New Application of a Geotechnical Technology to Remediate Low-Permeability Contaminated Media

Stephen D. Richardson, Justin A. Long, Michael L. Schofield, Luz Rocha, and Charles J. Newell (GSI Environmental, Inc., Austin & Houston, TX, USA)

Background/Objectives. A critical challenge preventing many chlorinated solvent sites from reaching groundwater cleanup goals is the persistent release of residual contaminants from low permeability (low-k) clays and silts. To address this challenge, this ESTCP-funded project aims to demonstrate an innovative application (or "repurposing") of a widely-used geotechnical technology, the "Grout Bomber", to improve delivery of remedial amendments at sites with contaminants trapped in low-k zones. Specific objectives include demonstrating that:

- conventional "Grout Bomber" equipment can be repurposed to efficiently install hundreds of closely-spaced vertical reaction columns containing remedial amendment (i.e., zero valent iron [ZVI], vegetable oil);
- the remedial amendment stimulates degradation processes and generates concentration gradients that drive contaminant diffusion from low-k zones into the reaction columns; and
- by having closely-spaced (every 2 to 3 ft) vertical reaction columns, chlorinated solvent concentrations in low-k zones can be reduced, thus, significantly shortening the "long tail" of contaminant flux from matrix diffusion processes.

Approach/Activities. The "Grout Bomber" is a subsurface stabilization technology that uses an excavator equipped with specialized equipment (a "stitcher" mast) to quickly "push" 3.5 inch diameter vertical columns into the ground, subsequently filling them with cement grout (from bottom to top) via an in-line grout delivery system. For our environmental application, a remedial amendment mixture of ZVI, vegetable oil, and sand was used (instead of cement grout) to create hundreds of biotic/abiotic reaction columns for degradation of chlorinated solvents. The field demonstration was conducted at Site 17, Naval Support Facility Indian Head, Maryland. The treatment area consists primarily of silts, sandy clays, and lean clays with TCE concentrations in soil and groundwater of up to 250 mg/kg and 400 mg/L, respectively.

Results/Lessons Learned. Eight hundred reaction columns (consisting of ZVI/sand or oil/sand), were installed 2-3 ft apart, to a depth of 30 ft below ground surface at the site. Approximately 100 reaction columns were installed per day, with our most productive day totaling 180 columns. During operation, installation time for each reaction column was on the order of 1-2 minutes. Post installation monitoring events (at 1 and 7 months) of treatment area groundwater have showed reductions in TCE in site monitoring wells and detections of key degradation indicators for both abiotic and biotic mechanisms (acetylene, ethene/ethane). In addition, samples from Continuous Multilevel Tubing (CMT) wells installed within reaction columns (anulus filled with ZVI amendment) have demonstrated 2-3 orders of magnitude reductions in TCE relative to the surrounding formation (i.e. site monitoring wells) water. These results provide evidence that the reaction columns are creating steep concentration gradients that are driving contaminants out of low-permeability zones. Results to-date are very promising and, although several operational improvements were identified (e.g., improved pumpability of ZVI/sand mixture; minor equipment modifications; improved site prep practices), the Bomber technology appears to be a viable alternative for amendment delivery at low-permeability contaminated sites.