Site Characterization and Monitoring Case Study
Vertical Profiling at Nellis Air Force Base, Site 46, Las Vegas, NV

SITE INFORMATION

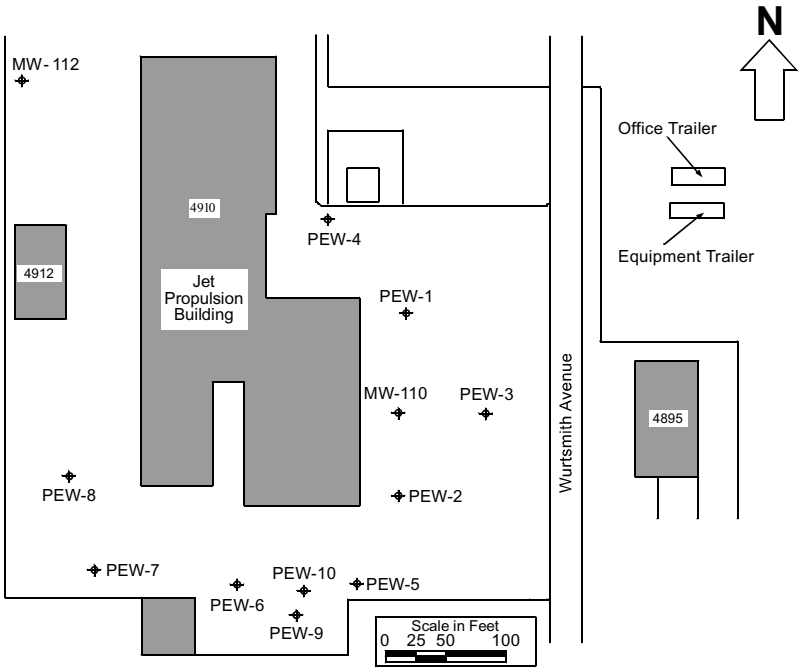
Identifying Information

Site Name:	Nellis Air Force Base (Figure 1), Site 46
Location:	Eastern side of the Las Vegas Valley, an intermountain basin within the Basin and Range Province of the western United States
Technology:	PneuLog® Vertical Profiling
Scale:	Demonstration
Period of Demonstration:	1998

Background

Site 46 at Nellis Air Force Base, in Las Vegas NV, is the location of JP-4 jet fuel spills (approximately 2,000 gallons each) that occurred between 1954 and 1982. In 1989, monitoring wells were installed at the site and sampling results showed that BTEX was present in the groundwater as free product and dissolved phase. Figure 1 shows a layout of the site and location of wells.

Figure 1. Site Layout



Since the initial investigations, Site 46 was expanded northward to include an area of groundwater contaminated with chlorinated VOCs (primarily trichloroethene [TCE]). TCE, tetrachloroethene (PCE), and 1,1-dichloroethene (1,1-DCE) have been regularly detected in monitoring well (MW)-86 at concentrations above their respective

MCLs. As a result, additional monitoring wells (MW-108 through MW-116) were installed between late 1995 and early 1997 to investigate the source and extent of the chlorinated VOCs found in MW-86. Data from those new wells confirmed the existence of a plume of chlorinated VOCs in shallow groundwater to the north and northwest of the Site 46 BTEX plume. The source of the chlorinated VOCs is suspected to be the Jet Propulsion Maintenance Facility, Building 4910, with the highest concentrations found in MW-110.

To investigate the possible presence of TCE in the vadose zone, a field demonstration was conducted using PneuLog® vertical profiling technology. The goals for the demonstration were to characterize the soils in the vadose zone, determine the extent of solvent contamination, install SVE wells and temporarily operate them on the most highly-contaminated soils, and develop a remedial strategy. Further, the demonstration was to accomplish these goals in a shorter time period than would be used in a more traditional site characterization approach.

