Implementation of an In Situ Soil Vapor Extraction Pilot Study at Technical Area 54 at the Los Alamos National Laboratory

T. Anderson, K. Kisiel, S. Dunn, M. Hartmann, D. Wykoff
Apogen Technologies
1350 Central Ave., Los Alamos, NM 87544
USA

J. Hopkins, P. Stauffer
Los Alamos National Laboratory
Los Alamos, NM 87544
USA

ABSTRACT

Non-radioactive liquid chemical waste was disposed at Material Disposal Area (MDA) L within Technical Area 54 (TA-54) at the Los Alamos National Laboratory (LANL) from the early 1960s until 1985. The surface of the site is currently used for Resource Conservation and Recovery Act (RCRA)-permitted chemical waste storage and for mixed waste storage under interim status authority. The major contaminant release at the site is a subsurface organic solvent vapor-phase plume consisting of several volatile organic compounds (VOCs) including 1,1,1-trichloroethane (TCA), trichloroethene (TCE), carbon tetrachloride, chloroform, tetrachloroethene (PCE), toluene, and benzene. Other contaminants that have been detected, but at much lower concentrations, and include chlorobenzene, xylenes, and 1,2,4-trimethylbenzene. TCA was found in the greatest concentration, and it also exhibits the greatest lateral and vertical extent in the organic vapor plume. The measured concentrations of TCA are almost an order of magnitude greater than values measured for TCE, the contaminant of second highest concentration.

Under LANL's Environmental Stewardship–Environmental Remediation and Surveillance Program, extensive sampling and analysis have been conducted to determine the nature and extent of the plume, and a conceptual model to characterize the subsurface plume has been developed. Data analysis has shown that the site does not currently pose a potential unacceptable risk to human health or the environment.

LANL proposes to conduct a study to determine whether a soil vapor extraction system can effectively remove VOC contamination from the subsurface vapor-phase plume at MDA L. Previous investigations conducted at MDA L on plume remediation include a Pilot Vapor Extraction Test (PVET), in which a soil vapor extraction (SVE) system was constructed and operated near the outer boundary of the plume. The results of this test demonstrated the potential effectiveness of SVE at MDA L. The proposed study entails installation of an active soil vapor extraction system to evaluate the rate of reduction of the contaminant concentrations immediately around the source terms. Active extraction will be conducted over an approximately four-month period, which should be complete by the end of March 2006.

Continued subsurface monitoring of the vapor contaminant concentrations will capture soil vapor concentration rebound and will determine when or if additional extraction should take place. Rebound analysis will also provide valuable information on the nature of the source. Should future monitoring indicate an increase in the soil vapor concentrations, the emplaced extraction system may be used to remove and treat contaminants, ensuring that the subsurface plume does not increase in size or concentration. Continuous monitoring of the off-gas will be conducted to ensure that all regulatory requirements are met. Data from this study will be used in the corrective measure evaluation for MDA L to assess the effectiveness of SVE as a remedy for remediation of the subsurface vapor-phase plume at MDA L.

INTRODUCTION

Los Alamos National Laboratory (LANL or Laboratory) is a multidisciplinary research facility owned by the U.S. Department of Energy (DOE) and managed by the University of California (UC). The Laboratory’s Environmental Stewardship–Environmental Remediation and Surveillance (ENV-ERS) Program is charged with investigating sites contaminated or potentially contaminated by past Laboratory operations. The nature and extent of contaminant releases are determined in accordance with the 2005 Compliance Order on Consent (the Order). Work plans are prepared to present recommendations for activities required to complete the site characterization.

