TCE Remediation in Deep Bedrock
Eastern Pennsylvania

ERH Remediation in 90-foot Rock Formation

Project Summary

TRS Group (TRS) implemented an electrical resistance heating (ERH) remedy to remove trichloroethylene (TCE) in a 90-foot thick rock sequence at a confidential site in eastern Pennsylvania. This marks the first time that anyone has applied the technology in such a thick rock unit. A prominent environmental consulting firm (Consultant), representing the property owner, selected TRS due to its vast experience applying ERH in tight matrices.

Remediation practitioners have known for years that ERH works exceptionally well in tight soil matrices. Sedimentary rock treatment has become rather common in the last five years; however, until now, no one has applied ERH to such a thick layer of rock. The Consultant, working closely with TRS, decided that the sedimentary rock sequence would be an ideal setting for the technology and recommended ERH in the Remedial Action Plan submitted to the Pennsylvania Department of Environmental Protection (PADEP). PADEP agreed and approved ERH as the remedy.

Background

The site was an active manufacturing facility in eastern Pennsylvania that used chlorinated solvents as degreasers in its production process. The focus of the remedy was source zone remediation adjacent to the plant building (Figure 1). The goal was the removal of the estimated 483 pounds of TCE. The contract stipulated the remedy would be considered complete upon the removal of the total mass, observing asymptotic vapor concentrations in the surface vapor treatment system, or input of the design energy (1,640,000 kWh), whichever occurred first.

Figure 1. Site Plan

Site Characteristics

Historical data indicated that the primary compounds of concern were TCE and *cis* 1,2-dichloroethylene (*cis* 1,2-DCE). Although other chlorinated volatile organic compounds (CVOCs) were present, their concentrations were low and considered insignificant. TRS designed the system to remove solvents from the 20 feet of overburden, which was mainly medium to fine sand and clay, and 90 feet of rock (sample of area rock shown in Figure 2 below), which was primarily sandstone with some siltstone and thin seams of coal. The Consultant reported that the highest concentration of TCE was 560 mg/kg, which was near the degreaser, as expected.

Figure 2. Area Rock Formation

Depth to perched groundwater was about 17 feet below ground surface. There was a significant downward vertical gradient of the perched aquifer. Fractures in the bedrock dominated flow, which made detailed characterization difficult. Groundwater flux was low because the site is on top of a hill and the rainfall catch-basin is small.

The aerial extent of the treatment zone was 2,800 square feet; the treatment interval extended from 4 to 110 feet bgs. The treatment volume was about 11,000 cubic yards.

Design Parameters

TRS considers treatment zone geometry, contaminant loading and remediation goals when designing an ERH system. Design parameters include electrode design, optimal energy density, electrode depth and spacing, subsurface heating intervals and the location of vapor recovery screens. Most important is TRS' commitment to provide a safe and secure remedial solution throughout the installation and operation of the system.

Site specific considerations included:

- Achieve results quickly
- Recover and treat the volatilized vapors
- Stay well within PADEP discharge limits
- Measure and report subsurface temperatures, vacuum and air flow in the vadose zone
- Coordinate sampling events with Consultant
- Complete system installation within strict time limits
- Provide data as needed by Consultant and PADEP
- Minimize impact to plant operations
- Operate safely

System Construction/Operations

In March 2012 TRS Group installed 17 vertical electrodes with co-located vapor recovery wells and three temperature monitoring points (TMP), each containing about 20 thermocouples, spaced at 5-foot depth intervals. The electrode and equipment compound are shown in Figure 3.

Figure 3. ERH electrodes and equipment compound

TRS Group estimated that applying 1,640,000 kWh of energy over a 70 to 90 day time interval would remove the reported solvent mass and reach the remedial goals.