Points of Contact

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MEDIA AND CONTAMINANTS

Type of Matrix Sampled and Analyzed: Soil

Contaminants of Concern: Chlorinated VOCs, primarily TCE

Site Geology/Stratigraphy: The subsurface stratigraphy at Site 46 consists primarily of fine-grained alluvial sediments, including clay, fine sandy clay, and clayey fine sand (Radian, 1994). The entire sedimentary profile is intermittently calcified, with the degree of cementation varying. The valley-fill deposits beneath Nellis AFB are estimated to be 2,000 to 5,000 feet thick (Plume 1989). The depth to groundwater at Site 46 in late December 1997 ranged from about 49 feet at well MW-80 to about 85 feet in well MW-110. The direction of groundwater flow is to the east in the western part of the site, but shifts towards the southeast in the eastern half. The gradient is approximately 0.0085 ft/ft across most of Site 46.

SITE CHARACTERIZATION TECHNOLOGIES

PneuLog® Vapor Extraction Wells

Pneulog® vapor extraction wells (PEW) were installed in the vicinity of MW-110 near Building 4910, as shown on Figure 1, using a phased approach to locate the highest concentrations of TCE. The first three wells (PEW-1, PEW-2, and PEW-3) were installed to form a triangle with MW-110 in the middle. PEW-4 and PEW-5 were installed to further evaluate the possible north-south extent of contamination near MW-110. Installation included simultaneous pneumatic (the act of performing PneuLog®) well logging and overnight extraction in each well. During PneuLog® the air flow and contaminant concentrations were measured simultaneously along the depth of the well screen. Soil from each boring was sampled and analyzed by off-site laboratories for chemical and physical properties. Extraction and pneumatic well logging was performed for two weeks from the well closest to the identified TCE source (PEW-5).

Analytical results from the demonstration were provided in terms of total vapor concentrations based on results from traditional SVE extraction tests (Figure 2), as well as results from pneumatic well logging tests (Figures 3-8). The pneumatic well logging tests, provided for initial, intermediate, and final testing, show air flow rates and vapor concentrations (individual and cumulative) for selected parameters as a function of depth to 80 ft bgs. It is important to note that the scale for reporting numerical results varies among the figures for pneumatic logging results. Information was not provided about the relative timing and activities that may have been performed between the initial, intermediate, and final well logging events.

Figure 2 shows that PEW-1 and -3 had relatively low vapor concentrations, while PEW-2 and -5 had elevated concentrations. Figure 3, based on results from pneumatic well logging tests, confirmed that PEW-1 had relatively low concentrations (TPH <1,000 mg/m3) as well as that PEW-4 had low vapor concentrations. As a result, investigations to the north and east of MW-110 was terminated. Figure 4 shows that the TCE vapor concentration in PEW-5 was as high as 700 mg/m3 during initial well logging activities, while Figure 5 shows that the TCE vapor concentration in PEW-5 had decreased to <300 mg/m3 during intermediate well logging.