One site that ENV-ERS is currently investigating is Material Disposal Area L (MDA L) at Technical Area 54 (TA-54) at Los Alamos National Laboratory (the Laboratory). MDA L, approximately 2.5 acres, was used for subsurface disposal of Laboratory-generated nonradiological liquid chemical waste. Characterization of the site began in 1985. The major contaminant release at the site is a subsurface organic solvent vapor-phase plume. Since 1997, the Laboratory has conducted quarterly sampling of volatile organic compound (VOC) pore gas throughout the subsurface area. This monitoring and completion of activities defined in the MDA L investigation work plan (LANL 2004, 87624) have provided sufficient data to estimate the nature and extent of the VOC vapor-phase plume. Extraction data from a previous soil vapor extraction (SVE) pilot study carried out between 1994 and 1997 (discussed further in Section 2.3.1) showed that the contaminant movement through the media was not retarded. This finding, coupled with the fact that rock samples from boreholes as deep as 300 ft showed no condensed liquid VOC or sorption of organic compounds on the matrix, indicates that no free-liquid form of the contaminant is present. This observation is consistent with the absence of organic carbon, low moisture content, and low specific surface area of the media. Based on these observations, the conceptual model of the site assumes that organic liquids leak slowly from the buried containers and volatilize rapidly and that the VOC vapor-phase plume is at near steady state.

Previous investigations conducted at MDA L include a Pilot Extraction Study Plan (PESP) and an independent Technical Advisory Group (TAG) study to evaluate potential plume treatment alternatives. The PESP included a Pilot Vapor Extraction Test (PVET), in which an SVE system was constructed and operated near the outer boundary of the plume. The results of this test demonstrated the potential effectiveness of SVE at MDA L. Based on a detailed data review, including the results of the PVET, the TAG concluded that SVE may be a potentially effective method for removing VOCs at the site.

This document describes a pilot study which implements in situ SVE technology at MDA L. The study will support the MDA L corrective measures evaluation (CME) by evaluating SVE technology as a method for removing organic vapor from the subsurface and as a potential method to minimize the growth of the plume in the event that the source term changes substantially (e.g., one or more containers holding the liquid waste fails). The results of the pilot test will be used to evaluate the potential effectiveness of SVE for treating the vapor plume at MDA L and to determine the SVE treatment system design criteria.

Background

From the early 1960s until 1985, MDA L was used as a subsurface nonradiological liquid, chemical-waste disposal facility. Both containerized and uncontainerized liquid chemical wastes, including chlorinated solvents, were disposed of at the site. The MDA L disposal facilities consist of 3 surface impoundments, 1 pit, and 34 vertical shafts, as shown in Figure 1 (to be added). None of the disposal areas were lined.

Pit A operated between 1964 and 1978, during which time uncontainerized bulk quantities of treated aqueous waste were disposed of directly into the pit and left to pool and evaporate. Disposal records indicate 38,333 gal. of waste were disposed of during the life of the pit. When the pit was decommissioned in 1978, it was covered with crushed tuff. The waste was not reported to contain VOCs; thus, Pit A is not considered to be a source of the subsurface VOC contamination. The surface impoundments (B, C, and D) operated from 1969 to 1986. Impoundment B operated between 1969 and 1985, Impoundment C operated between 1972 and 1986, and Impoundment D operated between 1972 and 1974. Surface Impoundments B and C were used as evaporative lagoons for treated salt solutions such as ammonium bifluoride and electroplating wastes, which are sources of copper, barium, chromium, and zinc. Impoundment D was used exclusively for treating small-batch quantities of lithium hydride by reaction with water and allowing the neutralized solutions to evaporate. After decommissioning, the impoundments were covered with a minimum of three ft of crushed tuff. Most wastes disposed of in the surface impoundments were inorganic chemicals; therefore, Impoundments B, C, and D are not considered to be sources of the subsurface VOC vapor contamination.

The 34 disposal shafts are split into two areas on either end of MDA L. Shafts 1–28 operated between 1975 and 1985 and are grouped on the east end of MDA L around Pit A. Shafts 29–34 operated between 1983 and 1985 and are grouped on the west end of MDA L. The majority of the shafts are approximately 60 ft deep and range from 3 ft to 8 ft in diameter. The shafts primarily received 55-gal. metal drums containing chemical liquid waste. The drums were layered with one to six barrels per layer. Each layer was covered with approximately 6 in. of crushed tuff to provide absorbent material for any leaks and to provide structural support for the drums. Before 1982, containerized liquids were disposed of without adding absorbents to the containers in which they were placed. In addition to the drums, unknown quantities of small containers and uncontainerized liquids were disposed of in the shafts. The shafts are considered to be the contaminant sources for the VOC plume. No existing records provide estimated waste volumes in the shafts.

