Combined In Situ Chemical Reduction and In Situ Bioremediation Groundwater Treatment for a Chlorinated VOC Plume

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Background/Objectives. The shallow aquifer beneath Site 24 (former dry cleaning facility) at the former Naval Station Treasure Island was contaminated by chlorinated volatile organic compounds (cVOCs). Releases of tetrachloroethene (PCE) generated a cVOC groundwater plume extending over 1,100 feet to the San Francisco Bay. The Navy conducted a multiphase treatability study from 2003 through 2012. That study assessed the potential for in situ bioremediation (ISB) technology to degrade the cVOCs. The effort reduced the extent of cVOCs to several smaller plumes. Based on this initial success, the selected remedy consisted of excavation and off-site disposal of impacted vadose zone soil; groundwater treatment using a combination of in situ chemical reduction (ISCR) and ISB; and performance monitoring. The combined groundwater remedy is intended to destroy saturated zone cVOC mass while reducing the potential for generation of toxic intermediate dechlorination products. It also seeks to manage back diffusion from low-permeability zones. The remedy is anticipated to meet unrestricted use for future redevelopment of the site.

Approach/Activities. Approximately 1,200 cubic yards of cVOC-impacted vadose zone soil were removed from the site. Excavation was followed by a combined application of microscale zero-valent iron (mZVI) injection to promote ISCR and the injection of an electron donor to promote ISB. Groundwater treatment was implemented as grids of temporary injection points in three remaining plume areas. Injection materials were emplaced in 2.5-foot vertical intervals to promote vertical and lateral distribution. At each interval, half the dose of extracted groundwater amended with electron donor (ISB solution) was injected to induce small scale soil fractures. The target dose of mZVI, guar, and extracted groundwater was then injected, followed by the second half of the ISB solution. Performance monitoring of groundwater and soil gas occurs quarterly to verify effectiveness of groundwater treatment.

Results/Lessons Learned. The results of the first two quarterly performance monitoring events demonstrate that groundwater cleanup goals have already been achieved at one treatment area, reducing cVOC concentrations from 1200 micrograms per liter (mg/L) to 3 mg/L. At the other two treatment areas, additional cVOC mass was likely liberated during remedy injection into groundwater from low-permeability soil zones, increasing cVOC concentrations from 253 mg/L to 4650 mg/L. The second performance sampling event documented decreases in concentrations of all cVOCs in groundwater. This demonstrates that the cVOC mass is now in contact with treatment products and is actively being remediated, resulting in the production of intermediate products (cis-1,2-dichloroethene and vinyl chloride) and the reaction end-product ethene. Except for significant decreases where cVOC-impacted vadose zone soil was removed, results of the second performance monitoring event for soil gas indicated increasing concentrations of intermediate dechlorination products. This is likely due to the production of these constituents and subsequent volatilization into soil gas during groundwater treatment. The conceptual site model indicates remaining cVOC source mass remains in the saturated zone; therefore, as the saturated zone contaminant mass is degraded in situ, soil gas cVOC concentrations are anticipated to decline in equilibrium in accordance with Henry's Law dynamics. Results from five quarterly monitoring events will be available for presentation.