Figure 2. Results from Traditional SVE Extraction Tests

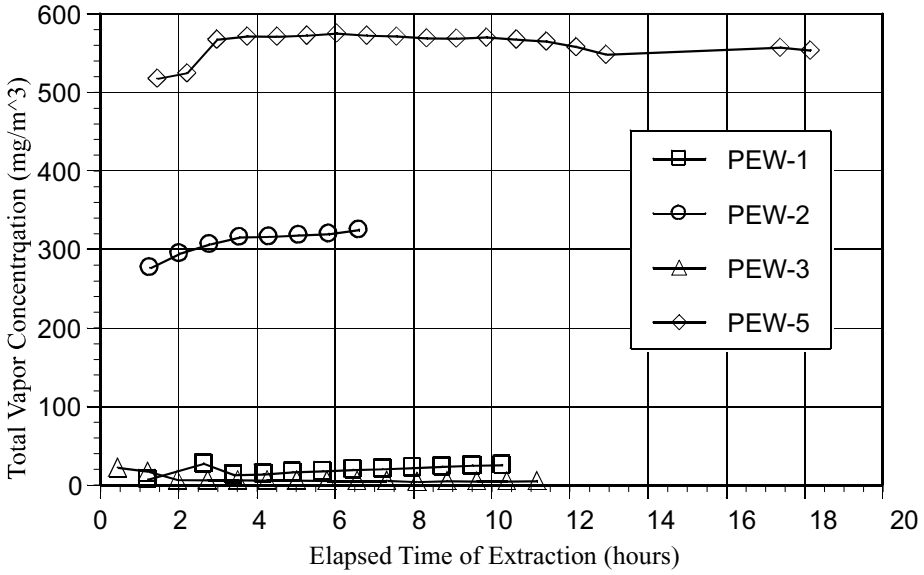
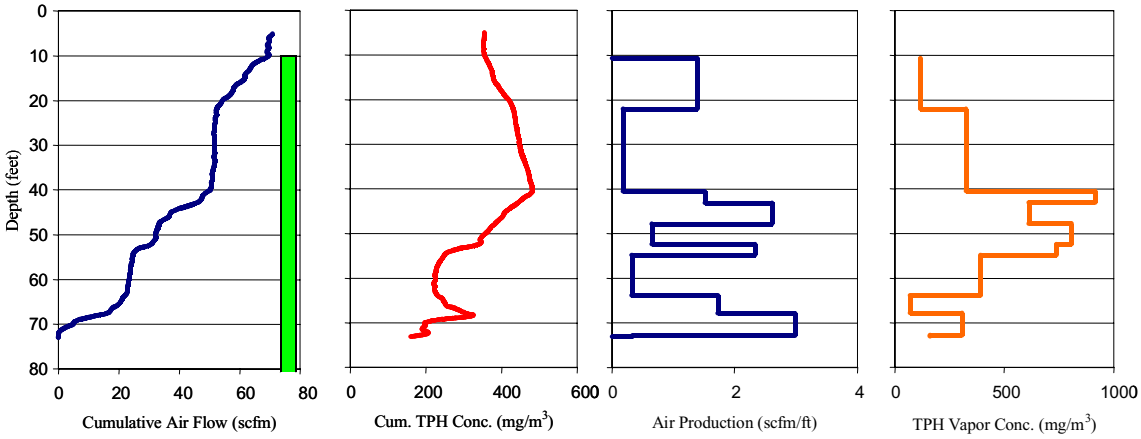
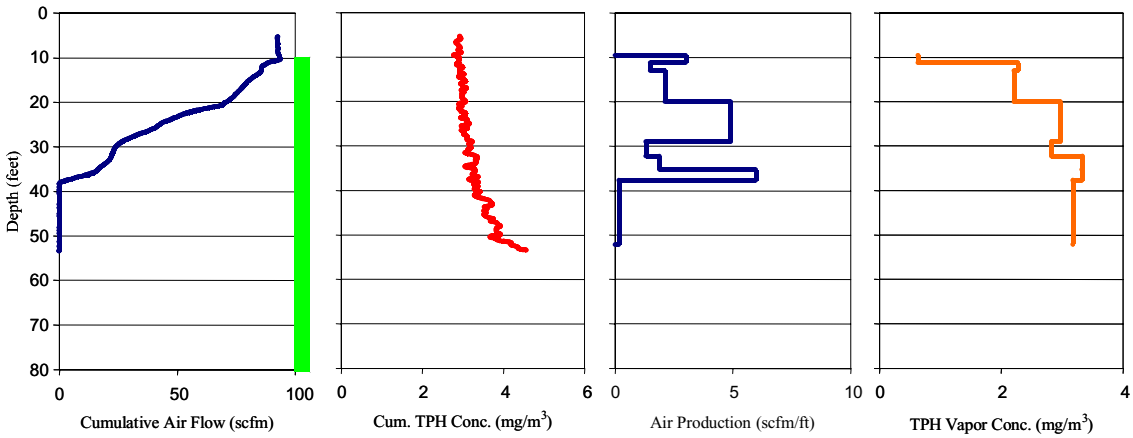