After subsurface disposal activities at the site ended, most of the surface was covered with asphalt and/or chemical waste storage structures. Area L is used for Resource Conservation and Recovery Act (RCRA)-permitted chemical waste storage and treatment and for mixed-waste storage under interim status authority.

Site Conditions

The Laboratory lies on the Pajarito Plateau between the Jemez Mountains and the Rio Grande. Bandelier Tuff, a thick sequence of ash-fall pyroclastics, caps the plateau. Erosion of the tuff over time has created a series of canyons separating the narrow, finger-like mesas that comprise Pajarito Plateau. MDA L is situated atop one such mesa, Mesita del Buey.

The strata below MDA L are composed of nonwelded to moderately welded rhyolitic ash-flow and ash-fall tuffs interbedded within pumice beds. The rhyolitic units overlie a thick basalt unit, which, in turn, overlies a conglomerate formation. Canyons on either side of MDA L (Cañada del Buey to the north and Pajarito Canyon to the south) lie approximately 100 ft below the steep-sided mesa. The regional aquifer is located approximately 985 ft below the disposal pits. No perched aquifers are known to occur below the mesa (LANL 1998). The Bandelier Tuff is the upper most formation and consists of the Tshirege and Otowi Members separated by the Cerro Toledo. Three upper units make up the Tshirege Member of the Bandelier Tuff. Unit 2 (Qbt 2) and the upper portion of unit 1v (Qbt 1v) are fractured, and the fractures are often filled with calcite and/or clay. The Cerro Toledo stratum (Qct) is made up of volcanoclastic sediments interbedded with minor pyroclastic flows. The Otowi Member (Qbo) underlies the Cerro Toledo interval and consists of nonwelded to poorly welded tuff containing little evidence of fracturing (Vaniman and Chipera 1995). The Cerros del Rio basalts lie beneath the tuffs and make up roughly 35% of the vadose zone. Characteristics of this unit vary widely, ranging from extremely dense with no effective porosity to highly fractured to very vesicular so as to appear foamy (Turin 1995). The Puye Formation is a conglomerate deposit that underlies the Cerros del Rio basalts. The water table occurs within the Puye Formation beneath TA-54. A summary of the site geology and geologic properties can be found in the MDA L investigation work plan (LANL 2004).

Table 1 summarizes the geohydrologic and hydraulic properties for the stratigraphic layers and provides the bulk density, porosity, in situ permeability, moisture content by volume, percent saturation, saturated hydraulic conductivity, and degree of induration and fracturing of the various formations. The bulk permeability of the media can be inferred from data collected in boreholes at the site (SEA 1997). Anemometry measurements from boreholes at the site provide information on the bulk flow within the media. These data indicated that in the upper 300 ft of strata, air flows primarily through the Cerro Toledo. Subsequent discrete point permeability measurements confirmed the Cerro Toledo has a higher permeability than the other stratigraphic layers (3–10 darcies compared to 0.2–0.9 darcies). Figure X (to be added) shows both the anemometry and discrete-point permeability measurements from borehole 54-01018. The variability in the anemometry readings in the Qbt 1g unit resulted from measurement variability; however, the general trend of the data is consistent with the permeability results.

