Contraction of a 15-Acre TCE Plume in Overburden and Bedrock Three Years after Full-Scale Barrier Construction by Controlled-Jet ZVI Injection

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Background/Objectives. We present data demonstrating continued contraction of a 15-acre TCE plume in overburden and bedrock over three years after full-scale construction of a zero valent iron (ZVI) permeable reactive barrier (PRB) treatment zone utilizing controlled-jet injection. Plume-area groundwater TCE concentrations as high as 110,000 ug/L resulted from discharges at an industrial facility in Greenville, SC. The plume spread across a large area because of the source location at the top of a hill and because there is virtually no natural degradation due to the naturally acidic groundwater. The overburden is relatively low permeability, saprolitic soil. The underlying partially weathered schist and gneiss bedrock has predominantly horizontal, water-bearing fractures. Access to the plume area is very limited due to a steep slope, a highway, and a forested area, and groundwater discharges to surface water at the toe of the plume. A separate remedy was implemented to mitigate TCE flux from the source area.

Approach/Activities. ZVI was selected due to treatability of the VOCs, long reagent lifetime, and no release of dissolved products that could impact the surface water. The presence of TCE in the fractured rock aquifer, relatively thin (<5 ft) mantle of overburden, and hydraulic communication between the overburden and bedrock ruled out traditional trench and fill PRB construction. We utilized controlled-jet injection of a solid slurry of ZVI to construct three PRBs across both the overburden and shallow bedrock aquifers. Results of a 2011 pilot test were utilized to refine the full-scale design. Full-scale construction consisted of injection of 725 tons of ZVI into 391 discrete intervals in 67 injection wells, across three barriers totaling 1,168 ft in length. Construction was completed in March 2014.

Results/Lessons Learned. Three years of groundwater monitoring data (frequency varying from quarterly to annual) are available for 22 monitoring and former recovery wells within the plume area and downgradient from at least one PRB. TCE concentration in the most impacted well, located approximately 30 ft downgradient from a PRB, has decreased to 25.8 ug/L from 110,000 ug/L (99.98%). TCE concentration in eight overburden/saprolite wells located downgradient from the first barrier exhibit a reduction in the geometric mean to 140 ug/L from 1,944 ug/L (93%). TCE in four wells screened across overburden/saprolite into shallow bedrock exhibit a reduction to 36 ug/L from 1,195 ug/L (97%). TCE in nine wells in shallow bedrock exhibit a reduction to 158 ug/L from 2,598 ug/L (93%). TCE in one deep bedrock well has decreased to 6.8 ug/L from 3,230 ug/L (99.8%). Overall, the geometric mean TCE concentration has decreased to 100 ug/L from 2,050 ug/L (95%) in three years. Concentrations of cis-1,2-dichloroethene (generated as a TCE degradation product) exhibited large initial spikes proportional to TCE degradation, but have subsequently also subsided. Not all wells exhibit sequential reductions or reductions at similar rates. Breakthrough of permanganate (from the source area remedy) is apparent in groundwater quality data from a portion of the most upgradient PRB. The full-scale remedy performance is consistent with pre-construction remedial design modeling and objectives.