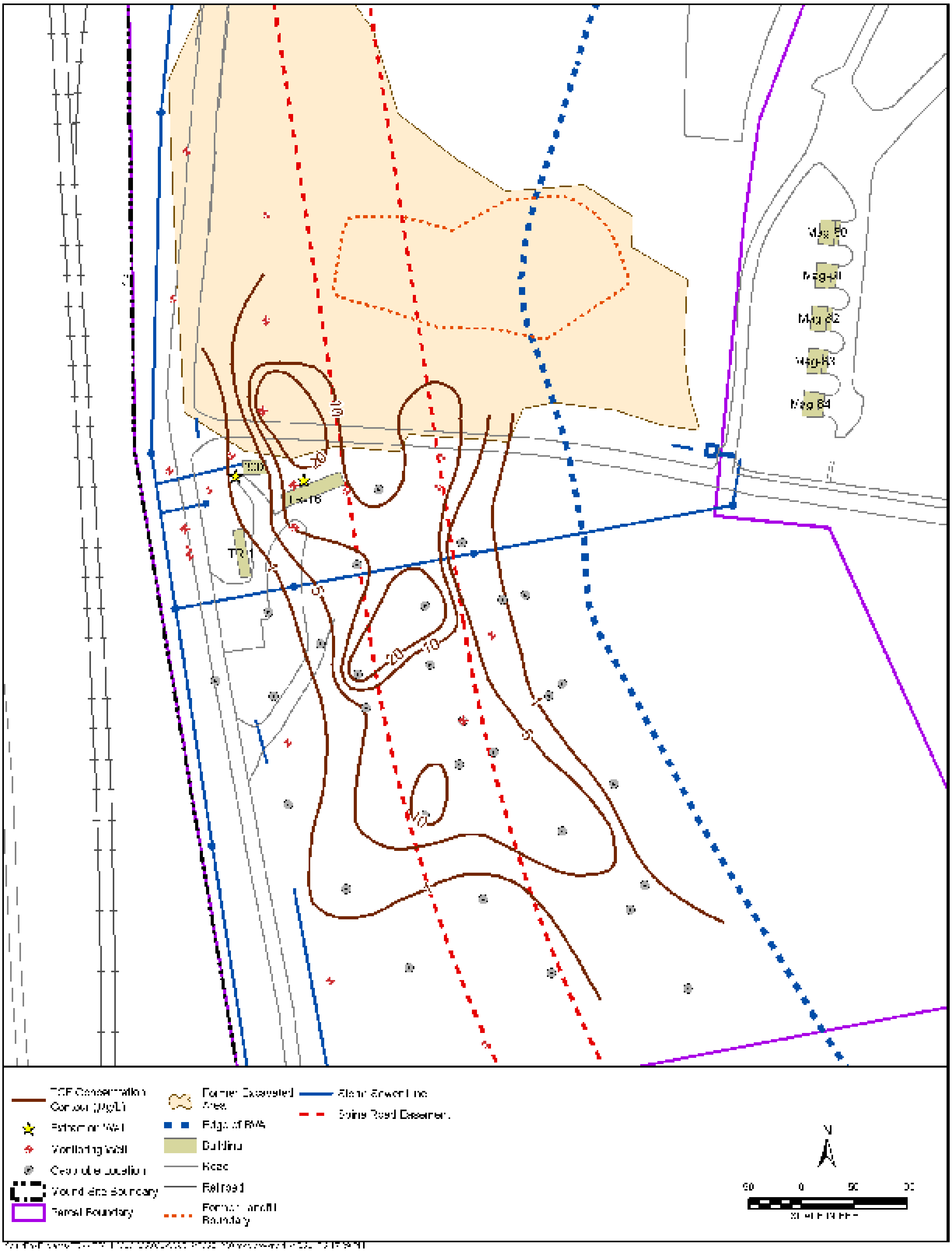

Figure 5. Distribution of TCE in Groundwater in December 2011.

