RCRA Cleanup Reforms: Region 4 Success Story

Successful Pilot Test:Enhanced In-Situ Anaerobic Dechlorination of PCE and Reductive Precipitation of Uranium

Regulatory Background

Nuclear Fuel Services, Inc. (NFS) is both controlling and remediating groundwater contamination at its uranium fuel production facility in Erwin, Tennessee. Multiple source removals and groundwater remediation are being performed in accordance with requirements of the Nuclear Regulatory Commission (NRC), the U.S. Environmental Protection Agency (EPA), and the State of Tennessee Department of Environment and Conservation (TDEC). Pursuant to its EPA HSWA Permit issued in 1993, NFS has completed the RCRA Facility Investigations (RFI) and Corrective Measure Study (CMS) for the facility. Although a groundwater risk assessment indicated no further action was warranted on the basis of current risk, NFS plans to remediate groundwater to reduce the uranium and tetrachloroethylene (perchloroethylene or PCE) concentrations, contain migration and ensure that any potential dose from groundwater is as low as reasonably achievable (ALARA).

Site Hydrogeological Conditions

NFS is a nuclear processing facility that has been operating since the late 1950's. The NFS facility is approximately 64 acres and is located in the mountainous region of east Tennessee within the city limits of Erwin. The NFS site is located in the alluvial valley of the Nolichucky River. The site is underlain by 0 to 30 feet of unconsolidated alluvium consisting of silts and clays, clayey sand, and sand with varying amounts of gravel and cobble. The alluvium coarsens with depth into cobbles and boulders. This cobble/boulder zone overlies weathered, fractured bedrock consisting of steeply dipping beds of shale or shale interbedded with dolomite and siltstone.

Historical activities resulted in the presence of uranium and PCE in the groundwater at the NFS facility. The size of the PCE groundwater plume that exceeds the National Drinking Water Maximum Contaminant Level (MCL = 0.005 mg/L) is approximately 19 acres (1200' by 700'). PCE concentrations in the PCE plume range from approximately 0.005 to 14 mg/L [Refer to Figure 1 -- Pre-pilot PCE Plume, March 2000]. Associated PCE degradation product concentrations are also present in portions of the PCE groundwater plume. The uranium groundwater plume which exceeds the EPA Proposed MCL (30 pCi/L) is about 0.7 acre (250' by 120'). Uranium concentrations range from approximately 30 to 1100 pCi/L.

Environmental Strategy

As part of the CMS, NFS conducted a remedial alternatives analysis (RAA) to select an appropriate technology for controlling and / or remediating groundwater. The RAA identified enhanced anaerobic bioremediation and reductive precipitation (EABRP) as the selected technology. This technology, which is patented by ARCADIS Geraghty and Miller, has been used successfully to remediate PCE and chromium at other sites. However, this is the first time the technology has been tested to remediate dissolved uranium. This technology involves the enhancement of in-situ biological degradation and precipitation of the constituents of concern (COC) by supplying an additional organic carbon source (molasses) as an energy substrate to the previously existing bacteria within the groundwater system. The molasses expedites oxygen depletion creating strongly anaerobic and reducing conditions conducive to the degradation of the PCE by reductive dechlorination and the immobilization of the dissolved uranium as an insoluble precipitate.

Groundwater Field Pilot Test (EABRP)

With the agencies' expedited approval, NFS conducted a six month pilot test at a location within the facility to determine effectiveness of the selected technology on controlling/remediating PCE and uranium in groundwater. The injection of the diluted molasses began on August 3, 2000 and continued through January 10, 2001. Approximately 2,270 gallons of reagent was injected throughout the six month test period. Field parameters were collected prior to each injection phase using a portable, down-hole multi-parameters meter. These field parameters included water-level elevation, pH, conductivity, temperature, total dissolved solids, dissolved oxygen, oxidation-reduction potential, alkalinity, and ferrous iron. During the six month field pilot test, the test wells and surrounding monitoring wells were sampled and analyzed four times. The water samples were analyzed for five volatile organic compounds (PCE, trichloroethylene, trans-1,2-dichloroethylene, cis-1,2-dichloroethylene, and vinyl chloride), tributyl phosphate, total and dissolved iron and manganese, phosphate, sulfate, nitrate/nitrite, total organic carbon, dissolved organic carbon, chloride, biological oxygen demand, chemical oxygen demand, ammonia nitrogen, total and dissolved uranium, ethene, ethane, carbon dioxide and methane.

Preliminary evaluation of the field pilot test results are very encouraging. Overall PCE concentrations in the test area were reduced by 83% [Refer to Figure 2 -- Post pilot PCE Plume, March 2001] and the dissolved uranium was reduced by 60%. As expected, the associated PCE degradation products increased during the test period due to the reductive dechlorination process. The most significant reduction occurred approximately 40 feet downgradient from the injection point where the highest concentration of PCE (12.4 mg/L) was reduced to 0.083 mg/L during the six month test (a 99% reduction). The highest precipitation of the dissolved uranium occurred approximately 10 feet downgradient from the injection point with a decrease in dissolved uranium concentrations from 1,572 ug/L to 387 ug/L (a 75% reduction).

The anaerobic degradation of PCE and the precipitation of uranium was achieved by creating a highly anaerobic and reducing environment. The results clearly illustrated the significant reduction of PCE and the increase in concentration of the degradation products, which will be quickly degraded by the aerobic buffer surrounding the test area. The pilot test was considered a successful demonstration of the EABRP technology which, in turn, will be implemented at other locations at the plant site where groundwater is contaminated. NFS anticipates "getting to yes" for their Government Performance and Results Act (GPRA) environmental indicators (RCRA CA 750) by demonstrating control of the migration of PCE and uranium groundwater plumes, thus minimizing human and environmental exposure to both hazardous and radiological toxins.

This technology may produce similar results at other sites. However, in tighter formations with lower hydraulic conductivity (K) the reagent will take longer to inject into the aquifer and will not disperse in the aquifer as quickly as formations with a higher K such as the cobble zone on the NFS site. Therefore, lower K formations may not establish as large of a reactive zone as quickly as higher K formations.

Next Steps

The next step will be to implement this technology on a full scale basis at designated source areas within the NFS facility. NFS plans to begin implementing this technology full scale by completing the planning and design phase in first quarter 2002, completing installation of additional injection wells by second quarter 2002, and beginning full scale injection activities during second quarter 2002.

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