

# **Arsenic Fate, Transport, and In Situ Bioremediation at a Large Former Industrial Site**

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**Background/Objectives.** The primary objective of this project was to develop an in situ treatment approach to significantly reduce the concentration and transport of arsenic in groundwater originating from several shallow soil source areas. The findings are relevant to arsenic-impacted sites and to natural anaerobic groundwaters with elevated arsenic concentrations.

**Approach/Activities.** A site conceptual model describing arsenic distribution and transport within an approximate 200-acre area was developed using dozens of shallow soil borings to map arsenic source areas, vertical soil and groundwater profiling extending through approximately 30 feet of sandy saturated sand, geochemical analysis of soil and groundwater samples, and a model developed to predict arsenic transport in response to different remedial approaches. Laboratory treatability tests evaluated a variety of approaches to sequester arsenic in place by generating arsenic scavenging minerals. Based on these results, three pilot tests were conducted to evaluate enhanced microbial sulfate reduction for generating sulfide minerals. One pilot test evaluated oxygen diffusers to generate ferric iron minerals for arsenic sequestration.

**Results/Lessons Learned.** Native anaerobic conditions and microbial iron reduction, driven in part by the presence of deposited peat, aid arsenic solubility and migration with groundwater flow from the source areas. Laboratory treatability test results indicate that although the direct addition of ferric iron and aeration with or without supplemental iron resulted in arsenic decreases to below the MCL, these treatments did not result in permanent arsenic sequestration under the site's native reducing groundwater conditions. The enhanced sulfate reduction treatability test results showed arsenic sequestration to varying extents (typically above the MCL) depending on the sample and treatment type. Less effective arsenic sequestration was observed with treatments that led to hydrogen sulfide accumulation.

The enhanced sulfate reduction pilot test results, solid phase arsenic geochemistry, and treatability test results indicate that a fraction of the arsenic in the saturated sands is associated with ferric iron minerals subject to reductive iron dissolution and release to groundwater prior to being sequestered under enhanced sulfate reducing conditions. Reductive iron dissolution was greatest where the native redox conditions were less reducing, and where dissolved hydrogen sulfide concentrations increased. Therefore, over a year was required to evaluate the enhanced sulfate reduction pilot tests at which time a 72% average arsenic reduction was observed in two pilot areas at wells with elevated baseline arsenic ( $\sim > 0.2$  mg/L). Arsenic concentrations increased at three locations (minor arsenic increase in two of three wells) where less reducing or oxidizing conditions and low arsenic in groundwater was present prior to the injections. Other process optimization findings include that sufficient organic carbon and distribution thereof was required to stimulating microbial sulfate reduction versus stimulating microbial iron reduction which liberates arsenic to groundwater, a PRB-like treatment of arsenic including after sulfate reduction stopped, and the injection interval should not overlap zone(s) with oxidizing conditions.