Summary of Previous Site Characterization Investigations

In 1985, the Laboratory received a compliance order from the New Mexico Environmental Improvement Division (NMEID, now the New Mexico Environment Department [NMED]) addressing numerous waste issues (NMEID 1985). The order specified six tasks involving site investigation activities in and around MDA L. These tasks required measuring specific soil characteristics at the site, including intrinsic permeability, soil-moisture characteristic curves, and unsaturated hydraulic conductivity; analyzing the infiltration and redistribution of meteoric water into the site soil; characterizing the core and pore gas in the vadose zone; and analyzing the potential presence of perched water. In 1987, the Laboratory provided the results of work performed to complete those tasks (LANL 1987, 76068). Implementation of quarterly pore-gas monitoring at MDA L began in 1990. Phase I of the RCRA facility investigation (RFI) for MDA L began in 1993 and was completed in 2001. Analysis of core and pore-gas samples collected at the site during the Phase I RFI and quarterly monitoring has led to the following conclusions:

- The 34 disposal shafts, grouped at the east and west ends of the site, are considered to be the source of the VOCs.
- The primary constituents of the plume are 1,1,1-trichloroethane ([TCA] 75%); trichloroethene ([TCE] 12.5%); and Freon (11%).
- Free organic liquid has not been detected below the shafts.
- Sorbed organic chemicals have not been detected below the shafts.
- Pore gases are contaminated with VOCs.
- The VOC vapor plume has migrated over 330 ft laterally along the long axis of the mesa from the shafts; the depth of the10 ppmv TCA contour is approximately 300 ft bgs.
- The total mass of VOCs in the plume is at least 2200 lbs.

In 1993 and 1994, the surface flux of VOCs and tritium was measured (Quadrel 1993; Quadrel 1994; Eklund 1995; Trujillo et al. 1998), and core samples were collected (LANL 1994). In 1994, channel sediments from tributaries of Cañada del Buey were analyzed (LANL 1996), and ambient-air samples were collected. Between 1994 and 1997, the PESP was carried out to determine whether SVE is an effective method for removing VOCs beneath the site. Soil matric potential, in situ soil permeability, and borehole anemometry measurements were made, and poregas pressures and chemical constituents were recorded at several boreholes. In 1996, the VOC vapor plume at the site was modeled using T2VOC, and a tracer gas injection/monitoring system was used to evaluate the disturbance of pore gas by air-rotary drilling. In 1997 and 1998, the effectiveness of passive vapor extraction of subsurface vapor-phase VOCs was studied. In 2001, the impact of a single drum failure on the VOC plume extent was evaluated (Stauffer et al. 2002, 88400). The results of these previous investigations are summarized in Appendix B of the MDA L investigation work plan (LANL 2004).

In 2004 and 2005, ENV-ERS completed field work to finalize the characterization of the nature and extent of contamination at MDA L as specified in the investigation work plan for MDA L (LANL 2004). Seven boreholes were drilled in 2004 and 2005 to supplement the data from the 1995 investigation at MDA L (LANL 2004). Pore-gas samples were collected from each of the seven boreholes and analyzed for VOCs.

Characterization of the Vapor Plume

A review of analytical results for pore gas samples collected from boreholes at MDA L between 1988 and 1992 was presented in a report entitled "Pilot Extraction Study Plan for the Organic Vapor Plume at MDA L" (LANL 1993), which stated,

> the principal vapor phase organic compounds, listed in descending order of concentration, were TCA, trichloroethene (TCE), carbon tetrachloride, chloroform, tetrachloroethene (PCE), toluene, and benzene. Other contaminants that have been detected, but at much lower concentrations, include chlorobenzene, xylenes, and 1,2,4-trimethylbenzene. TCA was found in the greatest concentration, and it also exhibits the greatest lateral and vertical extent in the organic vapor plume. The measured concentrations of TCA are almost an order of magnitude greater than values measured for TCE, the contaminant of second highest concentration.

Pore-gas analytical results from quarterly sampling continue to indicate that the highest concentrations of vapor-phase VOCs exist in close proximity to the two shaft clusters (at the east and west ends of MDA L). Concentrations of vapor-phase VOCs decrease in all directions from the two source areas. TCA has consistently been the most prevalent VOC detected in pore-gas samples and is the best indicator of the extent of the plume.

