Using Two Mass Flux Methods to Evaluate Areas of TCE Discharge to a Creek

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Background/Objectives. Boeing has been investigating, monitoring, and performing various interim actions related to a roughly 3,000-foot long trichloroethene (TCE) plume originating from beneath a stormwater detention basin at the headwaters of Powder Mill Creek at the Boeing airplane manufacturing plant in Everett, Washington. The TCE plume migrates adjacent and parallel to the creek and shares varying levels of hydraulic connectivity with the creek as influenced by hydrogeologic and physical features. Boeing and the Washington State Department of Ecology (Ecology) agreed to an interim action involving installation of extraction wells to hydraulically control the plume and minimize contaminated groundwater discharge to the creek. During planning, an evaluation was conducted to determine where extraction wells would be necessary to minimize TCE discharge to the creek.

Based on groundwater contours and TCE concentrations measured along the creek, it appeared evident that TCE discharge to the creek was highest from approximately 400 to 600 ft downgradient of the source area (“upper plume”) and at approximately 1,800 to 2,600 ft downgradient of the source area (“toe of the plume”) where the plume terminates as discharge to the creek. The central (“mid-plume”) area appeared to have negligible inputs of TCE to the creek due to a culverted section of the creek followed by a channelized section that substantially reduces the hydraulic connection between the creek and groundwater. This suggested that extraction wells were not needed in the mid-plume area to minimize TCE discharge to the creek. A more detailed investigation and evaluation was performed to validate this supposition.

Approach/Activities. An investigation was performed that included installation of a series of monitoring well pairs and staff gauges aligned perpendicular to the creek to provide detailed cross sectional groundwater gradient and groundwater quality data. Using groundwater gradient, hydraulic conductivity, and concentration data, TCE flux ($\mu g/ft^2$-sec) values were calculated for each cross section. This evaluation method was deemed the “groundwater flux method”. Volumetric stream flow measurements and surface water quality sampling were also conducted at the same staff gauge locations, and the mass flux of TCE (µg/sec) passing each point within the creek was calculated. The differences in flux values at each consecutive location were then compared to identify positive or negative flux of TCE to the creek (i.e., the net difference between TCE discharge into the creek from groundwater and out of the creek from volatilization). This flux evaluation method was deemed the “creek flux method”.

Results/Lessons Learned. Although not directly comparable due to difference in units, the general trends and magnitude of the groundwater flux method and the creek flux method shared significant similarities. The groundwater flux method indicated that TCE flux from groundwater in the mid-plume area was an order of magnitude or more lower than at the upper plume and the toe of the plume. The creek flux method identified a negative net flux through the mid-creek area indicating that the rate of TCE loss through volatilization was higher than inputs of TCE from groundwater. Based on the strong agreement of multiple lines of evidence, including two distinct methods of evaluating flux, it was recommended that no extraction wells were necessary in the mid-plume area to minimize discharge of TCE to the creek.