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Full-Scale Implementation of In Situ Chemical Reduction and Enhanced Bioremediation of VOC-Impacted Fractured Bedrock and Groundwater

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Background/Objectives. The application of in situ chemical reduction (ISCR) reagents in combination with emulsified oil augmented with red rice yeast extract was applied to enhance reductive dechlorination processes within a fractured bedrock formation for the treatment of groundwater impacted with volatile organic compounds (VOC) including perchloroethylene (PCE) and its daughter products, trichloroethylene (TCE), 1,2-dichloroethylene (DCE) and vinyl chloride (VC). Soil vapor extraction (SVE) and limited excavation of impacted soils within the release areas had been performed as interim remedial measures. However, the static water table at the site was located in the shallow fractured bedrock consisting of sedimentary stratum. The goal of the remedy was to induce abiotic degradation of the dissolved contaminants within the groundwater filled fractures followed by the promotion of ERD to address potential back diffusion of the contaminants from the bedrock matrix.

Approach/Activities. The implementation of the remedy included the performance of a pilot test to determine the injection point spacing and potential injection pressure required for distribution of the ISCR/ERD reagents throughout two target treatment areas of approximately 30,000 square feet. Following the completion of the pilot testing activities, the injection point array was installed using an NX coring tool to create an open borehole of approximately 4-inch interior diameter (ID) within the bedrock. After the collection of representative groundwater samples from the injection points and downgradient existing groundwater monitoring wells, the injection of the reagents was performed using low pressure (<25 PSI) pumps. Post injection monitoring was conducted on a 30-day frequency for the first 90 days followed by semiannual and annual sampling events. Monitoring parameters included field indicator parameters, dissolved and total metals, total organic carbon (TOC), the parent compounds and anticipated daughter products including ethene, ethane, methane and chloride. The intrinsic microbial population was determined before and after the injection program to evaluate the effectiveness of the emulsified oil to promote the growth of dehalococcoides ethenogenes (DHC), and dehalobacter (DHB) species using quantitative polymerase chain reaction (qPCR) analysis.

Results/Lessons Learned. Groundwater monitoring results indicated an over 50% reduction of contaminant concentrations within the downgradient existing monitoring well locations within 60 days post injection with significant increases in the dissolved iron (Fe) and TOC concentrations indicating that the reagents had been distributed throughout the target treatment area to promote the growth of the indigenous DHC and DHB species identified within the bedrock matrix prior to the injection. This presentation will provide an analysis of the project data collected including bedrock core analysis, groundwater quality data and functional gene activity.