

## Distribution of Permanganate via 100-Foot Deep Horizontal Well

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**Background/Objectives.** The Naval Facilities Engineering Command (NAVFAC) Mid-Atlantic 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. Groundwater is predominantly impacted by tetrachloroethene (PCE) at concentrations nearing 100 parts per million (ppm) at depths of 100 feet (ft) below ground surface (bgs). A pilot study was conducted in 2016 to evaluate permanganate distribution via a HDD injection well and then with the addition of vertical extraction wells to recirculate groundwater. The study also evaluated the use of geophysical mapping to assess amendment distribution in the subsurface.

**Approach/Activities.** A HDD injection well was installed with a 500-foot screened interval to a depth of 100 ft bgs through the PCE groundwater plume. The distribution of permanganate in the subsurface was evaluated by assessing groundwater geochemistry changes in surrounding monitoring wells. Additionally, a geophysical mapping technique that uses electrical resistivity imaging (GeoTrax Survey, developed by Aestus, LLC) was used to evaluate the distribution of the permanganate based on a comparison of baseline and post-injection results.

The tracer study was conducted in two phases. During Phase I, approximately 100,000 gallons of 2 percent permanganate was injected through the HDD well. In Phase II, a closed-loop extraction/recirculation system was employed for one month. Performance monitoring and geophysical mapping was conducted to assess whether recirculation significantly improves permanganate distribution, allowing for optimization of the spacing of HDD injection wells during full-scale remedy implementation.

**Results/Lessons Learned.** Results of the tracer study, including identification of critical design parameters needed for a full-scale design (permanganate dosage, injection rates, and extraction/recirculation rates) will be presented. The presentation will also discuss the feasibility and effectiveness of ISCO using permanganate delivered with a HDD injection well for treating PCE at the site, as well as the effectiveness of using geophysical mapping as a means of assessing permanganate distribution following injection through a HDD well and following extraction/recirculation. The tracer study proved that recirculation via the HDD injection well was an effective method to enhance substrate distribution in the subsurface. A lateral distribution of 25 feet was observed using traditional performance monitoring techniques; however, geophysical mapping results indicate that permanganate was distributed up to 33 feet laterally from the injection well. The delivery of permanganate via the HDD injection well yielded a 20- to 25-foot vertical distribution, based on geophysical mapping results. During the tracer study, PCE concentrations were observed to decrease up to 97 percent, with an overall reduction of constituents of concern of up to 82 percent.