The Consultant performed routine operations and compliance sampling of recovered vapors. The sampling events included field measurements using a photo ionization detector (PID) and periodic collection of vapor samples in summa canisters for laboratory analyses. The Consultant used the results to calculate the vapor recovery parameters, determine granular activated carbon treatment efficiency and the rate and total mass of CVOCs removed. When on-site, TRS assisted in insuring compliance with PADEP established standards.

The results from the vapor stream sampling, shown in Figure 4 below, provided indicators of changing subsurface conditions and helped to determine what, if any, optimization would benefit the remediation. Most significantly, vapor sampling results indicating asymptotic CVOC concentrations aided in helping TRS, the Consultant and PADEP reach consensus when to cease ERH operations.

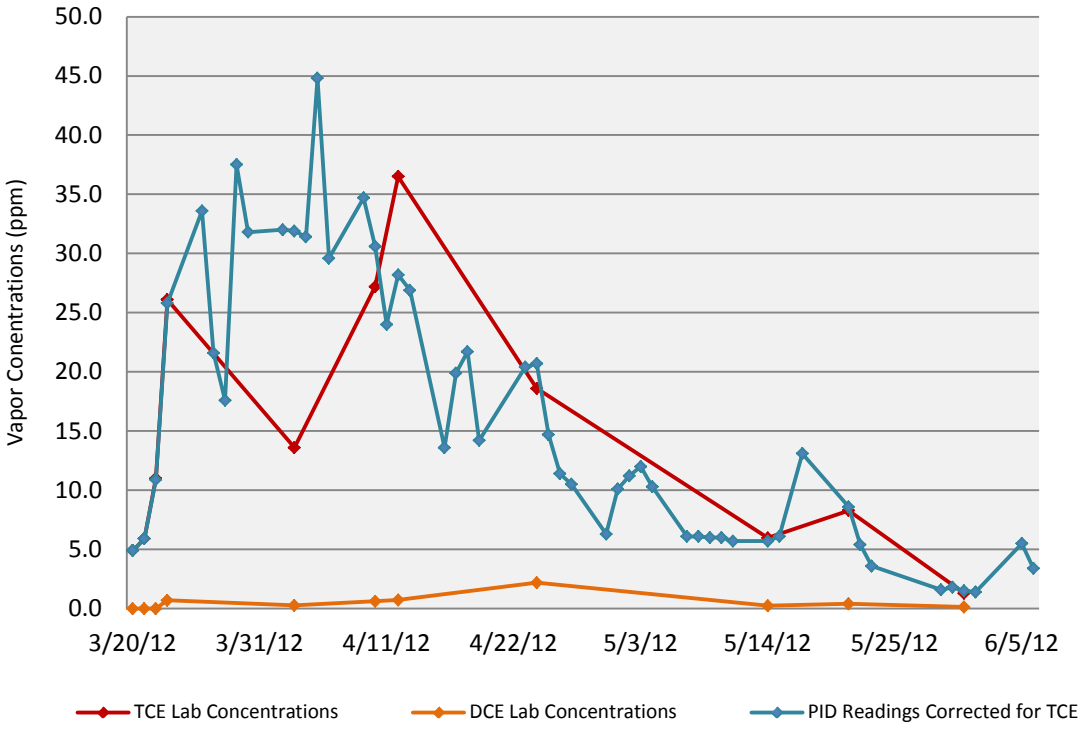

Figure 4. Vapor Concentrations over Time

Results

The ERH system removed 399 pounds of chlorinated solvents from the matrix and operated until reaching the design energy of 1,640,000 kWh. PADEP approved shutdown based on the system achieving sustained asymptotic vapor concentrations.

Although there was no contractual obligation to reduce groundwater CVOC concentrations, TRS expected there would be a significant effect. The Consultant collected samples from two monitoring wells within the treatment zone, one screened from 15 to 35 feet bgs and the other from 100 to 110 feet bgs. The analytical data from sampling before and after remedy implementation showed a 99.9% reduction of TCE concentrations in the shallow well and a 99% reduction in the deep well. Results are shown graphically in Figure 5 below.

