Temporal Surface Geophysical Mapping to Assess Permanganate Injection Distribution and Recirculation Using a 100-Foot Deep Horizontal Well

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Background/Objectives. The Department of Defense (DoD) has identified in situ chemical oxidation (ISCO) through injection of permanganate via horizontal directionally drilled (HDD) wells as a potential alternative for groundwater treatment at a former dry cleaning facility above a sand aquifer. Groundwater is predominantly impacted by tetrachloroethene (PCE) at concentrations nearing 100 parts per million (ppm) at depths of 100 feet (feet) below ground surface (BGS). A pilot study was conducted to evaluate permanganate distribution via a HDD injection well and subsequently with the addition of vertical extraction wells to recirculate groundwater. The study evaluated the use of surface geophysical mapping to assess amendment distribution in the subsurface.

Approach/Activities. A HDD injection well with a 500-foot screened interval was installed to a depth of 100 feet BGS through and perpendicular to the PCE groundwater plume. The distribution of permanganate in the subsurface was evaluated by using specialty temporal surface electrical resistivity imaging technology (Aestus GeoTrax Survey LTM™). Permanganate was injected as ISCO treatment and included a saline tracer to enhance electrical conductivity changes to the groundwater and subsequent detection by the imaging methodology. Electrical image data and interpretation were confirmed using groundwater geochemistry data changes in surrounding monitoring wells.

The chemoelectric tracer study was conducted in three phases. Phase I consisted of baseline imaging of chemistry and electrical properties of the site. Electrodes were permanently installed and remained in the same fixed locations for the remainder of the study. During Phase II, approximately 100,000 gallons of 2 percent permanganate was injected through the HDD well. Following the injection, performance monitoring from vertical monitoring wells and geophysical imaging were conducted and compared to baseline conditions. Phase III involved temporal imaging following operation of a closed-loop extraction/recirculation system consisting of vertical extraction wells with submersible pumps and conveyance piping to route groundwater to the HDD well for re-injection. Another round of performance monitoring was conducted to assess whether recirculation significantly improved permanganate distribution.

Results/Lessons Learned. All three phases of the HDD injection well and recirculation system construction, with associated geophysical temporal imaging, have been completed. Tracer was injected and imaged and then recirculated and imaged again. Interpretation of temporal electrical resistivity data and integrated performance monitoring well data suggested two channel features which influenced the flow from the horizontal well. One of these channels accepted significant quantities of injectate, but was located past the end of the screened interval. These data also indicate potential for significant vertical movement of tracer from the injection well. Finally, the results of this pilot scale test suggest recirculation was successful at improving the distribution of tracer at the site, and they allow for optimized HDD well spacing during a full-scale remedy implementation.