Figure 3. Initial Pneumatic Logging Data

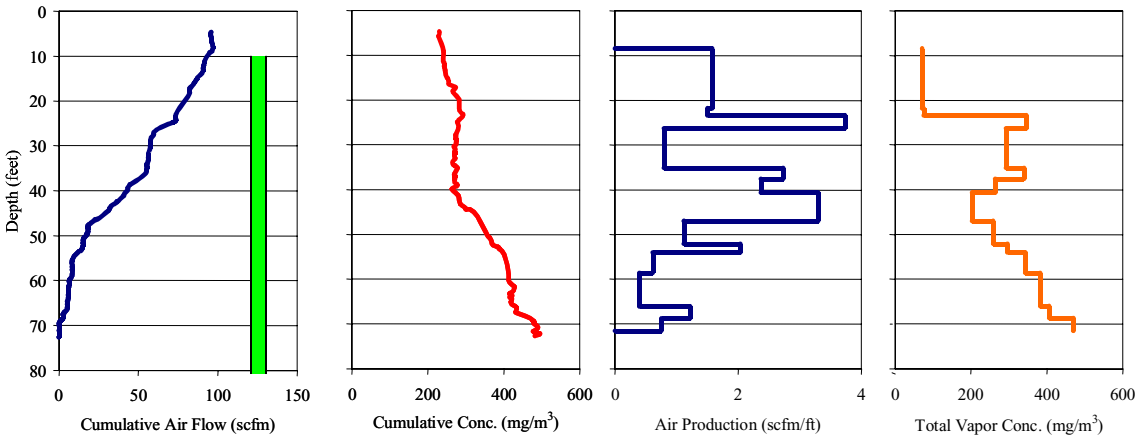


a. PEW-1

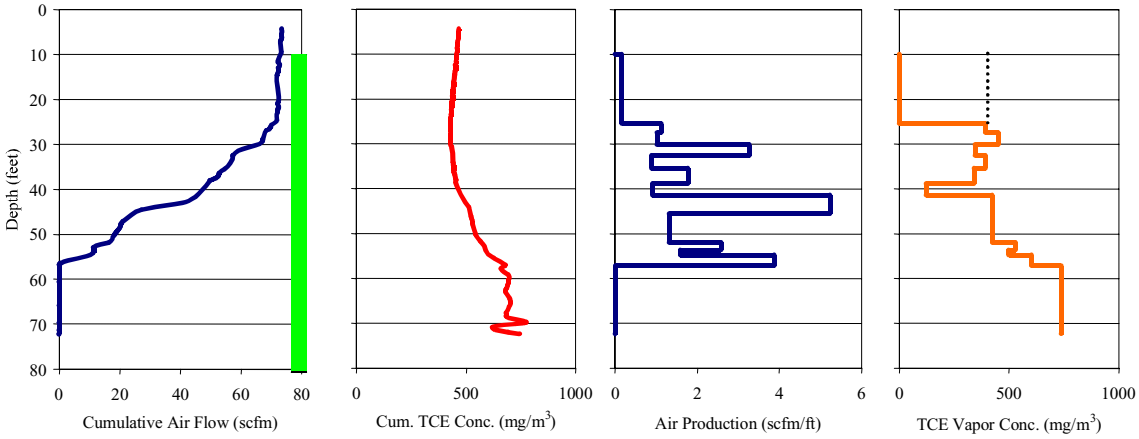


b. PEW-4

Figure 4. Initial Pneumatic Logging Data



