Naval Training Center at Orlando, Study Area 17

In Situ Chemical Oxidation—Biostimulation—Monitored Natural Attenuation

Site Name: Naval Training Center, Study Area 17
Site Location: Orlando, Florida
Technology Used:

- In Situ Chemical Oxidation (ISCO) (Hydrogen Peroxide)
- Biostimulation
- Monitored Natural Attenuation (MNA)

Regulatory Program: Federal Facilities Base Realignment and Closure (BRAC) Program
Remediation Scale: Full
Project Duration: November 2000 to present

Site Information: The military facility originally opened in 1942 as an Army Air Corps base. It later became known as the Orlando Air Force Base. In 1968, about 1,100 acres of the air base became the Naval Training Center, which closed in 1995 under the BRAC program. Study area 17 is a 25-acre parcel that was used as a motor pool storage area.

Contaminants: The contaminants of concern were trichloroethene (TCE) and its degradation products dichloroethene (DCE) and vinyl chloride. TCE as a dense non-aqueous phase liquid (DNAPL) (one percent rule) was suspected to have produced a plume that was about 670 ft long, 260 ft wide and over 40 ft deep. Groundwater TCE concentrations were high throughout a large part of the plume, which had a known source area. The highest TCE concentration detected in groundwater at the site was 577,000 µg/L.

Hydrogeology: The stratigraphy at the site consists of sand and gravel interbedded with silty sand to a depth of about 50 ft where a clay unit exists. Groundwater occurs at 3-5 ft below ground surface (bgs); the gradient is very low. Low-permeability layers occur 10-15 ft bgs and 25-30 ft bgs (Figure 1).

Project Goals: The initial project goal was to reduce the total chlorinated contaminant concentration to 500 µg/L in groundwater where MNA might be used to degrade the remaining contamination before it crossed the Navy property line. Following treatment, this goal was revised to provide a containment strategy for the source area and prevent offsite migration for the remainder of the plume.

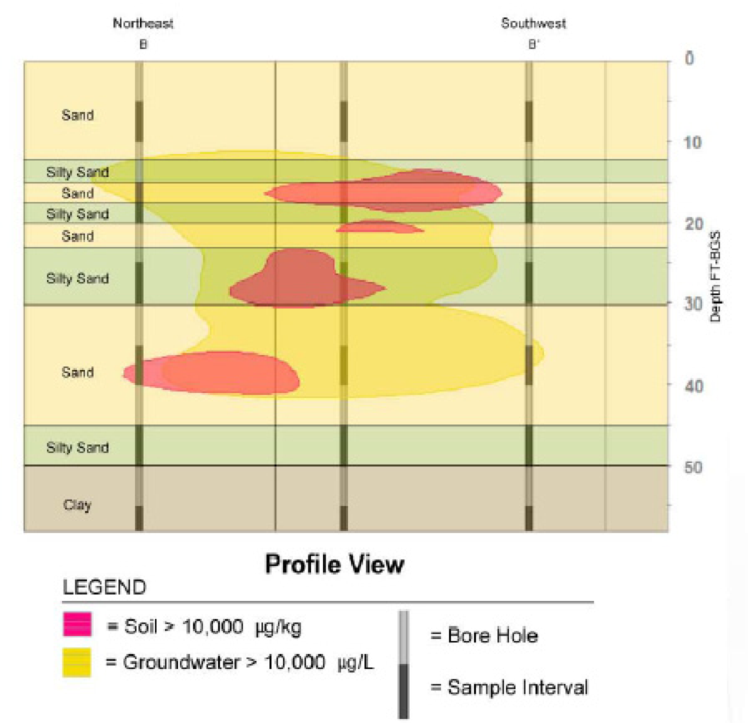

Figure 1. Generalized Cross-Section and Contaminant Distribution after ISCO Treatment

Source: Favara et al. 2006 (PowerPoint)

