Innovative ISCR Remediation of Hexavalent Chromium-Impacted Groundwater in a Challenging Subsurface

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Background/Objectives. We summarize our results for bench-, pilot-, and full-scale implementation of calcium polysulfide (CP) reduction of hexavalent chromium (Cr(VI) at a site characterized by heterogeneous industrial conditions, with an innovative push-pull injection approach coupled with detailed geochemical monitoring to evaluate progress and identify additional source areas for treatment. Hexavalent chromium impacts to the subsurface resulted from improper waste storage and fire suppression activities in the late 1980s in which contaminated water overflowed the building foundation to impact surficial soils and leach into groundwater. Assessment activities for Cr(VI) residuals identified two, 2,000 square-foot areas requiring treatment. Despite the relatively manageable size of these two areas, subsurface conditions presented remediation challenges due to: (i) tidally-influenced groundwater levels and proximity to an adjacent river, (ii) interbedded low permeability silt and clay hydro-stratigraphic units, and (iii) remaining below-grade foundations following building demolition.

Approach/Activities. Bench-scale laboratory tests were conducted using CP and sodium meta-bisulfite to evaluate effective dosing necessary to reduce Cr(VI) below the regulatory standard of 3 mg/L. Test procedures involved exposure of site soil and groundwater to variable concentrations of each reagent in an inert atmospheric glovebox to minimize oxidative-state sensitivities. Both ISCR reagents demonstrated effectiveness, however CP showed a slight advantage due to the unexpected re-oxidation of Cr(VI) in SMB groundwater test samples following inadvertent exposure to atmospheric conditions. Each reagent was evaluated at the pilot scale, with CP emerging as the preferred reagent due to effectiveness treating higher concentrations of CrVI, lesser induced pH changes than SMB, and concerns with re-oxidation identified during bench testing. A pull-push approach for CP delivery was used during the full-scale to establish a greater injection ROI following depression of the water table during the extraction step followed by immediate re-injection of treated groundwater dosed with excess CP. To enhance CP distribution, steps were taken to minimize the time lag between extraction, ex situ treatment, and batching by actively re-circulating CP-dosed groundwater in area-specific mixing tanks and manipulation of hydraulics to support radial flow patterns outward from the center of each area. Following initial full-scale injection, performance monitoring occurred on a quarterly basis to evaluate progress toward achieving results below 3 mg/L.

Results/Lessons Learned. Within several months following concentrations of Cr(VI) were reduced below 3 mg/L in six of the eight monitoring wells used for compliance. Geochemistry monitoring at the lagging well within each test area confirmed Cr(VI) had rebounded to pre-treatment levels. In one of the areas, treatment was incomplete due to low permeability aquifer materials and micro-scale tidal fluctuations over time. Despite efforts to control mounding effects and migration of groundwater outside the treatment areas, Cr(VI)-impacted groundwater had been pushed upgradient and was slowly migrating toward the source area. These conditions were addressed during a smaller re-injection event included a more tightly-spaced injection network and higher concentrations of CP batched with smaller groundwater extraction volumes. Concentrations of Cr(VI) were reduced below regulatory standards in all but one location, prompting this location to receive periodic treatment using a scaled-down approach involving direct CP addition at the well-head.