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Hydraulic fracturing used for groundwater cleanup on former Atlas missile site

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A new process involving hydraulic fracturing being used by a team from the U.S. Army Corps of Engineers Omaha District is proving successful at reducing or stabilizing trichloroethylene in groundwater at six test wells at the former F.E. Warren Atlas Missile Site 12 near Windsor, Colo.

The team is using the hydraulic fracturing process for groundwater cleanup at the site. Hydraulic fracturing can be used to create new fractures in consolidated, water-bearing formations and to deliver substantial volumes of amendments that are used to promote groundwater remediation.

Hydraulic fracturing is generally considered to be an innovative technology, given that it has very rarely been used for groundwater remediation on Department of Defense sites. There is a considerable amount of interest in hydraulic fracturing as a means of hastening groundwater cleanup by improving delivery and distribution of remediation amendments. The work was done under a performance-based contract, with North Wind, Inc. as the prime contractor and Frac Rite Environmental, LTD as the sub-contractor.

The contaminated groundwater zone being treated at the Atlas 12 site lies within a sandstone / siltstone formation. A pilot test performed in April and May 2009 determined that fracturing would be feasible at the site and allowed the team to assess the radius of influence that could be obtained through fracturing. Post-pilot test data indicated that TCE concentrations were reduced by about 80 percent in the area where the pilot test was performed. During the pilot test, surface tiltmeter geophysics were used to assess the orientation and extent of the fractures.

The fracturing process entailed high pressure injection of a slurried amendment that included potable water, plant-based cellulose material/micro-scale zero-valent iron and a protein gel. The micro-scale zero-valent iron amendment is designed to facilitate chemical reduction (abiotic TCE dechlorination), and the organic carbon amendment facilitates biotic anaerobic reductive dechlorination of TCE. Full-scale implementation of the fracturing process was completed in July and August 2011 as an interim measure at the site.

The interim measure work entailed injection of more than 134,000 pounds of amendment into six borehole locations. Within each borehole location, amendment was injected at three to seven discrete depth intervals for a total of 11,000 to 29,000 pounds of amendment per borehole. Water-filled, inflatable packers were used to pack-off the borehole above and below the injection interval to force the fracture to occur at the desired depth. The fractures were initiated by injecting a guar gel formulation. Once the fracture has been initiated, the pump intake is quickly switched over so that the amendment slurry can be injected, without pausing. After the required volume of amendment has been injected, more of the guar gel is injected as sort of a “chaser”.

The borehole locations for amendment injection were selected to provide coverage across most of the 100 parts per billion TCE contour of the plume. It was assumed that amendment would be propagated a radial distance of approximately 60-80 feet from each borehole. According to the subcontractor, there were instances where the amendment was observed to be day-lighting from open bore holes that were as much as 120 feet away from the injection borehole. However, uniform distribution of amendments

cannot be assured during hydraulic fracturing. There can be substantial differences in the distance of amendment propagation in each direction.

About 2,900 gallons of the slurried amendment was injected at each discrete depth interval in which a fracture was initiated within each boring. The slurry was injected continuously, until the prescribed volume had been injected. Injection pressures were near 62,660 pounds per square inch. It took about 30-45 minutes to inject the full volume of amendment at each depth interval. However, the crew had to wait until the pressure had dissipated to move to the next depth interval (or to the next borehole location). It usually took about 1-3 hours for the pressure to dissipate, following injection at each of the discrete depth intervals. This appears to be one of the main “bottle-necks” that drives the time required by the field crew. The amount of time required for pressure dissipation generally depends on the permeability of the formation and the viscosity of the slurry. After completion of amendment injection at each borehole location, the boreholes were sealed with bentonite grout.

Post-treatment groundwater monitoring data indicates that TCE levels are continuing to decline, or remaining stable in most of the monitoring wells. The TCE levels in most of the monitoring wells remain above the cleanup goal of 5 micrograms per liter. However, it is not uncommon for a monitoring period of about 3 to 5 years to be required before one can properly assess the effectiveness of *in-situ* chemical reduction for groundwater. At some of the monitoring well locations, substantial reductions in TCE were accompanied by increases in DCE. DCE is an intermediate breakdown product of TCE. Generation of DCE indicates that biotic reductive dechlorination is occurring. Continued monitoring will be needed to confirm that complete dechlorination of DCE is proceeding.

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Acronyms:
TCE trichloroethylene
DCE dichloroethylene

Photo caption:

Contractor's field crew lifts a super-sack containing micro-scale zero-valent iron/organic carbon into position above the mixing tank so that the material can be blended into the amendment formulation that will be injected into groundwater via hydraulic fracturing. Photo by Delma Stoner