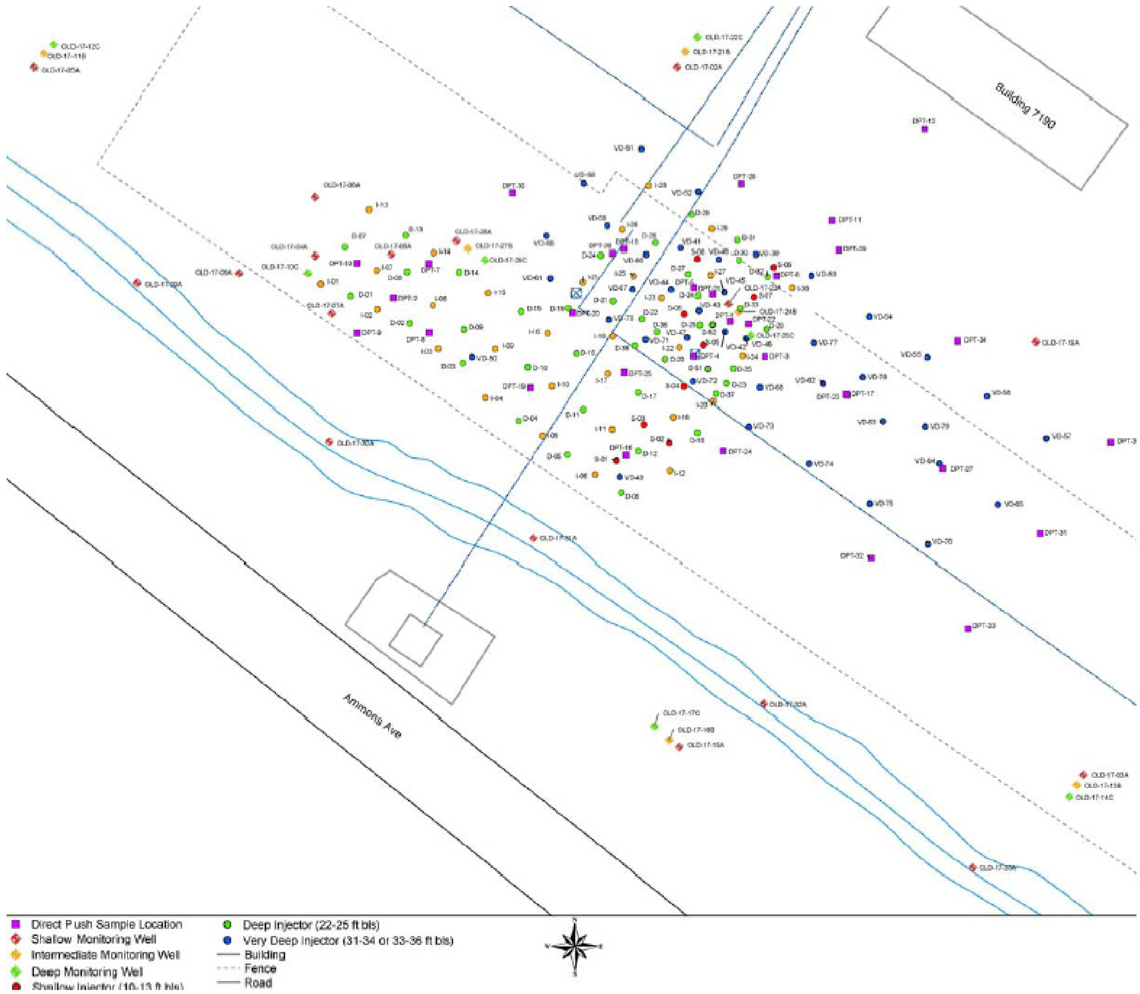

Figure 2. Location of Monitoring Points and Injector Wells

Source: Favara et al. 2006 (PowerPoint)

Cleanup Approach: Over 100 injection wells were placed at the site at various depths for ISCO treatment (Figure 2). A 50% solution of hydrogen peroxide was injected in two phases. The first occurred during November 2000 to March 2001 and the second between March 2002 and September 2002. A total of 20,230 gallons (about 100,000 pounds) of peroxide was used to treat the area.

Following the ISCO treatment, the remedial team performed an optimization evaluation to determine if further ISCO treatment was warranted or if another treatment technology would be preferable. Hotspot areas were identified from rebound data. These areas were then targeted for an intensive contamination stratification investigation using a membrane interface probe (MIP) at 48 locations. The MIP provided data at 1-ft intervals on total volatiles present and on specific conductivity. This information was used to target specific intervals for discrete soil and groundwater sampling for speciation of the contaminants.

All the collected data were placed in software for 3-dimensional modeling. Figure 1 shows the area where TCE concentrations exceed 10,000 ppb. The site used the U.S. Geological Survey/Virginia Institute of Technology's Natural Attenuation Software and the Air Force's SourceDK to calculate the remediation time and stabilization time for the plume. The results of the modeling showed that further source reduction would yield only a limited reduction in cleanup times. The modeling also showed that a flux management strategy for the source zone would result in a plume that stabilized before reaching the property boundary.

The area of concern was divided into three zones: the property boundary, contaminant plume, and source area. The plume had not yet reached the property boundary, which is about 600 ft from the source area. Before the application of the ISCO, there was substantial evidence that biodegradation was occurring within the plume. Thus, after ISCO, the remediation goal expanded to prevent contaminated groundwater from leaving the facility property using MNA of the plume outside the source zone and a recirculation well system with biostimulation to manage the source flux.

Beginning in May 2006, 12,147 gallons of a 12% solution of emulsified vegetable oil substrate (EOS®, Figure 3) was injected into 12 outer injection wells and recovered through two centrally located extraction wells (Figure 4). One of the two source zones that was treated had a relatively high hydraulic conductivity (C zone) and the other had a relatively low hydraulic conductivity (B zone). The recirculation system operated for two weeks. A bromide tracer, which could be measured by a field electrode, was used to estimate breakthrough.

The oil was well dispersed in the C zone, but preferential flow prevented effective distribution in the B zone. While sulfate reducing conditions were slower to develop in the B zone, they are now present in both zones. Since Fenton's Reagent tends to acidify groundwater, a pH adjustment was made to the recirculation well system to make the groundwater more basic and hence more favorable to TCE biodegradation.

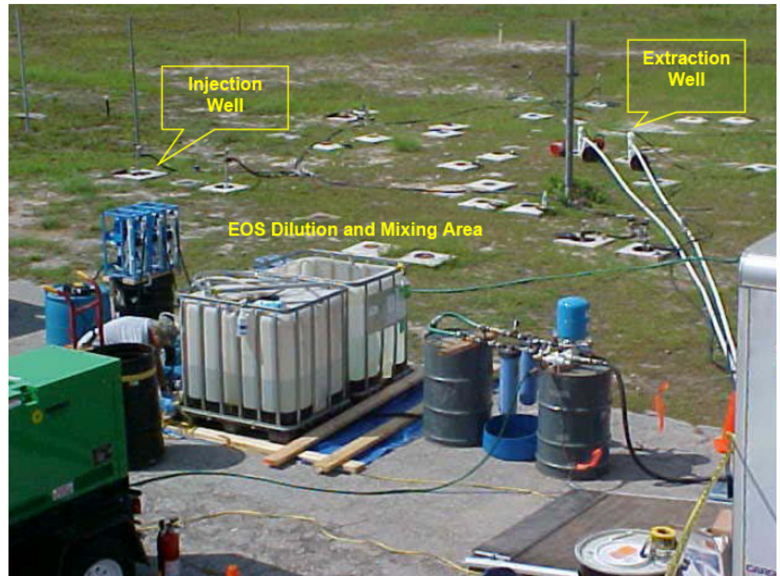

Figure 3. EOS® Injection Equipment

Source: Singletary 2007

Project Results: The ISCO treatment resulted in an 88% reduction in dissolved-phase TCE concentrations (Figure 5). The results were uneven however, with significant decreases in some wells and increases in other (Table 1).

The ISCO was unable to treat some areas because of preferential flow paths and the presence of fine-grained units whose back diffusion acted as a continuing source after depletion of the peroxide.

Table 1. Pre- and Post-ISCO Treatment TCE Concentrations for Selected Wells

Sample Location	Pre-ISCO (µg/L)	Post-ISCO (µg/L)	Percent Reduction
D-25	12,500	45,000	-260
D-28	33,700	282	99.16
D-30	306,000	110	99.96
VD-39	26,000	0.58	100
VD-43	36,000	684	98.1
VD-45	552	412	25.36
VD-55	67,200	6.9	99.99
VD-57	64,500	3.8	99.99
VD-58	323	1,620	-401.55
VD-69	11	3,150	-28536.36

Source: Favara et al. 2006 (Paper)

The emulsified oil treatment has brought about reducing conditions in the target zones. A modest reduction in TCE concentrations occurred in the B zone and a significant TCE reduction occurred in the C zone. (Table 2). These reductions, however, have not been accompanied by comparable increases in DCE concentrations, leading the Navy to speculate that the TCE is partitioning into the oil.

The Navy is evaluating the target zones for the continued presence of biomass (phospholipid fatty acids) and TCE-degrading microbes (quantitative polymerase chain reaction), and geochemical evidence that subsurface conditions are right for degradation to take place. The evaluation may lead to further actions, such as further pH correction and/or bioaugmentation. It is anticipated that groundwater cleanup will take 15 years (Dept. of Navy 2007). With institutional control restrictions, the property has been found suitable for transfer under the Base Realignment and Closure program.

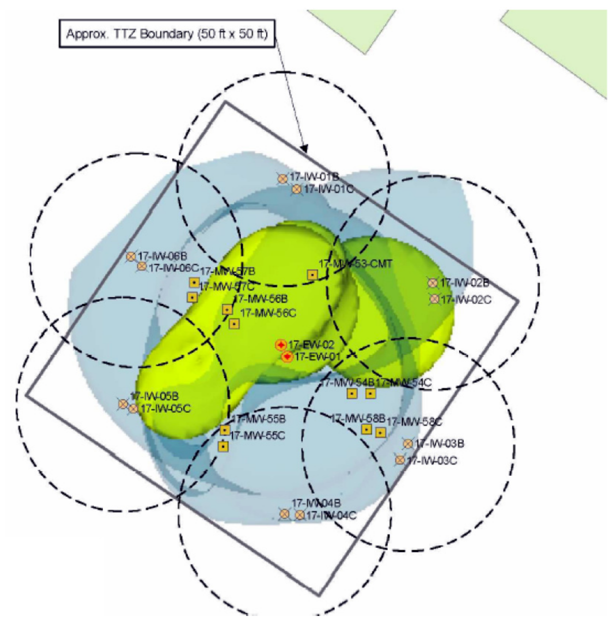

Figure 4. Locations of the 12 Injection and Two Extraction Wells Used for Placing EOS®

Source: Singletary 2007

Table 2. Trichloroethene Concentrations (µg/L) Following EOS® Injection

Well	June 2006	July 2007
EOS-MW-53B1	307J	22.7
EOS-MW-53B2	87.3J	10.6
EOS-MW-55B	9,100	5,820
EOS-MW-56B	8,420	6,580
EOS-MW-57B	48.4	26.4
EOS-MW-58B	1,100	60.2
EOS-MW-53C1	47,300	767
EOS-MW-53C2	47,100	294
EOS-MW-54C	24,200 J	2,390
EOS-MW-55C	4500 J	430J
EOS-MW-56C	3,320	181
EOS-MW-57C	387 J	86.4B
EOS-MW-58C	4,280 J	2,100

B=Also found in blank J=Estimate

Source: e-mail Michael Singletary (SE NAVFAC)

Sources:

Department of Navy. 2007. Finding of Suitability to Transfer McCoy Annex Early Transfer of Study Area 17 Naval Training Center Orlando, Florida.

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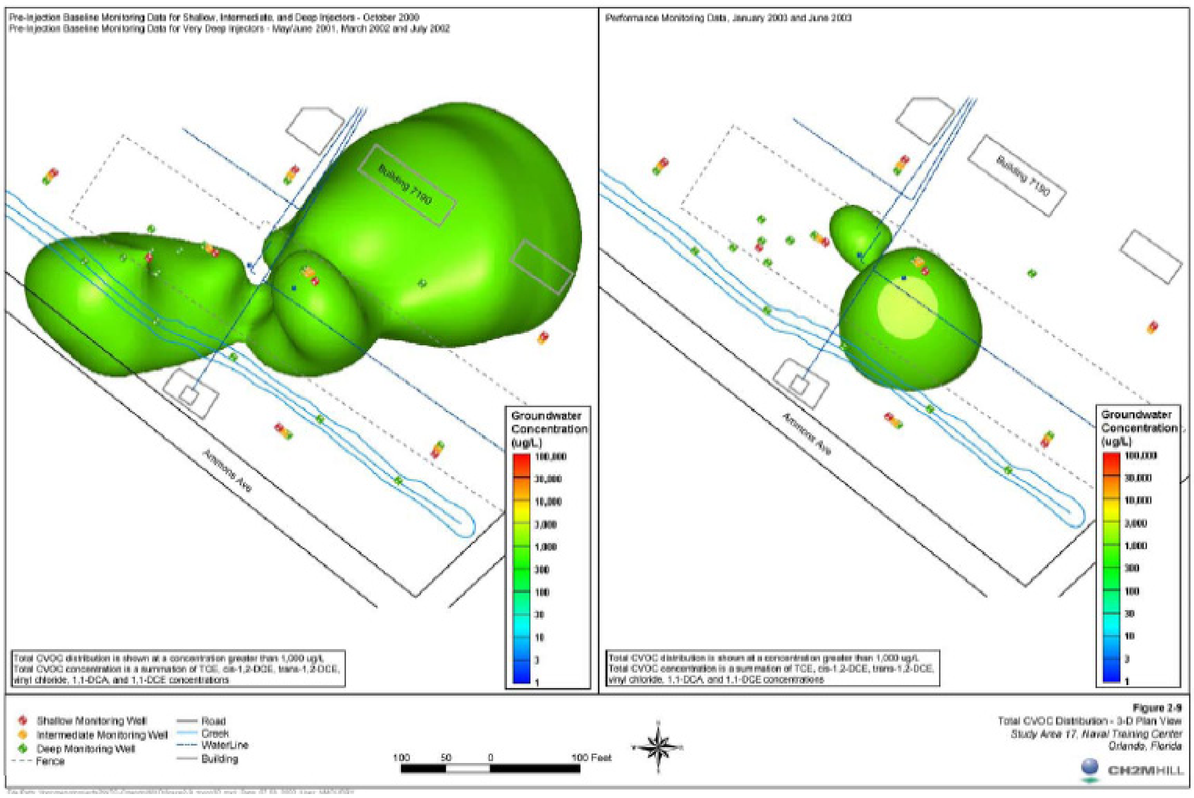

Figure 5. Total Chlorinated Organics Plume with Greater Than 1,000 µg/L Before and After ISCO

Source: Favara et al. 2006 (PowerPoint)