Since 1999, the long-axis areal extent of the plume, defined by the 10 ppmv contour of TCA, has fluctuated between 700 and 1000 ft. The short-axis extent has not fluctuated significantly because of the physical constraint of the mesa walls (zero-concentration boundaries). Vertically, the maximum extent of the 10 ppmv TCA contour is approximately 300 ft below the mesa top (pore-gas samples are monitored to a depth of 607 ft bgs). The extent has not fluctuated significantly since 1999. The 10 ppmv TCA contour is approximately 650 ft above the regional aquifer. Data analysis of pore-gas pressures and chemical constituents at boreholes 54-01015 and 54-01016 during 1995 and 1996 indicate that the Cerros del Rio basalt layer is vented to the atmosphere at a remote, unknown location. The plume decreases to field screening detection limit concentrations before the basalt contact; thus, any contaminant entering the basalt layer is at or below field screening detection levels. In this regard, the basalt appears to act as a barrier to vertical vapor migration.

An evaluation of preliminary vapor data collected from seven boreholes completed as part of site characterization activities in 2004 and 2005 indicates that the results are consistent with data collected during the RFI and during quarterly monitoring. Vapor concentrations are highest close to the source area and decrease with lateral distance and depth. Furthermore, these results do not indicate the presence of a free product release.

VOC concentrations have remained relatively constant or have decreased slightly over time. Therefore, it the plume appears to be in a near steady state. Stauffer et al. (2002) modeled the plume evolution using a three-dimensional finite element program. The model assumed vapor diffusion emanating from two source areas located at the two shaft fields at MDA L. The model was calibrated using the quarterly pore-gas monitoring data. The resulting modeled plume closely matches the shape, concentration gradients, and extent of the plume as measured. The model also predicted that the plume should be at or near steady state. This modeling supported the conclusion that the VOC plume exists predominantly in the vapor phase, that the VOCs move by diffusion, and that the plume is stable. Stauffer et al. (2002) also predicted the plume's evolution over time and concluded that if the assumed source remains constant, the plume will continue to grow slowly. The model fit was improved by allowing for the partitioning of VOC into pore water. If a constant source was removed in the simulations, the plume decreased in mass as VOC is lost to the atmospheric boundary, with the 10 ppmv contour contracting back toward the source region.

Given the relatively constant state of the plume, it can be deduced that the mass of contaminant added to the source by small leaks from the containers must be balanced by the atmospheric emissions through the mesa sides, basalt layer, and atmospheric boundary. However, wastes in the 34 disposal shafts represent a significant uncertainty for any future predictions because the magnitude of future contaminant release rates cannot be predicted. The number of intact drums, bottles, or other containers is not known, and it is not possible to predict when or if they will fail. The Laboratory recognizes the need to consider future drum failures in managing the site and, therefore, has proposed this pilot study.

To date, the major findings of plume characterization activities are:

- Releases from disposal units at MDA L resulted in a subsurface vapor-phase VOC plume extending beneath the site and beyond the boundary of MDA L.
- Vertically, the 10 ppmv TCA contour is approximately 300 ft bgs; VOCs have not been detected in vapor samples from the basalt or below.
- The long-axis extent of the plume along the length of the mesa, as defined by the 10 ppmv TCA contour, has fluctuated between 700 and 1000 ft. The short-axis extent is defined by the width of the mesa (approximately 450 ft across).
- VOCs are transported from the source areas in the vapor phase.
- TCA is the primary constituent of the VOC plume.
- TCA concentrations vary across the plume.
- The plume has changed very little in area or contaminant concentrations since 1999.
- Uncertainties associated with potential increases in the source term from container failure in the future are significant.

