Cost-Effectiveness of In Situ Aerobic Cometabolic Biodegradation for Treating Large Deep Dilute Plumes Containing 1,4-Dioxane and CVOCs

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Background/Objectives. One of the greatest challenges for environmental restoration is remediation of large, deep, dilute groundwater plumes caused by deep (>100 feet) sources of 1,4-dioxane (1,4-D) and chlorinated volatile organic contaminants (CVOCs) such as trichloroethene (TCE) and cis-1,2-dichloroethene (cDCE). For such sites, the pump-and-treat (P&T) approach can appear to be the most reliable risk mitigation measure for potential receptors; however, the presence of 1,4-D in extracted groundwater often requires above-ground treatment through an advanced oxidization process (AOP) that has relatively high capital and annual operation and maintenance (O&M) costs. A recent field test conducted at the former McClellan Air Force Base (McAFB) has shown that in situ aerobic cometabolic biodegradation (ACB) has great potential of concurrently treating many CVOCs and 1,4-D to levels below their respective site-specific cleanup goals. In addition, it was found that, when treating a dilute plume, the O&M cost for the in situ ACB technology may be significantly lower than that for treating a high concentration plume because a low substrate loading is sufficient to maintain the stability and performance of the in situ bioreactor. To assess the degree of cost effectiveness of the in situ ACB technology in comparison with the P&T with AOP, the hydrogeologic conditions at the former McAFB were used to serve as the basis for estimating the capital and O&M costs for both technologies.

Approach/Activities. A cost spreadsheet was developed to estimate the capital and O&M costs for the ACB and P&T technologies. The capital cost components were included: (1) installation of extraction/injection/monitoring wells, (2) pumps for groundwater extraction, (3) above-groundwater treatment system (for P&T with AOP) or amendment addition system (for ACB), and (4) other supporting infrastructure. The O&M cost components include: (1) treatment operation cost, (2) chemical/amendment cost, (3) performance monitoring cost, and (4) system maintenance cost (e.g., rehabilitation of injection wells for ACB and UV lamp replacement for AOP). Key system characteristics, such as plume depth, plume width, representative hydraulic conductivity, groundwater velocity, target contaminant concentrations, and degradation efficiency are used to evaluate the dependence of the capital and O&M costs on these system parameters. The cost basis is originated form actual project experience with adjustments to account for the difference in system scale.

Results/Lessons Learned. Our preliminary analysis indicates that, for both the capital and O&M costs, the ACB technology can be significantly more cost-effective than the P&T with AOP in many cases. P&T with AOP technology is expected to consume much more electricity and incur significantly higher chemical costs (e.g., hydrogen peroxide). The extent of concentration reduction required to attain the cleanup goals concurrently together with achievable site-specific ACB efficiency is very important for the cost effectiveness of the ACB technology. To the contrary, the P&T with AOP is less sensitive to the variation of contaminant concentrations. A detailed, quantitative analysis of system characteristics on cost benefit of the ACB technology will be discussed in the presentation.