a. PEW-2



b. PEW-5

Figure 5. Intermediate Pneumatic Logging Data – PEW-5

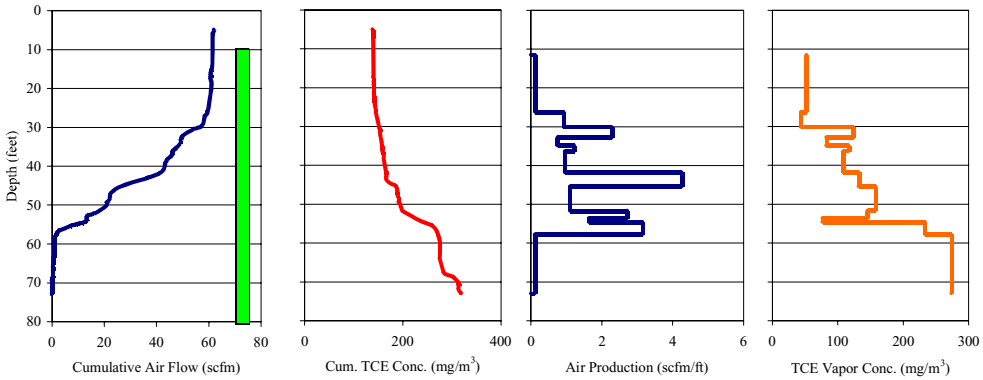
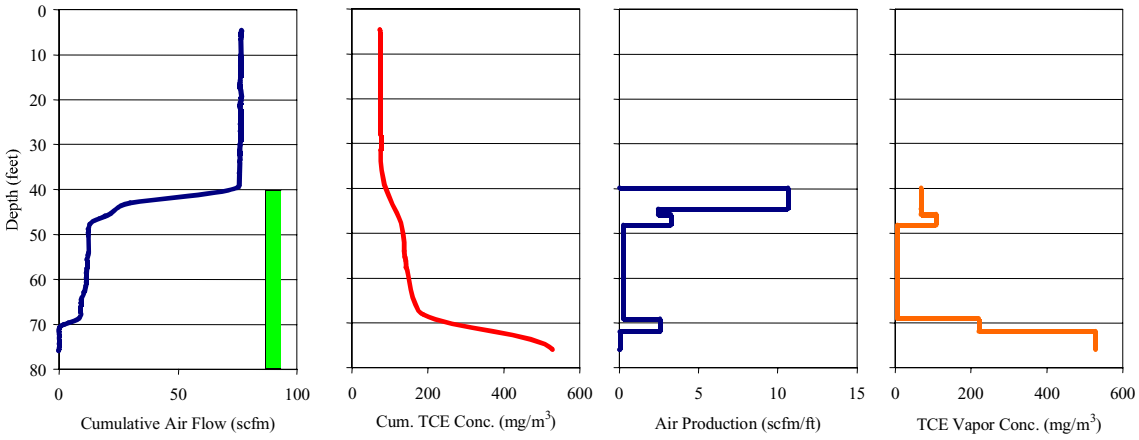
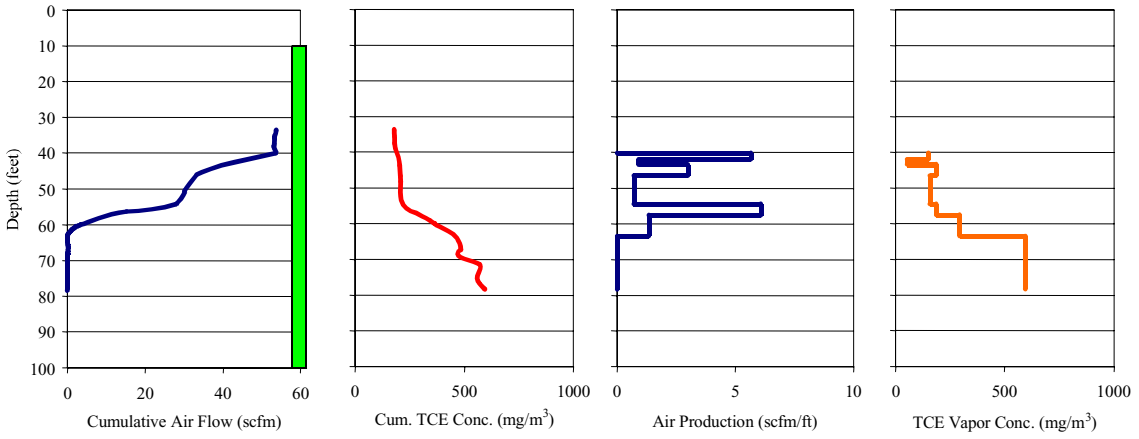