Soil Vapor Extraction

Soil vapor extraction (SVE) was studied as a proposed remedy for the MDA L vapor plume between 1994 and 1997. The initial goal was to us active SVE to retract the plume to the vicinity of the source, followed by using passive extraction techniques over the long-term to maintain the plume in its contracted state. Various tests conducted by the Laboratory helped to define the process of vapor venting in the Bandelier Tuff

SVE is an in situ technology to remediate soil in the unsaturated (vadose) zone whereby a vacuum is applied to the soil to induce the controlled flow of air resulting in removing volatile and some semivolatile contaminants from the soil. The gas leaving the soil may be treated to recover or destroy the contaminants, depending on local and state air discharge regulations. Vertical extraction vents are typically used at depths of 5 ft or greater and have been successfully applied as deep as 300 ft. In VOC contaminated soils with appropriate physical and chemical properties, SVE is a relatively inexpensive and efficient technology that can remove up to 99% of the VOC contaminants. This technology was shown to be effective at the Laboratory and at DOE's Hanford Site in Washington. Over a period of 20 months, the Laboratory's SVE system removed a total of 16,000 pounds of light-end hydrocarbons from the Knights of Columbus site in Los Alamos County. Over a period of nine years, the Hanford SVE system extracted a total of 170,000 lbs of carbon tetrachloride (CCl4) from the vadose zone. Over this period, CCl4 concentrations decreased from initial concentrations of 30,000 parts per million by volume (ppmv) to 40 ppmv.

This results of characterization studies had confirmed that subsurface properties were amenable SVE as a potential remediation strategy:

- Porosity of the volcanic tuff is high, with average values near 50%.
- Air permeability varies between 10-9 and 10-7 cm2, with the highest values measured in fracture zones.
- Intrinsic permeability varies between 1.5x10-9 and 2.5x10-9 cm2.
- Temperature is in the range 9-10° C and is quite stable at depths greater than 30 ft.

Moisture contents measured in the vadose zone beneath MDA L are relatively low (1% to 13% gravimetric moisture content). No intermediate or perched groundwater has been identified beneath MDA L. The regional aquifer is located 970 ft below the mesa top within the Santa Fe Group at 5820 ft above Mean Sea Level. Infiltration rates through the vadose zone at TA-54 have been estimated to be in the order of several centimeters per year.

Preliminary Pilot Vapor Extraction Test

The Pilot Vapor Extraction Test (PVET) was performed over a 34-day period between September and October 1995 at the edge of the VOC vapor plume. Borehole 54-01017 was completed as the extraction borehole for the test.

Steel surface casing (8 in. in diameter) extended to a total depth of 75 ft, and the open borehole (9 in. in diameter) extended to a total depth of 150 ft below ground surface (bgs). A 5hp, 208V regenerative blower capable of up to 203 ft3 per min and a maximum vacuum of 88 in. of water column were used to extract the soil gas. Given the low contaminant concentration of the soil gas in this area, no vapor treatment system was required. The extraction process, including the total flow from the borehole, borehole vacuum, extraction air temperature, and atmospheric pressure, soil-gas pressure, and soil-gas contaminant concentrations, was measured during the test (ERM/Golder 1997, 70334). No known open boreholes or holes were detected within the extraction zone during the PVET. During the test, the PVET system extracted approximately 25 standard cubic feet per minute (scfm) of air. The extraction rates of the contaminants monitored during the PVET are shown in Table 2 (to be added later). Analysis of the data showed that the influence of the extraction system extended approximately 140 ft horizontally from the extraction interval. It was determined that this radius of influence may be great enough that the plume at MDA L could be remediated and/or controlled with an SVE system.

Little change was seen in the soil-vapor contaminant concentrations or the measured pressures below the extraction interval. Fresh air from the surface was drawn down to the high-permeability region of the Qbt stratigraphic layer (starting approximately 120 ft bgs), particularly the Qbt 1v(c) layer, and then moved laterally through this layer to the extraction borehole. Hence, these layers, which coincided with the highest contaminant concentration levels, provided a large percentage of the total extracted flow. Data analysis using a pure resistive/capacitive circuit model estimated that up to 99% of the contaminants in the existing the plume could be removed in 90 to 175 days.

The test demonstrated that organic vapors in the tuff media beneath MDA L move readily toward an extraction borehole with little or no sorption, making this technology well-suited for plume control and/or remediation. Further, a comparison of the measured data with pre-test modeling results showed that standard numerical and analytical modeling techniques may be used to predict air flow within the media.

