

## Combined Remediation Approaches to Address Chlorinated Volatile Organic Impacts

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**Background/Objectives.** At an active manufacturing facility in Massachusetts, chlorinated volatile organics (CVOCs) have been detected above state criteria in groundwater at levels over 300 milligrams per liter (mg/L). Groundwater impacts include the shallow overburden, deep overburden, and bedrock aquifers. In addition, CVOCs were determined to be present in soil vapor in source areas beneath the buildings at concentrations that could result in potential impacts to indoor air. The original pump and treat remedy was replaced with large-scale chemical oxidation program (>200,000 gallons). Permanganate treatment has also been supplemented with enhanced bioremediation to treat CVOCs contamination adjacent to an on-site stream. The enhanced bioremediation treatment also targets elevated levels of 1,1,1-TCA (>50 mg/L) and acetone (> 20 mg/L) in the deep overburden.

**Approach/Activities.** A combination of treatments were used at this site, including soil vapor extraction (SVE), permanganate and enhanced bioremediation to treat unique site locations, target specific compounds, and progress towards remedial objectives. Remedial goals included reducing CVOC in groundwater below state upper concentration limits and reducing concentration of CVOC in indoor air below state threshold limits. To address shallow soil impacts and mitigate potential VOC migration into indoor air, SVE systems were installed at the two buildings located over the main source areas. One SVE system utilized horizontal wells installed with a drill rig and the second utilized horizontal trench extraction wells. Following several years of successful SVE operation, permanganate injections were conducted using one of the SVE systems. Using the second SVE system, enhanced bioremediation has been performed to provide additional groundwater treatment beneath the building and to reduce potential CVOC migration into indoor air. Bioremediation has also been used to treat CVOC impacts downgradient of the buildings, near a shallow stream which may have been adversely effected by permanganate applications. Additional bioremediation was conducted following permanganate treatment to target an area with 1,1,1-TCA and acetone groundwater impacts.

**Results/Lessons Learned.** Groundwater data show that permanganate treatment has reduced CVOC impacts in groundwater in several areas to achieve the remedial goal. Concentrations of trichloroethene at some source wells have been reduced by over 99 percent. Remediation of CVOCs in the shallow overburden adjacent to the stream has reduced of target CVOCs and breakdown products, also by over 99 percent. Following the additional groundwater treatment using subslab SVE wells, indoor sampling results have indicated lower levels of VOC under static conditions, further reducing potential migration of VOC into both buildings. The use of multiple remediation technologies has reduced significant amounts of CVOC mass in the soil and groundwater under and adjacent to the active manufacturing site, however remedial goals have not been met. Groundwater treatment continues at this site, including evaluating additional technologies to reach site goals.