Cost and Performance Summary Report
Soil Vapor Extraction at Camp LeJeune Military Reservation, Site 82, Area A
Onslow County, North Carolina

Summary Information [1, 2, 6]

Camp LeJeune Military Reservation (also known as Marine Corps Base Camp LeJeune), established in 1941, is a 170-square-mile installation near Jacksonville, North Carolina, that provides housing, training, logistical, and administrative support for Fleet Marine Force Units. Site 82 is located adjacent to Storage Lot 203. Lot 203 was operated from the 1940s to the 1980s for the Defense Reutilization Marketing Organization (DRMO) as a military scrap dealing and disposal area. Site 82 was a wooded area that also was used for disposal.

Drums and debris, both on the surface and buried, were removed from Site 82 in 1994. Area A was a portion of Site 82 at which residual soil and groundwater contamination remained after removal of drums and debris. Area A also is referred to as Operable Unit 2 (OU 2), Site 82, Area of Concern 1, Area A. No additional information is provided about OU 2 or Area of Concern 1.

Soil at Area A was found to be contaminated with volatile organic compounds (VOCs), primarily trichloroethene (TCE), tetrachloroethene (PCE), and benzene. Results of analysis of soil borings taken in July 1994 showed concentrations of TCE as high as 6.5 micrograms per kilogram (μg/kg) and PCE as high as 1,800 μg/kg. Benzene was not detected at levels above analytical quantification limits.

In the record of decision (ROD) for OU 2, signed September 24, 1993, soil vapor extraction (SVE) was selected for remediation of contaminated soil. From April 7 through December 21, 1995, approximately 17,500 cubic yards (yd^3) of contaminated soil were treated by a full-scale soil vapor extraction (SVE) system application at Area A.

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Lead:	DoD - Atlantic Division, Naval Facilities Engineering Command (LANTDIV), representing the Navy and Marine Corps and DoD

Timeline [1, 2]

September 24, 1993	Final ROD signed for OU 2, including Area A
December 1994	System construction awarded
February 1995	Final work plan approved; construction commenced
March 29 - April 7, 1995	System startup and optimization performed
April 7 - December 21, 1995	SVE system operation conducted
October 12 - 30, 1995	System temporarily shut down while awaiting results of analysis of confirmation samples
February 2, 1996	Final soil confirmation sampling performed

Factors That Affected Cost or Performance of Treatment [1, 8]

The Camp LeJeune site is underlain by five distinct sand horizons of variable thicknesses. The sand units typically are fine- to medium-grained and moderately sorted, contain traces of clay and silt, and extend to the water table at approximately 18 feet below ground surface (bgs).

Listed below are the key matrix characteristics at Area A that affected the cost or performance of this technology and the values measured for each during site characterization.

Matrix Characteristics

Parameter	Value
Soil Classification:	Not reported
Clay Content and/or Particle Size Distribution:	Sand with trace of clay and silt
Moisture Content:	Not measured
Air Permeability:	1.2 to 2.8 x 10^{-7} cm^2
Porosity:	Not measured
Total Organic Carbon:	Not measured
Nonaqueous Phase Liquids:	Not identified

Treatment Technology Description [1, 2]

The SVE system used at Area A included eight vertical vapor extraction wells (installed to a depth of 15 to 16 feet bgs), one horizontal air injection well (horizontal displacement of 330 feet; total depth of 15 feet bgs), 32 soil probe clusters (for measurement of subsurface vapors; each cluster consisted of one shallow and one deep probe at approximately 6 feet and 12 feet bgs, respectively), a vacuum extraction unit (VEU), one vapor-phase carbon vessel (initially loaded with 4,000 pounds (lbs) of vapor-phase granular activated carbon), a piping and manifold system, a diesel-powered generator, and a water storage tank (20,000 gallon). The VEU included a positive displacement vacuum blower rated at 1500 cubic feet per minute (cfm) at 15 inches Hg, a vapor-liquid separator, a liquid transfer pump, particulate filters, a silencer, a discharge stack, and a control panel. The positive displacement blower was used to apply a vacuum to the eight vertical vapor extraction wells.

Extracted soil vapors were routed through the piping and manifold system to a vapor-liquid separator to remove liquids entrained in the vapor stream. They then were treated with activated carbon before they were reinjected through the horizontal well or released to the atmosphere. Extracted liquids were pumped to a water storage tank and subsequently to the nearby groundwater treatment plant at Site 82.

Flow rates at the well heads ranged from 22 to 132 cfm. Total system flow rates ranged from 268 to 499 cfm, with an average of 409 cfm. Well head vacuums ranged from 3.9 inches to 7.0 inches Hg, with an average of 5.8 inches Hg.

Startup and optimization was conducted from March 29 through April 7, 1995. From April 4 through December 21, 1995, the system logged a total of 5,889 hours and an on-line time of 85 percent. The system was shut down from October 12 to October 30, 1995, while awaiting results of laboratory analysis of confirmation samples that were collected on October 4, 1995. No modifications of the system were reported by the vendor.

Listed below are the key operating parameters that affected the cost or performance of this technology and the values measured for each.

