ZVI/Clay Mixing to Treat DNAPL Source Zone after Previous Implementation of Several Innovative Technologies

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Background/Objectives. In situ mixing of contaminated soil with zero-valent iron (ZVI) and clay has been shown to be an effective technology to remediate source zones with chlorinated solvent contamination. In this treatability study, ZVI/clay soil mixing was implemented at a site containing dense non-aqueous phase liquid (DNAPL) consisting primarily of trichloroethene (TCE). The site is located within Operable Unit 2 (OU 2) at Hill Air Force Base in northern Utah. The DNAPL had accumulated in an alluvial paleochannel within a clay aquitard. This area of OU 2 had been previously treated over a period of 20 years with several other technologies, including extraction of mobile DNAPL by pumping, surfactant flushing, and a robust application of enhanced reductive dechlorination (ERD). ZVI/clay soil mixing was selected to treat remaining DNAPL within this area, eliminating the need for continued hydraulic control. Existing infrastructure surrounding the mixing area, depth of contamination, and site geology presented significant obstacles to in situ soil mixing. These obstacles were overcome by changes in the field to the mixing equipment and methodology.

Approach/Activities. The ZVI/clay soil mixing treatability study was implemented between October and December 2016. In situ mixing was preceded by a shallow excavation to remove as much clean overburden as possible. Approximately 2,600 cubic yards of contaminated soil were treated in 125 soil mixing columns, to depths of 31 to 41 feet below ground surface. Approximately 174,000 pounds of ZVI, 191,000 pounds of bentonite, and 300,000 gallons of water were mixed into the treatment zone by a fixed-mast, track-mounted rig.

Due to the presence of dense zones of coarse alluvial material including gravel and cobbles, several changes were made to the soil mixing equipment and methodology, including pre-drilling soil mixing columns in half of the study area with a rock auger.

Results/Lessons Learned. Prior to the ZVI/clay soil mixing treatability study, reducing conditions had been maintained within the contaminated zone of the aquifer for approximately 10 years due to previous ERD treatment. TCE concentrations in the aqueous phase had decreased by two orders of magnitude within this period. However, an increase was observed in the post-mixing TCE groundwater concentration within the treatment zone (greater than 10 percent of the solubility limit for TCE), compared to pre-mix concentrations. This indicated that residual DNAPL had still been present in the fine-grained material in the bottom of the mixing zone prior to mixing. With changes to the soil mixing equipment, the ZVI/clay soil mixing successfully mixed the residual DNAPL with the aquifer material, ZVI, and clay to the target depth. Within five months, the average concentration of TCE in groundwater within the mixing area decreased approximately 80 percent from the post-mixing peak. ZVI/clay soil mixing is expected to be the final remedial step for the treatability study area, and may be applied to the larger source area where DNAPL is still present.