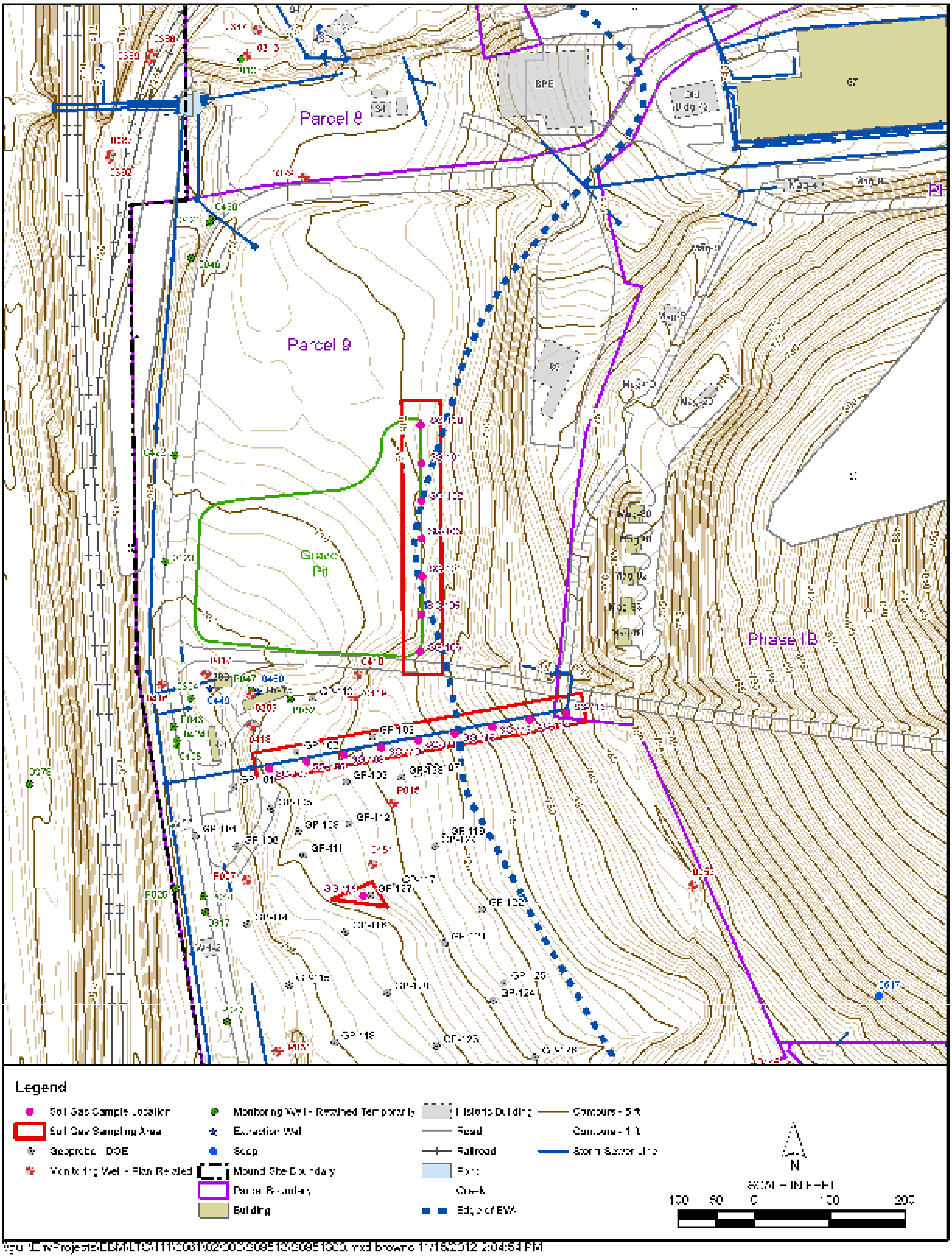

Figure 6. Additional VOC Investigation Study Areas and Sampling Locations.

A combination of groundwater sampling and soil-gas sampling was used to determine potential sources of VOCs at and downgradient of well 0451. Soil-gas samples were collected along the utility trench, along the buried excavation face, and within the wet area south of well 0451. Soil-gas sample collection started at a depth of 1.5 m (5 feet) below ground surface and continued at 1.2 to 1.5 m (4 to 5 feet) intervals to the top of the water table. Interval groundwater samples were collected from the locations along the buried excavation face in OU-1. Sample collection started at the top of the water table and continued at 1.2 m (4 feet) intervals to the top of bedrock, as determined by sampler refusal.

The results from the soil-gas sampling and interval groundwater sampling indicated the following:

- Soil-gas results did not indicate the presence of a residual soil source or the introduction of VOC-impacted groundwater along the utility corridor.
- Soil-gas results along the eastern side of the landfill indicated the presence of a residual soil source starting approximately 6.1 m (20 feet) below the ground surface and extending to the water table (Figure 7). The primary VOCs were TCE and *cis*-1,2-dichloroethene. The area of highest impact was centered on SG-103.
- Interval groundwater sampling results indicated that impacted soil acts as a source to groundwater, resulting in TCE concentrations greater than the MCL and increased *cis*-1,2-dichloroethene concentrations. It is likely this is the source causing the different contaminant signature in well 0410 and 0419 and extraction well 0450.

