Application of Enhanced Reductive Dechlorination for Groundwater Remediation under Challenging Injection Conditions near the San Francisco Bay

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Background/Objectives. In-situ bioremediation was applied to reduce concentrations of chlorinated volatile organic compounds (cVOCs) at the former Naval Fuel Depot Point Molate in Richmond, California. Enhanced reductive dechlorination (ERD) was selected as the preferred in-situ remedy due to the relatively low cVOC concentrations, the diffuse distribution of cVOCs, and the timeframe within which remedial goals were to be achieved. The design of the ERD injection program included both source area treatment and dissolved phase VOC to mitigate migration of impacted groundwater into the San Francisco Bay. The objective of the groundwater remediation was to reduce cVOC concentrations to below Regional Water Quality Control Board Environmental Screening Levels in estuarine surface water. Challenges associated with the injection program included accounting for shallow bedrock that controls the extent of the horizontal and vertical contamination in a large portion the treatment. The bedrock has a steep slope with a change of elevation of more than 25 feet within the treatment area. A clay matrix around the bedrock fragments has very low permeability and inhibits the movement of groundwater, therefore creating for relatively low groundwater velocities in the treatment area. Another challenge was the large variation in groundwater elevations.

Approach/Activities. Approximately 107,000 gallons of an emulsified vegetable oil substrate mixture were injected into 67 injection points distributed among eight rows, perpendicular to groundwater flow direction, throughout the treatment area. The distance between injection points along each row was approximately 15 feet, and the rows were placed approximately 30 feet apart. The 15-foot injection point spacing along each row was based on an anticipated radius of influence (ROI) of 10 feet, and provided an overlap of injection areas of approximately 18% around each injection point, to optimize the distribution of substrate along the entire length of each row. On average, approximately 1,500 gallons were injected into each point at an average flow rate of approximately 3 gallons per minute and an average pressure of 62 psi. Visual observation of a fluorescent dye indicated that the design ROI was achieved. Measures were taken to prevent the substrate from entering the Bay. In addition, special caution was taken to not distub or harm wildlife or historical artifacts since the injection area was located within designated biological and cultural resource areas.

Results/Lessons Learned. Analysis of groundwater in the source area four months after the injection indicated that TCE concentrations were reduced by 95% with an observed increase in daughter products. Concentrations of cVOCs in groundwater monitoring wells within the dissolved plume area have decreased by an average of 69% with an increase in daughter products. In addition, innocuous dechlorination end products including ethane and ethane were detected in the wells sampled within the treatment area, which were non-detect during baseline sampling. The data indicates that the ERD program has been successful in reducing cVOC concentrations and is ahead of its anticipated goal for cleanup. Performance monitoring will continue to be conducted for a two-year period following injection.