Use of In Situ Sensors and Injection Measurements to Evaluate Electron Donor Distribution in Low-Permeability Aquifer at Minimal Cost

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Background/Objectives. A pilot test was conducted to evaluate the potential for an in situ remedial approach to achieve closure of a challenging chlorinated solvent site with limited access, a low-permeability loess and glacial aquifer, and small business budget constraints. The pilot test involved top-down direct-push injection of a low-viscosity enhanced reductive dechlorination (ERD) substrate where total dissolved chlorinated ethene concentrations exceeded 27,000 micrograms per liter (µg/L). Concurrent measurement of injection parameters and groundwater levels was conducted during the pilot test to provide further three-dimensional subsurface characterization and technology evaluation at minimal cost.

Approach/Activities. An engineered hydrogen release compound designed to treat chlorinated volatile organic compounds (CVOCs) was injected approximately 15 to 25 feet below ground surface in seven injection points located upgradient of the site monitoring well exhibiting the highest CVOC concentrations (MW-3.01). Prior to initiating pilot test injections, a pressure transducer was deployed in MW-3.01 to continuously measure water levels throughout injection activities. Recorded pressures were corrected for barometric pressure effects and transformed to groundwater elevations. Injection pressures and volumes were measured with an in-line analog pressure gauge and flow meter, respectively, along with time intervals and depths for each injection interval at each injection point. Semiannual groundwater monitoring of CVOCs, geochemical parameters, and ERD substrate metabolites continued at the site following the pilot test. Concurrent location- and depth-specific injection flow rate, injection pressure, and groundwater elevation data were evaluated with collected groundwater data to assess aquifer properties, preferential pathways, and viability of a full-scale ERD injection approach.

Results/Lessons Learned. Pilot test data evaluation identified locations of varying permeability and hydraulic connectivity with monitoring well MW-3.01. Groundwater data indicated strongly reducing conditions, complete ERD of CVOCs to ethene, and 83% reduction in total CVOC concentrations were achieved near MW-3.01 without observed CVOC rebound 5 years after the pilot test. Groundwater data collected at crossgradient and downgradient locations also indicated influences of the pilot test up to 250 feet from the injection locations.

Pilot test results demonstrated that sufficient fluid distribution could be attained through traditional direct-push injection methods, and subsequent groundwater data demonstrated the aquifer was capable of dispersing the emplaced remedial fluids. CVOC removal rates confirmed that treatment occurred as CVOCs fluxed through the pilot test area and ERD was a viable remedial technology for the site. Based on the pilot test results and limited site access, a full-scale ERD remedy using a multiple permeable reactive barrier (PRB) approach was developed and implemented. Concurrent water level, geochemical, and injection parameter measurements aided further characterization of subsurface properties and fluid distribution during PRB injections. Two years after full-scale ERD implementation, site closure criteria were achieved. In conclusion, low-cost data collection during pilot test injections provided site-specific information to evaluate and tailor an in situ ERD remedy, where strategically-placed immobile barriers were established to treat mobile-phase CVOCs and achieve site closure.