The strong correlation between the model and the measured data confirmed that discrete near-field permeability measurements were adequate in representing bulk flow in the media. The main conclusions of PVET activities may be summarized as follows:

- During active vapor extraction, the vapor moved at the same velocity as the pore gas. By tracking the concentration at several depth intervals in several boreholes, it was concluded that the contaminant movement through the media was not retarded. This conclusion was further supported by the lack of a restart spike in the active extraction borehole.
- The Laboratory measured both the in situ horizontal permeability as a function of depth in several boreholes and the gross borehole flow using an anemometer. Pressure data from the active and passive extraction tests indicated that the vertical permeability was different from the measured horizontal permeability at some locations. The Laboratory also measured the flow in open boreholes induced by variations in barometric pressure. Close agreement of the data with modeling efforts indicated that the flow into and out of a borehole is governed by the horizontal permeability and is reduced by the vertical penetration of barometric pressure variations into the earth from ground surface. In addition, the passive tests showed air flow rates at most locations across the mesa will be fairly similar, although occasionally a borehole will hit a cavity or fracture that alters the flow.
- Measured penetration of barometric pressure variations within the Bandelier Tuff and the underlying Cerros del Rio basalt showed that air flow in Qbt 1v(c) is dominated by fractures and vertical flow.
- Based on induced subsurface vacuum pressure at steady state, the radius of influence of the PVET was approximately 140 ft. The test also indicated that the depth of influence was equivalent to the depth of the extraction borehole.
- Air velocities of the plume within the Qbt 1v(c) (colonnade) averaged approximately 1.6 ft per day.
- The PVET effect on TCA concentrations and negative-pressure propagation was different in various subunits of the Bandelier Tuff.

- The greatest change in TCA concentrations and air flow caused by the PVET occurred in Qbt 1v(c). This subunit demonstrates geohydrologic characteristics that are conducive to enhanced air flow, including induration-supporting fractures, fine-grain size that enhances porosity, and overall higher permeability than the units above and below it.

Results of the Technical Advisory Group Evaluation

In mid-2001, a TAG was formed by DOE’s Innovative Treatment and Remediation Demonstration (ITRD) Group to provide technical assistance in evaluating remedial technologies for the vapor-phase plume at MDA L (LANL 2004). The specific goals of the TAG were to evaluate the site and to assess passive and active venting versus other applicable technologies in order to remediate the vapor phase plume. The TAG used a remediation technologies screening matrix that was originally developed by the U.S. Environmental Protection Agency (EPA) and the U.S. Air Force (EPA/542/B-93/005). The screening matrix identifies processes used to remediate contaminated soil and groundwater with some degree of success. In situ biological treatment, in situ physical/chemical treatment, in situ thermal treatment, ex situ biological treatment, ex situ physical/chemical treatment, ex situ thermal treatment, containment, and other treatment processes were considered. After reviewing the data, the TAG concluded that vapor extraction and natural attenuation were viable remediation technologies. In addition, the TAG concluded that because waste in the 34 disposal shafts constitutes a VOC vapor source term that will probably continue to release contaminants into the formation, vapor extraction was deemed more feasible than natural attenuation. The TAG report (LANL 2004) listed the following as primary factors favoring vapor extraction:

- the absence of phase separated liquid (free product),
- a large depth to the bottom of the plume (10 ppmv TCA at approximately 300 ft bgs),
- very low organic carbon in tuff that resulted in easy desorption of adsorbed VOCs,
- the presence of the contaminant only in unsaturated medium,
- reasonable soil flow characteristics, and
- high volatility and low sorption of the halogenated VOCs.

The combination of these factors led the TAG to conclude that contaminant removal rates by vapor extraction would be very high and that the vapor-phase plume at the site could be remediated by SVE.

MDA L Soil Vapor Extraction Pilot Study

The results of the PVET indicate that an SVE system may be used effectively to extract VOCs from the subsurface vapor plume at MDA L. Additional data on the effectiveness of SVE in the two source areas are needed to support evaluation of this technology as part of the corrective measures evaluation (CME) for MDA L.

