In Situ Solidification/Stabilization of a Residual Acid Tar via Deep Soil Mixing with Large Diameter Augers

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Background/Objectives. Site investigations identified a highly acidic waste composed primarily of water, organic carbon, sulfate, aluminum, and iron, referred to as residual acid tar. Dissolved chemicals in groundwater that contacted the residual acid tar include organic acids, petroleum hydrocarbons, and metals. In situ solidification/stabilization (ISS) via deep soil mixing with large diameter augers was selected for an interim corrective action to limit transport of dissolved phase contaminant mass across a compliance perimeter and protect downgradient sensitive receptors. Specific objectives of the ISS treatment included increasing the pH and reducing dissolved nickel in leachate from treated material to greater than 5.5 and less than 0.140 µg/L, respectively, and achieving an unconfined compressive strength of 15 psi and reducing hydraulic conductivity to below $2x10^{-6}$ cm/s in the treated solids.

Approach/Activities. Over 265 simulations were performed using a flow and solute transport model to estimate mass discharge towards the compliance perimeter, refine the treatment footprint, and develop treatment goals for the injection slurry. Sixty-five individual treatability tests were conducted to evaluate various reagents and mix percentages. Mix columns were installed utilizing a 6,000 liter-per-day custom batch plant and Bauer BG-39 rotary drill rig equipped with a custom fabricated 10-foot diameter auger lined with injection ports along the mix blades. Prior to full-scale implementation, a field demonstration was performed to evaluate and select drill parameters, confirm the ability of the injection slurry to meet treatment objectives, troubleshoot mix plant and drill rig equipment, and evaluate geotechnical responses during drilling.

Results/Lessons Learned. Simulations of the groundwater flow model allowed the treatment footprint area to be reduced by over 70% from the conceptual design and indicated a hydraulic conductivity of $2x10^{-6}$ cm/s would reduce mass flux towards the compliance perimeter by two-thirds. Treatability testing identified a reagent slurry mix consisting of 80% ground granulated blast furnace slag, 20% Portland cement, and 3% hydrated lime at a 21% dose to treat the residual acid tar. Nineteen test columns were installed as part of a field demonstration. The tests indicated a penetration rate of 1.0 feet per minute (fpm) and injection rate of 300 gallons per linear foot (gal/LF) on the downstroke and extraction rate of 8.5 fpm and injection of 55 gal/LF on the upstroke were the optimum drilling parameters. Results of geotechnical monitoring showed ground surface movement due to heave, settlement, and lateral displacement were less than the 1-inch threshold established for the project and vibrational frequencies and peak particle velocity magnitudes were unlikely to result in resonance and damage to adjacent pipelines or other infrastructure. During implementation, 4.8 columns per day were installed over six months for a total of 564 columns at depths ranging from 15 to 55 feet below ground surface. Several critical lessons were learned during implementation of the S/S project and included utilizing pre-hydrated lime to eliminate the exothermic reaction and presence of inert particles associated with quicklime, limiting the time between drilling next to completed columns to minimize setting and prevent damage to the mix tool and drill rod, and utilizing smaller diameter augers to minimize heave and displacement near the treatment perimeter.