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Novel Use of Mass Flux Mapping to Optimize Large-Scale Biobarriers for Treatment of Perchlorate, TCE, Chromium and High Explosives

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Background/Objectives. Mass flux is a recently developed means of assessing impacts to groundwater and the effectiveness of remediation technology performance. The methods and results are presented of a mass flux based optimization of the ongoing operations and maintenance (O&M) of two in-situ bioremediation (ISB) systems that treat the constituents of concern (COCs) perchlorate, trichloroethene (TCE), chromium, and high explosives. ISB is currently being employed for groundwater remediation at the U.S. Department of Energy (DOE) Pantex Plant (Pantex) near Amarillo, Texas. The objective of this paper is to illustrate the use of spatial mapping of mass flux, as opposed to traditional mass flux evaluations that are typically conducted in a vertical plane. The use of mass flux mapping as a means to optimize COC treatment is highlighted.

Approach/Activities. As part of recent O&M activities, the project team revised the conceptual site model (CSM) for the vicinity of each of the two systems with recent data that were unavailable at the time the systems were constructed. The spatial variation in mass flux of constituents of potential concern (COPCs) within the system was an important aspect of the CSM revision. COPC mass flux was calculated from hydraulic testing results, depth to groundwater, and COPC analytical results using a geospatial software package.

Results/Lessons Learned. COPC mass flux into the treatment zone was highly variable as a result of local variation of both hydraulic conductivity and COPC concentrations in groundwater. In addition to COPC mass flux, desired physical residence time within the system was another means of evaluation. Multiple COPCs are present and some (e.g., TCE) require a longer residence time for complete treatment within ISB systems relative to others (e.g., perchlorate). COPC mass flux mapping and estimated required residence time were both used to scale the dose of ISB amendment to increase the efficiency of amendment application during injection events. Incorporation of mass flux mapping into the design of the ISB systems resulted in an additional order of magnitude concentration reduction of some COPCs at downgradient locations. An increase in performance from 99% to 99.9% treatment resulted in attainment of the target groundwater protection standard at these downgradient locations.
Mass flux mapping increased the project team's understanding of the relationship of the downgradient performance monitoring wells to the ISB systems. Because of significant local variation in hydraulic conductivity, the calculated travel time of treated groundwater to downgradient monitoring locations varies by an order of magnitude. These data have been used to provide additional context for trends observed in groundwater analytical data collected from downgradient of the ISB systems. In particular, low groundwater flux provides a sound mechanistic basis for downgradient locations at which COPC concentrations decreases were observed at later time.