DNAPL REMEDIATION

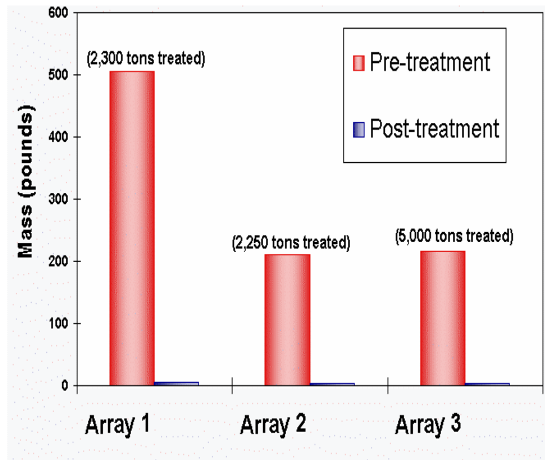
In Tight, Saturated Soil

Clients: URS-Woodward Clyde
US Army Corps of Engineers
United States Army

Fort Richardson,
Anchorage, Alaska

July – December 1997

The US Army Corps of Engineers conducted a design verification study of Six-Phase Heating (SPH) in Operable Unit B (OUB) at Fort Richardson in Anchorage, Alaska, to assess its potential to achieve OUB cleanup goals more rapidly than conventional soil vapor extraction methods.



AVERAGE SOIL CONTAMINANT MASS

The primary contaminants impacting the site were three chlorinated compounds, 1,1,2,2-tetrachloroethane, trichloroethylene (TCE) and perchloroethylene (PCE). Prior studies had indicated that, without heating, soil vapor extraction could take up to10 years to achieve OUB's cleanup goals. SPH was selected over steam injection and radio frequency heating because it had previously been shown to deliver energy to the subsurface more efficiently.

In three separate applications, each lasting six weeks, SPH successfully remediated dense non-aqueous phase liquids (DNAPL) from tight, saturated soil. Samples drawn after each six-week run (Figure 1) showed that more than 97 % of the primary contaminant had been removed at each array.

SITE

The lithology of the OUB site consisted of dense, low permeability, heterogeneous glacial tills. Three stacked aquifers existed between 8 and 40 ft below grade (bg).

The contamination by 1,1,2,2-tetrachloroethane, TCE and PCE extended to at least 35 ft bg. In the case of 1,1,2,2-tetrachloroethane, the soil concentration was up to 16,000 mg/kg, and the groundwater concentration was up to 1,900 mg/L.

TECHNOLOGY

SPH is emerging as a leading technology in difficult in-situ soil and groundwater remediation. It has proved an efficient, rapid means of remediating soil contaminated by volatile and semi-volatile organic contaminants.

The in situ cleanup of DNAPL remains one of the toughest challenges facing the remediation industry. Traditional remediation technologies require years of continued application to produce even marginal results at DNAPL sites.

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The technology was developed for the US Department of Energy at Pacific Northwest National Laboratories. Current Environmental Solutions (CES) was the first licensee of this technology, as well as the proprietor of sundry improvements.

SPH uses polyphase electricity to resistively heat the soil and groundwater to the boiling point of water. This increases the volatility of contaminants, which improves the effects of vacuum extraction. Once steam is generated in situ, it acts as a carrier gas which strips out contaminants from the soil or groundwater. The steam is collected from the subsurface by a soil vapor extraction process, and treated aboveground by conventional means such as activated carbon, and catalytic oxidization.

APPLICATION

At Fort Richardson, three SPH arrays were used to treat DNAPL to a depth of 40 ft bg. Arrays 1 and 2 were 27 ft in diameter, while array 3 measured 40 ft. Combined, the arrays treated approximately 6,800 yd^3 of soil.

The SPH arrays consisted of six electrodes in a hexagonal pattern, with a neutral electrode in the center. These electrodes were inserted to a depth of 38.5 ft bg, and had the capacity to heat the soil from 10-40 ft bg. The three arrays were activated in sequence, and each operated for six weeks.

At each array, the temperature of the subsurface was increased to 100 °C during the first two weeks of heating. This caused the stacked aquifers to boil for the subsequent four weeks, producing steam which stripped contaminants from the soil matrix within the treatment area (Figure 2).

Contaminant-laden steam were collected at the electrodes by means of soil vapor extraction, was condensed to water and vapor, which was subsequently treated by air stripping and catalytic oxidization.

RESULTS

The contaminated soil was sampled before and after treatment. Sampling extended from inside each array to a distance of 40 % of the array diameter beyond each array.
Results for arrays 1 and 2 showed that, on average, 96-97 % of volatile organic compounds (VOCs) were removed, and 1,1,2,2 tetrachloroethane concentrations were reduced by 98-99 %.

Results for array 3 indicated an average VOC reduction of 44.5 %. However, seven of 12 soil samples removed from the interior of array 3 contained VOCs at concentrations below detection limits, and the average reduction of VOCs from the interior of array 3 was 96.7 %.

CONCLUSIONS

SPH successfully increased subsurface temperatures to the boiling point of water within days, and held that temperature throughout the design verification period.
Treatment at arrays 1 and 2 extended beyond the arrays by at least 40 % of the array diameters, but treatment was limited by the unusually large diameter of array 3.

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