Operating Parameters

Parameter	Value
Air Flow Rate:	266-499 cfm (average 409 cfm)
Operating Vacuum:	3.9-7.0 inches Hg (average 5.8 inches Hg)

Performance Information [1, 2, 7]

The ROD identified the following cleanup goals for soil:

- TCE - 32.2 μg/kg
- PCE - 10.5 μg/kg
- Benzene - 5.4 μg/kg

Data were provided for TCE, PCE, and benzene for soil borings taken from 24 sampling locations, 8 locations and 3 depths per location, ranging in depth from 2 to 16 feet bgs. Soil boring samples were collected six times during this application (July 1994, July 1995, August 1995, October 1995, December 1995, and February 1996).

The results of analyses of soil borings collected before operation of the SVE system (July 1994) for contaminants exceeding the cleanup goals showed concentrations of PCE as high as 1,800 μg/kg. Benzene was nondetected (ND) and TCE levels were detected at levels less than the cleanup goal. Results of analyses of soil borings taken after startup (July 1995) showed maximum concentrations of TCE (101 μg/kg), PCE (16.3 μg/kg), and benzene (132 μg/kg) higher than the cleanup goals.

After treatment was complete, confirmation samples showed TCE and benzene at nondetectable levels in all soil boring samples. For 23 of 24 soil boring samples, PCE was reported at levels below the cleanup goal of 10.5 μg/kg. For one soil boring sample, PCE was reported at 29 μg/kg, compared to the cleanup goal of 10.5 μg/kg. According to LANTDIV, EPA approved shutdown of the system because the single exception was slightly above the soil remedial goals and the contaminated groundwater under the area of concern was being addressed by a pump-and-treat system.

Sampling data for extracted vapor were provided for PCE, TCE, benzene, and ethylbenzene for the total system and the discharge stack for sampling events conducted from April through August 1995. For the total system, concentrations ranged as follows: TCE - 44 to 583 micrograms per liter (μg/l); PCE - ND to 10.5 μg/l; benzene - ND to 18 μg/l; and ethylbenzene - ND to 17.5 μg/l. For the discharge stack, concentrations ranged as follows: TCE - ND to 2.2 μg/l; PCE - ND to 147.4 μg/l; benzene - ND to 10.2 μg/l; and ethylbenzene - ND to 7.4 μg/l. No air emission standards were specified for this application, however the State of North Carolina required the facility to provide documentation about potential air emissions for this application and to include carbon treatment for air emissions.

Performance Data Quality [1, 2]

For this application, quality assurance activities included use of trip blanks, field blanks, and duplicate samples. Data reported on July 18, 1995, and August 23, 1995, for field gas chromatography (GC) analysis of soil samples showed elevated levels of benzene in the soil that had not been seen previously at the site. According to LANTDIV, additional investigations and subsequent sampling events indicated that the anomalous levels were caused by inaccuracy in laboratory data, rather than elevated concentrations of benzene in the soils at the site.

Cost Information [2, 3, 8]

Actual cost information provided by Atlantic Division, Naval Facilities Engineering Command indicated that a total of $469,949 was expended for remedial activities at Area A. The total consists of $222,455 for capital costs and $247,485 for operation and maintenance (O&M) costs. The total cost of $469,940 corresponds to a unit cost of $27 per cubic yard ($yd^3$) for 17,500 yd^3 of soil treated. No information was provided about the mass of contaminant removed, and therefore no unit cost per pound of contaminant was calculated for this application.

Actual Project Costs

Cost Element	Cost ($ in 1995)
Capital	
Equipment and Appurtenances	
- Injection well	77,682
- System installation	26,741
- Equipment and installation (includes extraction wells)	66,768
Site Work/Preparation	
- Magnetic survey	2,587
- Clear and grub work	21,335
- Construction of access road	7,485
Startup and Testing	
- System start-up	1,344
Management Support	
- Proposal estimate	18,513
Capital Subtotal	**222,455**

Cost Element	Cost (in 1995 $)
Operation & Maintenance	
O&M (direct labor, equipment rental, fuel/oil/lube, final report preparation)	229,226
Analytical (related to technology performance, not compliance monitoring)	
- SVE area sampling	18,259
O&M Subtotal	**247,485**
Disposal of Residuals	**Included in total**
Analytical (related to compliance monitoring, not technology performance)	**0**
Total Project Cost	**469,940**

Observations and Lessons Learned [1]

The fact that significant other work was being performed at the site, including the construction and operation of a 500-gallon-per-minute (gpm) pump-and-treat plant to treat groundwater contaminated with VOCs, helped to keep costs down because overhead and operations costs were shared. In addition, an on-site laboratory was being used for other analytical work on the base, and the shared cost of the use of that facility also helped to keep the cost of the SVE application low.

The SVE system at Area A combined a horizontal air injection well with vertical extraction wells to remediate soil contaminated with chlorinated solvents, benzene, and ethylbenzene. The system met soil cleanup goals in less than 10 months of operation. According to the Naval Facilities Engineering Command Remedial Project Manager, the SVE system at Area A was cost-effective.

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