

# Combined use of ISCO for Source Treatment and Reductive PRB for Plume Control

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## ABSTRACT

Groundwater at an industrial site in Texas is impacted with Chlorinated Volatile Organic Carbon's (CVOCs), primarily PCE and TCE, from historical waste disposal. The topography at the site slopes steeply towards a small channel where the groundwater discharges. Depth to groundwater ranges from approximately 20 ft bgs at the source area to 1 ft bgs close to the channel. The soil consists of silty clays. Remedial objectives are to achieve the Texas Risk Reduction Program Tier 1 Residential Protective Concentration Levels (PCLs). Remediation of groundwater at the site has entailed a combined approach employing chemical oxidation at the source area and a reductive Permeable Reactive Barrier (PRB) for passive plume control along the channel. Reductive technologies were preferred adjacent to the channel in order to protect the water body and aquatic life. Prior to in situ applications, source area soil was excavated from the vadose zone. These combined measures have resulted in > 90% reduction in total chlorinated ethenes in groundwater at the source area (from a maximum of 2,211 mg/L measured in 2002 to a maximum of 0.216 mg/L measured in January 2009). Subsequent performance monitoring at the channel has confirmed > 98% removal of total chlorinated ethenes directly downgradient from the reductive treatment zone (from a maximum of 1.815 mg/L measured in April 2005 prior to the installation of the reductive zone to a maximum of 0.028 mg/L measured in January 2009).

## SUMMARY OF REMEDIATION ACTIVITIES

### June 2004:

- Approximately 522 tons of soil removed from source area. Blended potassium permanganate (KMnO<sub>4</sub>) and silica sand was added to the base of the excavation prior to backfilling. A water injection system was also installed to dissolve the emplaced KMnO<sub>4</sub> and then distribute the solution into the subsurface formation. Five large diameter injection borings (IB-1 through IB-5) was installed to a total depth of 24 to 27.5 ft bgs within the excavation zone and three water injection wells (IW-1 through IW-3) were installed to a depth of 37 ft bgs.
- A total of approximately 44,000 lbs of KMnO<sub>4</sub> was injected as slurry into 16 locations using hydraulic fracturing – total of 44 fractures emplaced at depths of 25, 31, and 37 feet bgs of (1,000 lbs KMnO<sub>4</sub> per fracture).

### June 2005:

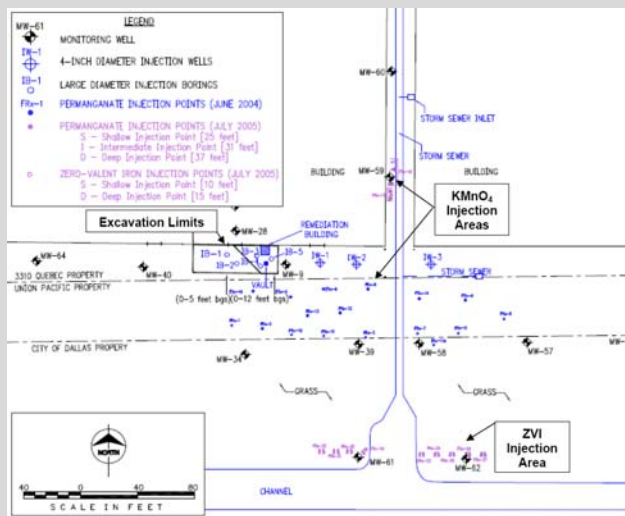
- An additional 6,000 lbs of KMnO<sub>4</sub> was injected as slurry into 2 locations at depths of 25, 31, and 37 feet bgs (1,000 lbs KMnO<sub>4</sub> per fracture).
- To address the continuing migration of the plume into the channel, a PRB was installed across the plume along the channel. A total of approximately 11,000 lbs of zero-valent iron (ZVI) was emplaced via hydraulic fracturing.

### October 2007:

- A total of 28,000 gallons of 3% NaMnO<sub>4</sub> was injected into five 1,200 ft<sup>2</sup> areas (Area-1 through Area-5) over a 20 ft vertical injection interval. Approximately 17,700 lbs of 40% NaMnO<sub>4</sub> was diluted on-site using specialized mixing equipment to a 3% NaMnO<sub>4</sub> solution.
- A total of 2,600 lbs of EHC was injected into 15 injection points at Area-6.
- Injections were performed using standard direct-push equipment and conducted in a top-down fashion targeting discrete injection intervals spaced 2 ft apart vertically.