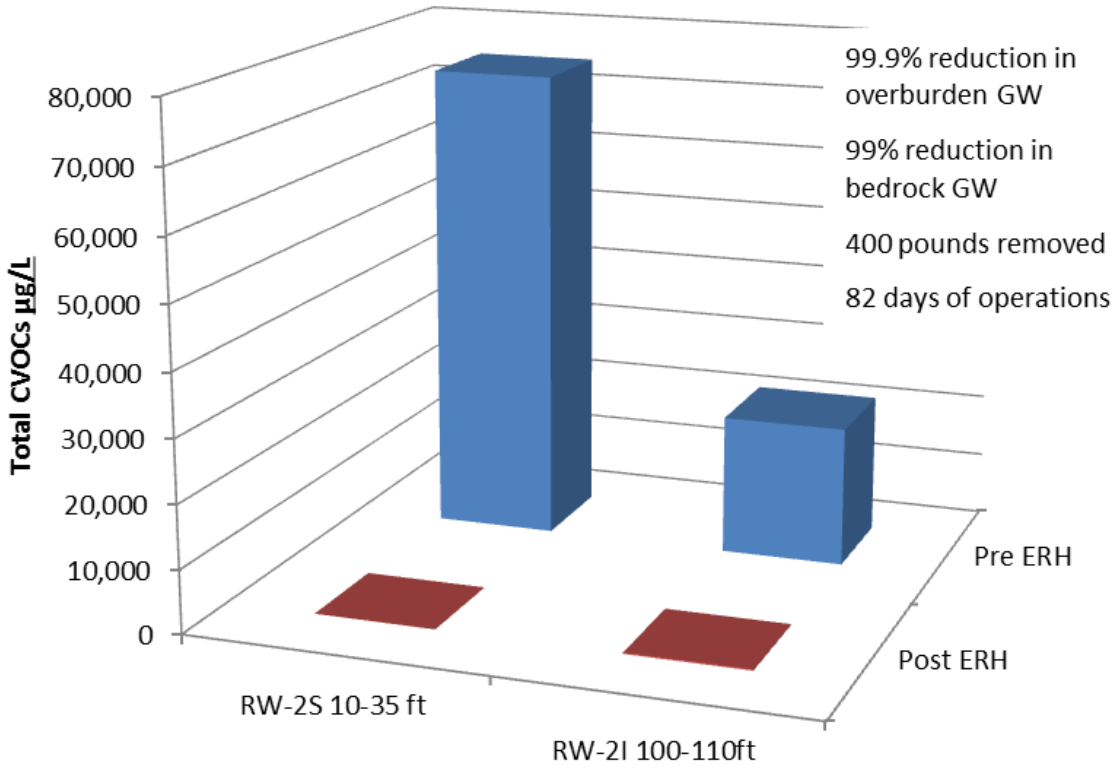

Figure 5. Pre and Post CVOCs – 2 Wells

Summary

Site Geology and Hydrology	*Medium to fine sand and clay (overburden from surface to 20 ft bgs). Sandstone bedrock from 20-ft to 110 ft-bgs. Groundwater at 17 ft bgs*
Treatment Area Size, Volume, and Depth	*2,800 ft^2; 11,100 yd^3; 4 to 110 ft bgs*
Beginning Maximum Contaminant Concentrations	*Soil: 527 mg/kg TCE; Groundwater: 46,000 µg/L TCE*
Remedial Goal(s)	*483 lbs of VOCs removed or asymptotic vapor recovery or 1,640,000 kWh*
Reduction Achieved/Remedial Goal Achieved?	*Yes - 399 lbs of TCE and DCE combined and 1,640,000 kWh of energy applied*
Period of Performance	*March 20, 2012 – June 10, 2012 (VR system through June 20, 2012)*
Contract Terms	*Standard Fixed Price Remediation*

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