Predictive Modeling of Downgradient Concentrations and Overall Closure Timeframe Resulting from Bioremediation

Friedrich J. Krembs, P.E., P.G. (fkrembs@trihydro.com), George E. Mathes, P.E., Mitchell R. Olson, Ph.D., P.E., and Michael G. Sweetenham (Trihydro Corporation, Laramie, WY, USA)

Background/Objectives. A large, dilute tetrachloroethene (PCE) plume is being managed using a combination of active remediation, natural attenuation, and institutional controls (ICs) at an active industrial facility located in Texas. The facility was built in 1975, and historical operations resulted in PCE impacts to a shallow groundwater unit. PCE and degradation products currently extend to adjoining properties. The area in which PCE concentrations exceed the maximum concentration limit (MCL) is approximately 40 acres. While monitoring and potential receptor surveys indicated that the plume does not pose a threat to human health and the environment, a strategy combining PCE treatment, natural attenuation, and ICs was identified as means to reduce the lifecycle cost of environmental management. Groundwater modeling was a key element in developing an optimal remediation strategy and estimating the duration required until project closure.

Approach/Activities. ICs and industrial standards were used for on-site areas, however, the use of ICs is not practicable in off-site agricultural/residential areas. Additionally, concentration trends in off-site areas did not support use of monitored natural attenuation (MNA) as a standalone remedy. In-situ bioremediation (ISB) was selected as the active remediation technology during technology screening and pilot testing. Per Texas regulations, full-scale design was documented in a Response Action Plan (RAP) that specified the cleanup timeframe. Because of the large footprint of the plume and access constraints in off-site areas, the initial design consisted of ISB implementation along the downgradient property line.

The analytical groundwater model RemChlor was used to develop site-specific estimates of the timeframe of remediation and attainment of MCLs. The modeling effort was a two-part process. First, the model was calibrated to a 15-year period of existing monitoring data in the source area, mid-point, and leading edge of the groundwater plume. Second, the calibrated model was used to estimate concentrations of PCE and degradation products in the plume after ISB was implemented.

Results/Lessons Learned. The RemChlor model used measured groundwater hydraulic properties and estimates of streamtube profiles based on lithology. During calibration, source decay, degradation rates, and retardation coefficients were used as fitting parameters. Iterative adjustment of these parameters allowed the model to accurately reflect plume movement and natural degradation over both time and space.

While the success of ISB was well-understood within the footprint of the treatment zone based on the pilot test, there was uncertainty regarding how quickly downgradient concentrations would be reduced if ISB was implemented on the client property line. The calibrated RemChlor model was used to assess this by greatly increasing degradation rates on client property, but not in downgradient areas. This modeling indicated that a 30-40 year period would be required to attain MCLs at the leading edge of the plume. As a result, an additional transect of ISB injection wells was incorporated into the design, shortening the timeframe to approximately 14 years.