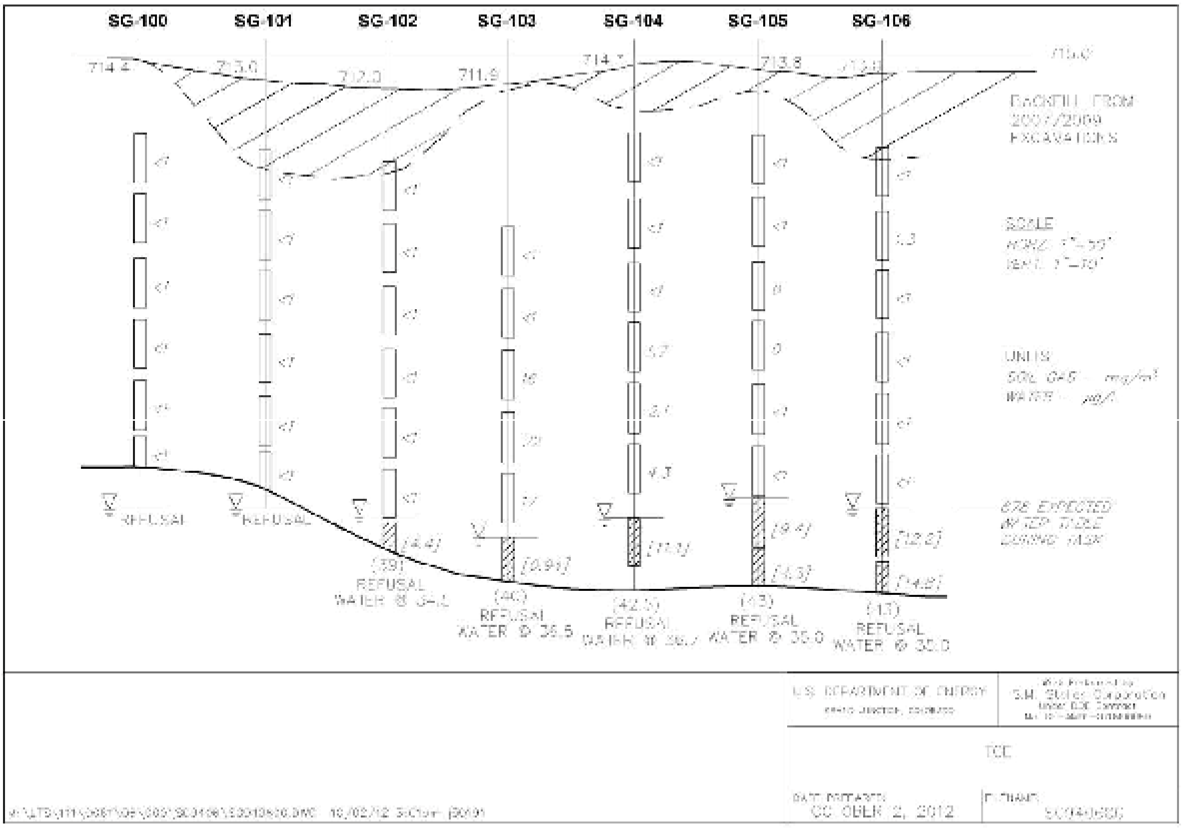

Figure 7. TCE Results from Soil-Gas and Interval Groundwater Sampling in OU-1 Landfill.

As part of the additional VOC investigations, the distribution of VOCs in groundwater was reevaluated in May 2012, approximately 6 months after the P&T system had been restarted. Concentrations of TCE in the farthest downgradient locations declined slightly while concentrations in the vicinity of well 0451 remained relatively unchanged. Concentrations under the landfill declined in response to the operation of the extraction system.

Upcoming Monitoring and Testing

The results and conclusions from the additional VOC investigations, as well as data from the two previous rebound tests and routine monitoring data, were used to develop a probable scenario of what happened in the occurrence or migration of VOC-impacted groundwater downgradient of the hydraulic boundary. It was concluded that the most plausible scenario was that during the initial OU-1 excavation project in 2007 a significant amount of VOCs were introduced into the groundwater and migrated southward with the natural groundwater flow. The excavation performed in 2007 targeted the materials with the highest VOC impact. A significant amount of construction water, as well as precipitation, were introduced into the excavation during that time. To support the excavation, the extraction wells were removed in June 2007 and then replaced in July 2007 when elevated VOCs were measured in nearby downgradient wells. However, the extraction rates during the first 6 months were very low (less than 38 Lpm [10 gpm]) and may not have accomplished complete capture of VOC-impacted groundwater originating from the landfill excavation. The wells were redeveloped several times in 2007 and 2008 and extraction rates were increased to 57 to 76 Lpm (15 to 20 gpm). With the reestablishment of the hydraulic barrier, a stagnation zone was created, preventing the natural dilution and dispersion of VOCs in the groundwater system. The area of groundwater impact is outside the influence of the extraction well system as determined by testing.

To identify whether the area of groundwater impact is (1) a remnant of a pulse of impacted groundwater that is held in place by the operation of the extraction wells or (2) an actively sourced plume, the following testing is being considered:

1. Chemical time-series sampling (also referred to as integral pumping testing) in well 0451 to identify the plume type (stagnant vs. active)
2. Geoprobe sampling to evaluate the distribution of VOCs in groundwater approximately 1 year after ending the rebound study and restarting the extraction wells

The conclusions reached from this testing will be incorporated into an overall evaluation of the OU-1 groundwater conceptual model for contaminant fate and transport. Elements would include:

- Using the results from the chemical time-series sampling and updating the OU-1 conceptual model regarding groundwater impact to reflect current conditions
- Modifying the groundwater remedy using the new data for a better understanding of the presence of elevated VOCs in groundwater downgradient of the hydraulic boundary

CONCLUSIONS

The body of data collected to date supports that MNA should be considered as a viable alternative to hydraulic containment for the following reasons:

- The majority of the source term has been removed from the former landfill.
- Concentrations of VOCs in groundwater have decreased since the removal of the source.
- Attenuation mechanisms, such as dilution, dispersion, and TCE degradation, have been observed in OU-1 groundwater under unstressed conditions.