Design of a Pilot-Scale ISCO Remediation Using Base-Activated Persulfate in a Fractured Dolostone Aquifer Contaminated by Mid-Distillate LNAPL

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Background/Objectives. The success or failure of a remediation using in situ chemical oxidation (ISCO) can significantly depend on the successful design and implementation of a pilot-scale remediation. A pilot-scale remediation confirms the effectiveness of the selected oxidant on the target contaminants and provides an understanding of the physio-chemical and hydrodynamic conditions before, during, and after applying ISCO. A study was implemented to design a pilot-scale ISCO remediation at a site in Ontario where the shallow confined fractured dolostone bedrock aquifer is contaminated with mid-distillate LNAPL and dissolved petroleum hydrocarbons (PHCs). The objective of the study was to design a pilot-scale ISCO remediation to be implemented to evaluate the feasibility of full-scale ISCO remediation.

Approach/Activities. The activities undertaken included: (1) several slug tests to determine the range of hydraulic conductivities involved; (2) the collection of baseline groundwater samples for laboratory analysis of PHCs and general chemical parameters [anions, alkalinity, COD, TOC, TIC, TDS, and various metals]; (3) laboratory oxidant demand testing; (4) the installation of five closely spaced boreholes to optimize injection well design and to use for radius of influence [ROI] and oxidant injection tests; (5) an ROI test using distilled water as tracer; (6) an oxidant injection test involving the injection of 4000 L of 20% sodium persulfate solution activated with sodium hydroxide to pH 13; and (7) a post-injection groundwater sampling program.

Results/Lessons Learned. The optimum method to install injection wells was to hollow-stem auger the overburden, then drill the bedrock with an air-hammer and install Schedule 40 PVC 51 mm diameter well casings and screens. For the ROI test, it was determined that the distilled water flowed predominantly in the bedrock fractures, with travel distances varying substantially, with a reasonable ROI for the pilot-scale remediation being 5 m, while injecting at 20 Lpm at 20 psi. The concentrations of Cl, SO_4, COD, TDS, Na, K, Ca, Mg, Mn, Co, Ni, and Zn were affected by oxidant injection, mostly by increasing in dissolved concentrations, in some cases to above regulatory standards. However, the concentrations were returning to pre-injection levels within approximately ten weeks after the injection, and all were below regulatory standards. Observations during the oxidant injection indicated the formation of a yellowish LNAPL-groundwater emulsion for a few weeks after injection with total PHC concentrations four times the historic levels. Due to the presence of LNAPL, there was no observable decrease of dissolved PHC concentrations; however, an observed increase in SO_4 concentration indicated a persulfate reaction occurred. Persulfate persistence was greater than 10 days. The high pH needs to be sustained to ensure the activation of residual persulfate. The pilot ISCO remediation design proposed from the study targeted the same area to take advantage of the new wells installed, and would involve injecting base activated persulfate at three locations, 10 m from each other, on three separate occasions, totaling 36 000 L. The proposed design also incorporated the use of groundwater extractions with vacuum trucks to remove any free product, anticipated emulsions, and groundwater with elevated concentrations of inorganic parameters between injections.