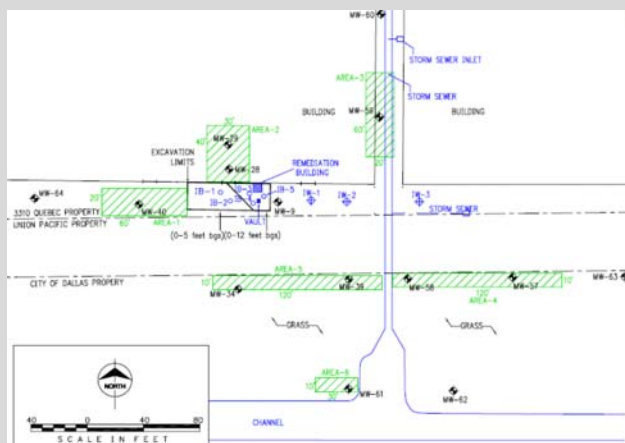
Areas targeted during June 2004 and June 2005 remedial activities:

- KmnO<sub>4</sub> injected at caissons (IB-1 to IB-5) and fracture locations FRx-1 to FRx-18
- ZVI injected at locations FRx-19 to FRx-27 along channel.



Injection areas October 2007:

- NaMnO<sub>4</sub> injected at Area-1 to Area-5
- EHC injected at Area-6.



Carus® RemOx™ S ISCO Reagent: Potassium Permanganate (KMnO<sub>4</sub>) provided as crystalline solid

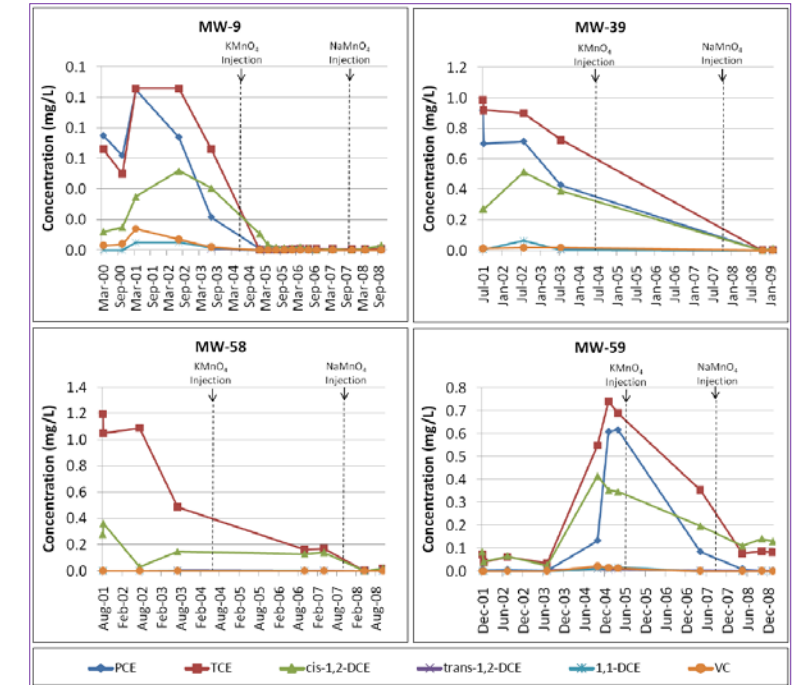
Carus® RemOx™ L ISCO Reagent: Sodium Permanganate (NaMnO<sub>4</sub>) provided as concentrated liquid



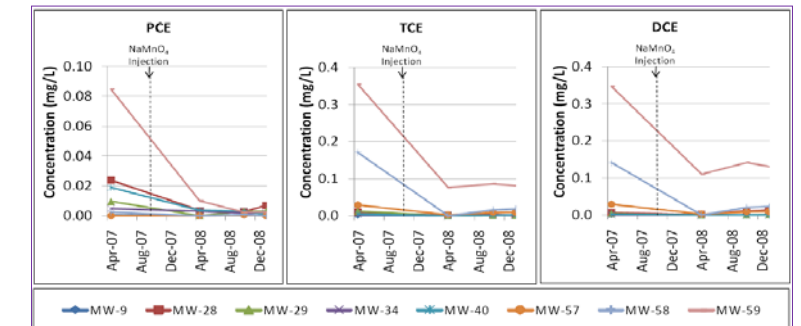
EHC® is a patented combination of micro-scale zero valent iron and organic carbon for ISCR of CVOCs in groundwater. EHC® is a registered trademark of Adventus Intellectual Property Inc.

## PERFORMANCE DATA

The combined effect from removal of source area soil and KMnO<sub>4</sub> and NaMnO<sub>4</sub> injection activities at wells located within and directly downgradient from targeted areas:



Effect from injections of NaMnO<sub>4</sub> at the margins and within the former source area:



Effect from installation of ZVI/EHC treatment zone at the channel:

