Fenton's Reagent In-Situ Chemical Oxidation of TCE Source Area, NTC Orlando, Florida

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ABSTRACT: An in-situ chemical oxidation (ISCO) treatment using Fenton's reagent is in progress at Study Area (SA) 17, Naval Training Center Orlando, Florida. The objectives are to rapidly reduce source-area chlorinated volatile organic compound (CVOC) concentrations in order to mitigate further plume expansion and to promote natural or enhanced biodegradation of the residual plume. The CVOCs present prior to treatment were trichloroethene (TCE) and its natural degradation products cis-1,2-dichloroethene (CIS) and vinyl chloride (VC), with a maximum TCE concentration of 306,000 ug/L. Gasoline-range organics (GRO) were also detected, with a maximum concentration of 78,500 ug/L. The study area is approximately 19,000 ft^2 in area and extends to about 26 ft below grade. During an initial injection in November 2000, 8,700 gallons of 25% hydrogen peroxide and 6,900 gallons of Fe(II) catalyst were injected via 69 injectors over the course of 17 days. Groundwater samples were collected 13 days following treatment. CVOCs were reduced an average of 92%, with a post-injection maximum CVOC concentration of 27,000 ug/L. GRO was reduced an average of 90% with a post-injection maximum GRO concentration of 9,190 ug/L. Additional polishing mobilization(s) are planned to achieve a total CVOC concentration less than 500 ug/L.

Introduction

SA 17 is a former motor pool area and includes a vehicle wash rack and historic drum storage area for waste fuel, oil, and ethylene glycol. The targeted treatment area has flat topography at approximately 90 feet above sea level, and a drainage canal (approximately 5 feet deep) borders the treatment area.

Soils at SA 17 are typically tan to gray, fine-grained, quartz sand to silty quartz sand, extending to a depth of approximately 26 feet below grade, comprising a shallow surficial aquifer overlying the Hawthorn Group. Groundwater is initially encountered at approximately 6 feet below grade. The horizontal gradient ranges from 0.003 to 0.004 feet/foot. A downward vertical hydraulic gradient of 0.007 to 0.020 feet/foot exists within the surficial aquifer except near the drainage canal, where groundwater discharges to the canal and an upward gradient of approximately 0.25 feet/foot exists. Hydraulic conductivity in the surficial aquifer ranges from 0.5 to 1.5 feet/day with lower conductivity in the deeper intervals of the surficial aquifer. Groundwater quality at SA 17 is slightly acidic, with pH ranging from 5.4 to 6.3, total alkalinity ranging from 8.6 to 111 mg/L, and iron concentration ranging from 0.4 to 74 mg/L.

Treatment Approach, Implementation and Monitoring

Sixty-nine injectors were installed in three vertical levels, with screened intervals from 10-13 feet (shallow; 9 wells), 16-19 feet (intermediate; 30 wells), and 22-25 feet (deep; 30 wells). The estimated required overall injection volume was 42,000 gallons of 25% H_2O_2 solution and Fe(II) catalyst solution. Per-injector target volumes ranged from 100 to 400 gallons, based upon

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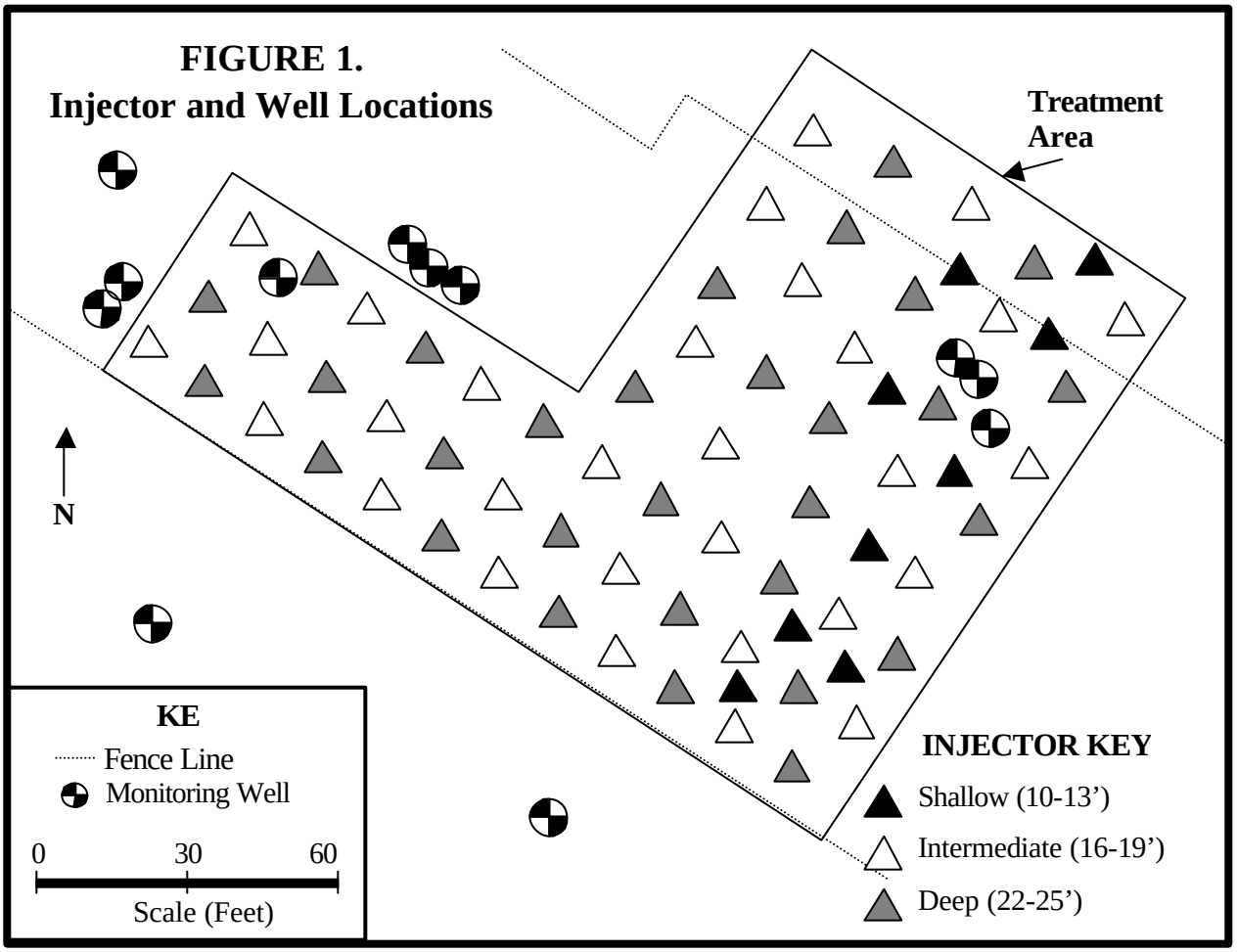
dissolved CVOC and GRO concentrations and a corresponding estimate of CVOC and GRO mass within the treatment area, plus a conservative excess for inefficiencies. The primary injection phase was estimated to require 15 days of drilling and 24 days of injection. If post-injection monitoring indicated that cleanup objectives were not achieved at all locations, secondary polishing mobilizations were included with installation of up to 12 additional injectors and injection of 4,000 gallons of 25% H_2O_2 and Fe(II) catalyst solution.