The PVET provided important data for the design of the SVE. However, the design will differ from the PVET in several ways. First, the design of the extraction boreholes places them closer to the source areas, and the highest plume concentrations are located directly beneath the asphalt pad at MDA L. Locating extraction boreholes beneath or near this cover will reduce the amount of surface air pulled into the extraction interval, potentially increasing the radial influence of the extraction system. Secondly, because the PVET extraction borehole was located on the outer edge of the contaminant plume, contaminants upgradient of the borehole were pulled towards the plume boundary, causing concentrations to increase over time. Concentrations of the contaminants decreased over time downgradient of the extraction borehole. The mass removal rate measured in the PVET remained fairly constant over time. Locating the extraction interval nearer to the contaminant plume will result in a decrease in concentrations of the soil gas over time at all distances from the extraction borehole. Similarly, the mass removal rate will be highest in the beginning and will decrease with time. Near the source, contaminant concentrations are higher both near the surface and at greater depths than was seen in the area where the PVET was installed. Using measured removal rates from the PVET for predicting the mass removal rates from the pilot study extraction borehole(s) provides only an estimate of the actual mass removal rate.

This pilot study will involve the following activities:

- Two boreholes will be drilled and configured specifically to be used as vapor extraction boreholes for this project. One borehole will be located in the immediate vicinity of each of the two source zones. The borehole diameters will be 9 in., the same as those used in the PVET.
- The boreholes will be drilled to a depth of 215 ft and cased to a depth of 65 ft.
- Existing boreholes will be instrumented to allow for pore-gas sampling and pressure monitoring. The total flow from the borehole, borehole vacuum, extraction air temperature, and atmospheric pressure, will be measured at regular intervals during the extraction process.
- Line power from the facility will be used to power the SVE system.
- SVE cycling will be performed to further characterize the source zones by providing rebound data and to increase the overall rate of VOC removal.
- Catalytic oxidation will be used to treat the VOCs removed from the plume. Other treatment methods will be considered as deemed necessary.
- Once initial extraction is completed, ongoing pore-gas monitoring at MDA L from surrounding boreholes will be modified as necessary to assess the effects of the SVE project.

The results of the pilot study data analysis will determine the appropriate extraction rate for reducing the extent of the plume. In addition, the study will assess the ability of an SVE system to respond to potential releases from the inventory resulting from possible container failure in the future.

Results of the MDA L PVET indicates that an extraction system that is capable of developing a pressure differential of 88 in W.C. (6.5 in-Hg) vacuum at a sustained flow rate of 25 SCFM will be capable of developing a sufficient pressure/flow field in the porous media to result in a radius of influence of 140 ft. from the extraction well bore. Many commercially available SVE systems possess pressure/flow capacities substantially above these values. This indicates that typical commercially available SVE systems will be capable of producing the required pressure/flow fields for this application.

SVE Pilot Test Results

Data from the pilot test will be used to evaluate the potential of SVE for remediating the current MDA L vapor plume and for controlling future releases from the vertical shaft source zone. In addition to providing critical lessons learned, these data will be used to assess the following SVE system design criteria:

- the vacuum pressure needed to induce adequate airflow and radius of influence;
- the airflow rates required to achieve maximum contaminant mass removal;
- large-scale SVE system component and equipment requirements;
- the number and configuration of extraction boreholes necessary to remediate the current VOC plume;
- the number and configuration of extraction boreholes necessary to control future potential releases from the source area;
- borehole screen position for maximum contaminant removal;
- the potential value of strategic passive borehole installation;
- confirmation of off-gas treatment technology performance;
- operation and maintenance and remote monitoring alternatives; and
- the management of SVE system closure.

This information will be presented in a pilot study report that will determine the effectiveness of the technology in remediating the plume at MDA L. The information will also be included in the CME for determination of the most appropriate site management strategy.

CONCLUSIONS

Conclusions will be provided upon completion of test, or for the January 20, 2006 submittal.

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