

## Comparison of EVO Injection Strategies in a Coastal Plain Aquifer

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A dual-injection strategy utilizing two different procedures for injection of emulsified vegetable oil (EVO) and a dechlorinating microbial culture were tested to evaluate the best means of injecting a biobarrier into a coastal plain aquifer. The first injection procedure sandwiched bioaugmentation of the aquifer by injecting equal amounts of EVO before and after adding the microbial culture. The second injection procedure added all of the EVO to the aquifer prior to bioaugmentation. The objectives of this study were to answer the following questions: 1) How much time is needed to achieve appropriate reducing conditions in the injection wells for each method? 2) Which method results in better distribution of EVO? 3) Is the distribution of the microbial culture achieved between adjacent wells and does the microbial culture survive?

During the injection process for both strategies, groundwater samples were collected from each line at the extraction manifold and analyzed for field parameters (i.e., dissolved oxygen, oxidation reduction potential, pH, and total organic carbon [TOC]). Performance monitoring parameters included anions, volatile fatty acids, and chlorinated volatile organic compounds while verification parameters included methane, ethane, ethene and *Dehalococcoides* (DHC) gene density. Sampling for performance and verification parameters was conducted in the biobarrier wells prior to bioaugmentation and after biobarrier installation. In addition, samples were collected from performance monitoring wells located directly downgradient of the source area biobarrier. Data collected from the wells was used to address the objectives of the study.

For the first objective, groundwater geochemistry (redox indicators and pH) results showed that for both injection strategies aquifer conditions were appropriate for bioaugmentation within 1 week or less of injecting the EVO. For the second objective of the dual injection strategy, the TOC concentrations were used as a surrogate to monitor distribution of the EVO in the subsurface. EVO breakthrough curves demonstrated groundwater communication between the injection and the extraction wells for both methods and appeared to adequately distribute the EVO in the subsurface. Finally, the third objective of this dual injection strategy addressed the distribution and survivability of the microbial culture. Performance and verification parameters showed that the microbial culture was becoming established within the biobarrier. To address distribution portion of the objective, samples were collected at downgradient performance monitoring wells. DHC levels increased from non-detect prior to the biobarrier installation to  $7.0 \times 10^4$  cells/L. Ultimately, the predominant factor in selecting an injection strategy was based on the impact of biofouling on extraction and injection rates. The additional time required with switching injection and extraction wells after reaching 50% of the EVO substantially reduced the ability to extract groundwater from the formation. Therefore to promote the distribution of the dechlorinating culture within the formation, an injection strategy of 80% EVO initially followed by the culture and then the remaining 20% of EVO was recommended.