Monitoring consisted of both process and performance parameters. Process monitoring samples collected daily during the injection included parameters to determine if appropriate geochemical conditions were established and reagents were dispersed effectively (pH, alkalinity, H_2O_2 and Fe concentration), organics were reduced (via headspace PID measurements) and oxidation products were generated (chloride). Offgases produced during the treatment were monitored for O_2, CO_2, volatile organics (by PID). Performance monitoring samples collected to benchmark CVOC destruction included a pre-test round of 5 monitoring wells and 20 injection points, and a process round during the primary injection of 2 monitoring wells and 20 injection points. Post-injection monitoring will include 5 permanent monitoring wells with samples collected at approximately 7 days and 30 days after treatment, and four quarterly sampling events of up to 15 permanent monitoring wells after conclusion of the ISCO program.

Treatment Operations and Observations

The initial phase of injection operations was conducted from November 6 - December 1, 2000. A mobile treatment unit was staged at the site, with tanks, pumps, gauges, and flow control valves to prepare and deliver reagents safely and effectively. A manufacturer-supplied H_2O_2 tanker truck and portable generator were also staged at the site. Specially designed mixing heads were attached to the injector riser pipes. The injection process was dynamic and several variables (including injection rate, pressure, and use of air to enhance reagent dispersion) were modified to evaluate optimal injection conditions. Injection rates ranged from <0.25 gpm to 1 gpm, and injection pressure (at which liquid reagents are delivered) ranged from 5 psi to 40 psi.

A total of 8,700 gallons of 25% H_2O_2 solution and 6,900 gallons of Fe(II) catalyst were injected during the initial 17-day effort. Groundwater pH during treatment typically ranged from 4 to 5 with iron concentrations typically >10 mg/L, indicating conducive geochemical conditions were established in the aquifer. Offgas CO_2 concentrations typically ranged from 0.5 to 2.0%, with a maximum of 11%. Monitoring during the injection to establish the radius of influence detected hydrogen peroxide up to 35 feet from active injection points, and groundwater mounding and bubbling similarly were observed 15 to 25 feet away from active injectors, indicating effective reagent dispersal. The initial injection phase was completed after groundwater headspace PID readings (used as a semi-quantitative measure of dissolved CVOC concentrations and treatment progress) were reduced to <1 ppm from pre-injection baseline readings of up to 465 ppm.

Results and Conclusions

A process round of performance samples was collected 13 days after the first injection phase was concluded. The 13-day waiting period was intended to allow residual H_2O_2 to react, the aquifer to return to ambient conditions, and to identify areas requiring additional injection as part of the primary injection phase. Samples were collected for VOCs, GRO and chloride, from 22 locations (20 injectors and 2 permanent monitoring wells). The average reductions in CVOCs and GRO were 92% and 90%, respectively. The most contaminated well at the site (injector D-30) experienced a reduction in CVOCs from 306,000 ug/L to 27,000 ug/L (91% reduction), and a reduction in GRO from 78,500 ug/L to 9,190 ug/L (88% reduction). The two compliance monitoring wells in the central portion of the source area experienced CVOC reductions from 10,600 ug/L to 0.7 ug/L (>99% reduction) and from 20,900 ug/L to 1,620 ug/L (92% reduction). Chloride concentrations observed during process sampling ranged as high as 50 mg/L. Comparison of the laboratory analytical chloride results indicate a site-wide average increase from 19.3 to 22.0 mg/L. Based upon the initial results, the target CVOC cleanup objective of 500 ug/L is attainable and the primary treatment phase will continue with additional H_2O_2 injection.