Figure 6. Initial Pneumatic Logging Data



a. PEW-9



b. PEW-10

Figure 7. Pneumatic Logging Concentrations for PEW-5

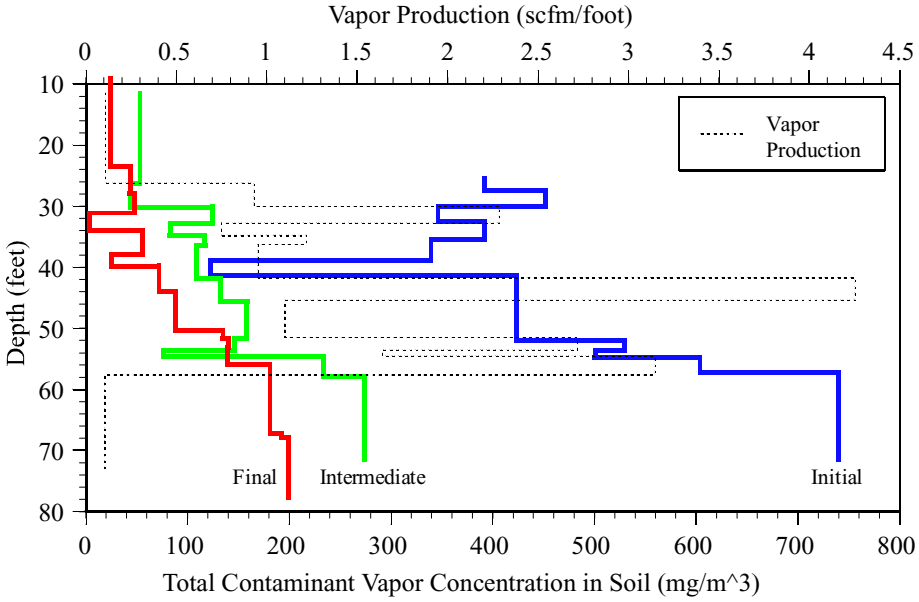
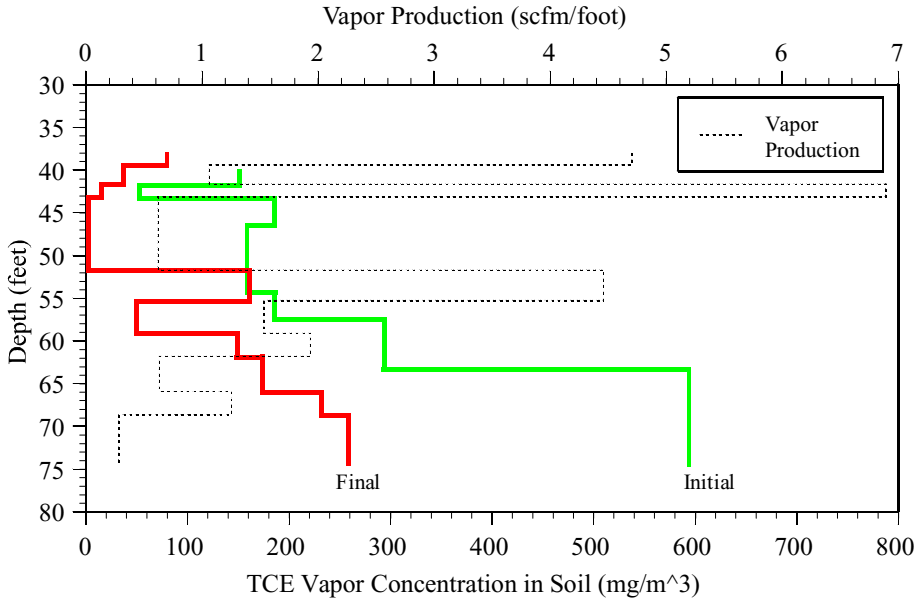


Figure 8. Pneumatic Logging Concentrations for PEW-10



Wells PEW-6, PEW-7, and PEW-8 were installed to further characterize the southern end of the building, as shown in Figure 1. PEW-6 was placed 100 feet from PEW-5, PEW-7 was placed another 100 feet to the west near an oil/water separator, and PEW-8 was placed west of the building but south of the clean groundwater monitoring well (MW-112). Testing of wells PEW-6 through PEW-8 showed that the highest detected TCE concentration remained in PEW-5, and that this location was the closest to the source area.

The final two wells (PEW-9 and PEW-10) were installed to refine the extent and depth of the source area, including use of screen intervals in deeper zones (PEW-9 screened from 40-80 ft bgs and PEW-10 screened from 10-100 ft bgs; results in Figure 6). The deep screens were chosen because the pneumatic well logging revealed the TCE contamination resided only deep in the vadose zone. Groundwater was encountered at 85 feet; the deeper screen interval in PEW-10 allowed this well to serve as both a vapor and groundwater monitoring well. PEW-9 was located midway between PEW-5 and PEW-6. This well had concentrations in excess of those found in PEW-5; however, TCE concentrations decreased rapidly from 76 feet to the bottom of the lower-most detectable flow interval. In contrast to PEW-9, the decrease in TCE concentration in PEW-10 through the permeable soils was not as abrupt. This indicates that the TCE vapors are present in greater quantity across the well screen in PEW-10 than in PEW-9.

