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Evaluation of Trichloroethylene Attenuation Rates and Mechanisms in Support of Monitored Natural Attenuation

Jaana Pietari (jpietari@exponent.com) (Exponent, Inc., Maynard, MA, USA)
Peter Mesard (pmesard@exponent.com) (Exponent, Inc., Oakland, CA, USA)
Todd Muelhoefer (Todd_Muelhoefer@kindermorgan.com) (Kinder Morgan, Colorado Springs, CO, USA)

Background. Located in the Midwest with a long history of various industrial operations, the Area of Interest (the Area) is contaminated with halogenated volatile organic compounds (HVOCs), principally trichloroethylene (TCE) and petroleum hydrocarbons (PHCs). First observed in the early 1980s, groundwater contamination led to decades of individual site investigations as well an Area-wide remedial investigation (RI) begun in the late 1990s and an Area-wide feasibility study (FS) begun in the mid-2000s. A Corrective Action Decision for an interim Area-wide groundwater remediation issued in 2012 divided the area into several groundwater units and consisted mostly of source abatement and Area-wide groundwater extraction and treatment and, to lesser extent, monitored natural attenuation (MNA) for HVOCs.

Prior studies on attenuation of HVOCs concluded that natural processes relying on anaerobic reductive dechlorination appeared to be active only in limited locations affected by PHCs (a source of electron donors to microbial populations). However, remedy-related investigations conducted in 2014 to support an Area-wide remedial design suggest substantial attenuation of TCE had occurred since the completion of RI- and FS-related investigations. Therefore, the objective of our study was to evaluate whether a large plume of TCE in groundwater was attenuating in one of the groundwater units (Unit G-2) for which groundwater extraction and treatment was selected as the preferred remedy. Our goal was to assess well-by-well attenuation and then to estimate the attenuation rates and evaluate potential attenuation mechanisms in addition to determining a timeframe to meet the TCE alternative treatment goal.

Approach. Current and historical groundwater data on HVOCs from both shallow and deep monitoring wells in Unit G-2 were compiled and reviewed. The analysis was limited to wells for which recent (2014) remedial design data were available (21 shallow and 18 deep wells). Based on TCE isoconcentration contours, “fence-diagrams” were established along the axis of the TCE plumes. HVOC concentration trends were evaluated in the wells along the fence lines in addition to wells located transverse to the fence lines. Furthermore, reasonably assuming first order attenuation kinetics, rate constants were determined for each well with sufficient data available (3 or more results above detection limits). Lastly, times to meet the TCE goal of 21 µg/L were determined.

Results. All examined wells indicated strong decreasing overall TCE and daughter HVOC trends. Many of the shallow and deep wells included in the analysis had already reached the TCE alternative treatment goal of 21 µg/L. TCE attenuation followed first order kinetics reasonably well in most wells examined. The average TCE half-lives in the shallow and deep groundwater zones were four and five years, respectively. We estimated that TCE treatment goals would be met in the wells examined by 2021 for the shallow zone and by 2022 for the deep zone, which strongly suggests that MNA is technically and cost-effectively superior to groundwater extraction and treatment. The HVOC trends indicated evidence of reductive dechlorination, but suggested that other attenuation mechanisms, including aerobic cometabolism, abiotic reduction by reaction with naturally occurring bivalent iron (such as the

mineral magnetite), dilution, and/or sorption (or combinations thereof), were responsible for the rapid reduction of TCE levels in Unit G-2.