Two weeks lapsed between the installation of the first five wells and the last five wells. During this period, continuous extraction and pneumatic well logging was performed in PEW-5 to aid in defining the extent of contamination. The flow profiles were virtually unchanged. However, the TCE concentration at the wellhead had decreased by more than half (Figure 7). The maximum TCE concentration observed at the bottom of the well was 320 mg/m^3 in contrast to the 755 mg/m^3 found two weeks earlier at the same depth. The wellhead concentration also followed the same trend decreasing from 465 mg/m^3 to 139 mg/m^3.

PERFORMANCE EVALUATION

Sample Collection

The use of pneumatic well logging and an on-site GC with the first five boreholes provided a definitive direction in which to seek the source of TCE observed in groundwater near Building 4910. At the end of the testing of wells PEW-6 through PEW-10, the TCE source area in the vadose zone was considered adequately characterized. This conclusion was based on the decreased TCE vapor concentrations observed in wells PEW-2, PEW-6 and PEW-9 which surrounded wells PEW-5 and PEW-10.

Sampling Results

The technology vendor reported that the PneuLog® approach reduced the period of performance from roughly 18 months to 2 months to complete the characterization and SVE design. At Nellis, PneuLog® contributed to remedial design mainly by classifying the underlying soils and permeabilities. Continuous coring in 10 locations revealed silts below an asphalt cap down to 10 feet below the surface where clay was encountered. Clay soils extended down to the water table at roughly 80 feet with irregularly encountered thin layers of caliche (i.e., hard pan) and one continuous caliche layer found across the site from roughly 44 to 50 feet. The flow paths were very complex since the caliche layers were irregularly located.

Technology Performance

At the end of the ten well installations, it was judged in the field that the TCE source in the vadose zone was adequately characterized and resided in the vicinity of wells PEW-10 and PEW-5. This conclusion was based on the decreased TCE vapor concentrations observed in wells PEW-2, PEW-6 and PEW-9 which surrounded wells PEW-5 and PEW-10. In addition, two weeks of extraction and pneumatic well logging in well PEW-5 resulted in the concentration decreasing by half.

Through site characterization employing PneuLog® technology the total volume of soil with TCE contamination was estimated to be 80,300 cubic meters. The estimated initial mass of TCE at the site was 142 pounds. After the five-month, low extraction and pneumatic well logging rate test an estimated 22 pounds of TCE remained in the vadose zone.

TECHNOLOGY COST

The technology vendor provided actual cost information, as shown in Table 1, for the demonstration at Nellis. The total cost was $276,482 consisting of $195,552 (for 22 field days performing PneuLog® and extraction testing, analytical, drilling, and extraction, including extraction equipment) and $80,930 (for data analysis and reporting). The total cost covered activities for both traditional and PneuLog site characterization and SVE testing. The costs covered installation of 10 wells (830 linear feet), with each well pneumatically logged multiple times, 8 overnight extraction and pneumatic well logging tests, with durations ranging from 7 to 38 hours, a 14-day SVE pilot test, a 6-month SVE pilot test, 419 screening samples (vapor) analyzed onsite with a portable GC, 28 vapor samples analyzed offsite for chemical concentrations, 133 soil samples analyzed offsite for chemical concentrations, and 20 soil samples analyzed offsite for physical properties. Reporting included preparation of a conventional site conceptual model, an improved site model using PneuLog® data, and estimates for SVE size and duration to attain cleanup of the vadose zone.

Table 1. Project Cost Breakdown at Nellis AFB, Site 46

PneuLog® & Extraction Testing Cost[a]:	Analytical Cost[b]:	Drilling Cost[c]:
$78,959	$28,918	$63,069
Vapor Treatment Cost:	**Extraction Equipment Cost[d]:**	**Data Analysis and Reporting Cost[e]:**
$0	$24,606	$80,930

Notes:

[a] PneuLog® and Extraction testing costs include PneuLog®, overnight tests, permeability tests, and SVE pilot tests.
[b] Analytical Costs include onsite GC screening analyses and offsite chemical and physical analyses.
[c] Drilling Costs include geologist, per diem, waste disposal and survey.
[d] Extraction Equipment Costs include costs to perform vapor extraction for all the tests
[e] Reporting Costs includes preparation of work plans, meetings, data compilation, data evaluation, modeling, and report preparation.

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8. Radian, 1994.