Mixed Plume Remediation using EHC In-Situ Chemical Reduction and Oxidation Technologies

Innovative Solutions for Federal Contaminated Sites in Pacific and Northern Regions
October 15, 2008

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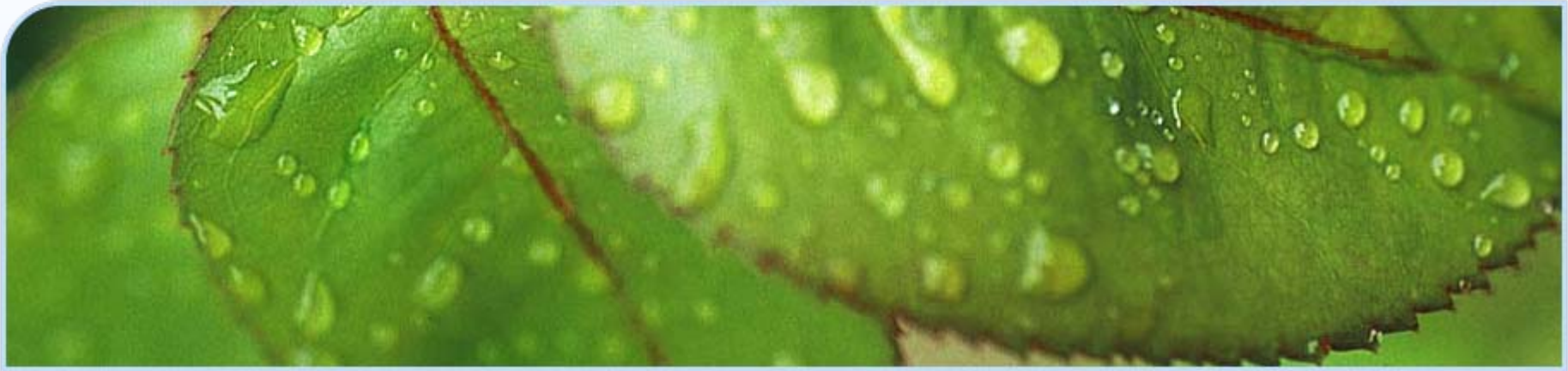
ADVENTUS

Proven Remediation Technologies for Soil, Sediment, and Groundwater



Outline of Presentation

- EHC® Groundwater Technologies
  - EHC for chlorinated solvents
  - EHC-M for metals
  - EHC-O for petroleum and BTEX compounds
- Mixed Plume applications
- Effective placement methods

EHC Technology for VOC Remediation

EHC materials are injectable particles composed of:

- Controlled-release, food grade, complex carbon
- Micro-scale zero valent iron (<150 µm)
- Major, minor, and micronutrients
- Food grade organic binding agent

EHC® for Treatment of VOCs in Groundwater

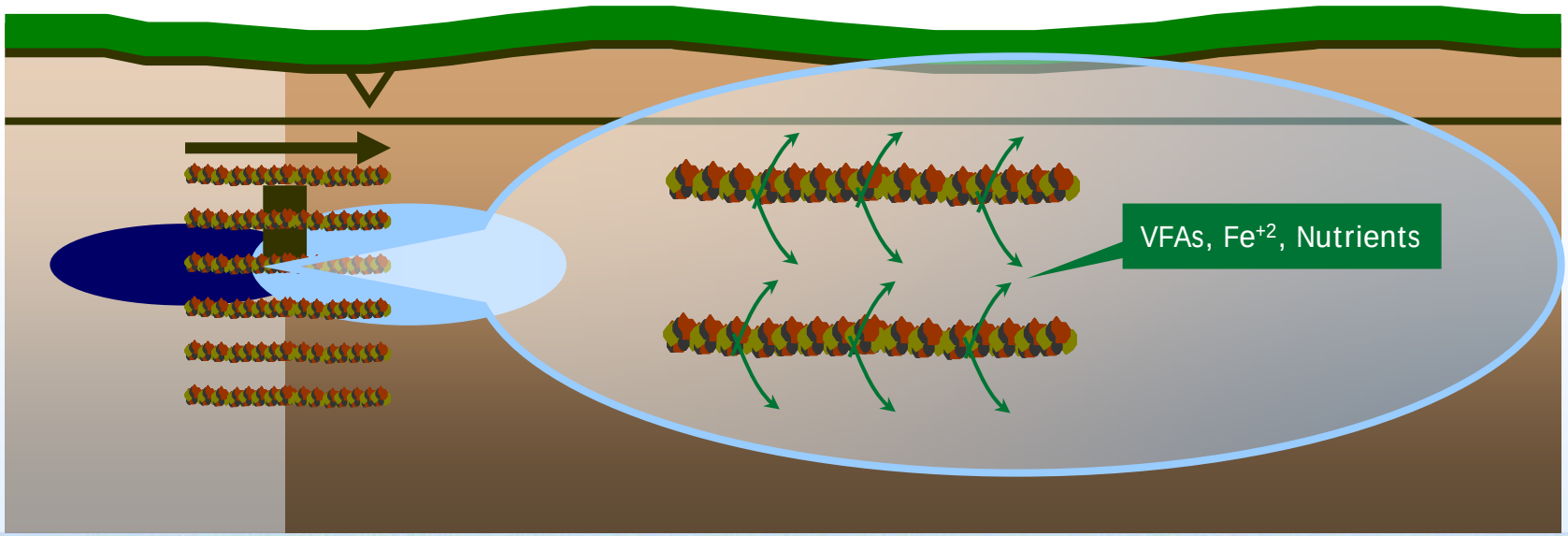
EHC integrates in situ biological and chemical reduction (ISCR)

- 15 years technology development experience
  - DARAMEND (Grace Bioremediation)
  - Iron PRBs (EnviroMetal Technologies Inc.)
- Balances acidity (VFAs) and pH increase (ZVI) to prevent acidification of groundwater
- Very long life from 36 to 72 months
- Usually emplaced in slurry form via direct push injection, hydraulic / pneumatic fracturing

Treatment Methods

In-situ Reactive Zones

- EHC mixture has higher K than most aquifers which encourages flow and direct treatment through the injected layers
- DOC, Fe2+ and nutrients released into neighboring regions enabling dechlorination of contaminants outside reactive zones



Verification of EHC Placement

Soil cores obtained at the beginning of the installation to verify radius of influence and determine injection spacing

Contaminants Treated

EHC

- Chlorinated Solvents
  - PCE, TCE, cDCE, 11DCE, VC
  - 1122TeCA, 111TCA, 12DCA
  - CT, CF, DCM, CM
- Pesticides
  - Toxaphene, Chlordane, Dieldrin, Pentachlorophenol
- Energetics
  - TNT, DNT, RDX, HMX, Perchlorate

EHC-M

- Heavy Metals including As,Cr, Pb, Zn, Cd

EHC-M for Immobilization of Metals

- Encourages the precipitation and adsorption of dissolved metals
- Controlled release of carbon and ZVI, source of sulphate if needed
- Formulation depends on the type of metal
  - ➥EHC-M for Arsenic, Me^{+2} (e.g. Pb,Ni)
    - precipitates as metal sulfides
  - ➥Low redox/ZVI
    - Chromium (6+) precipitates as Chromium (3+)

EHC Installation Methods

Injection Methods

- Direct injection
- Hydraulic fracturing
- Pneumatic fracturing
- Jetting

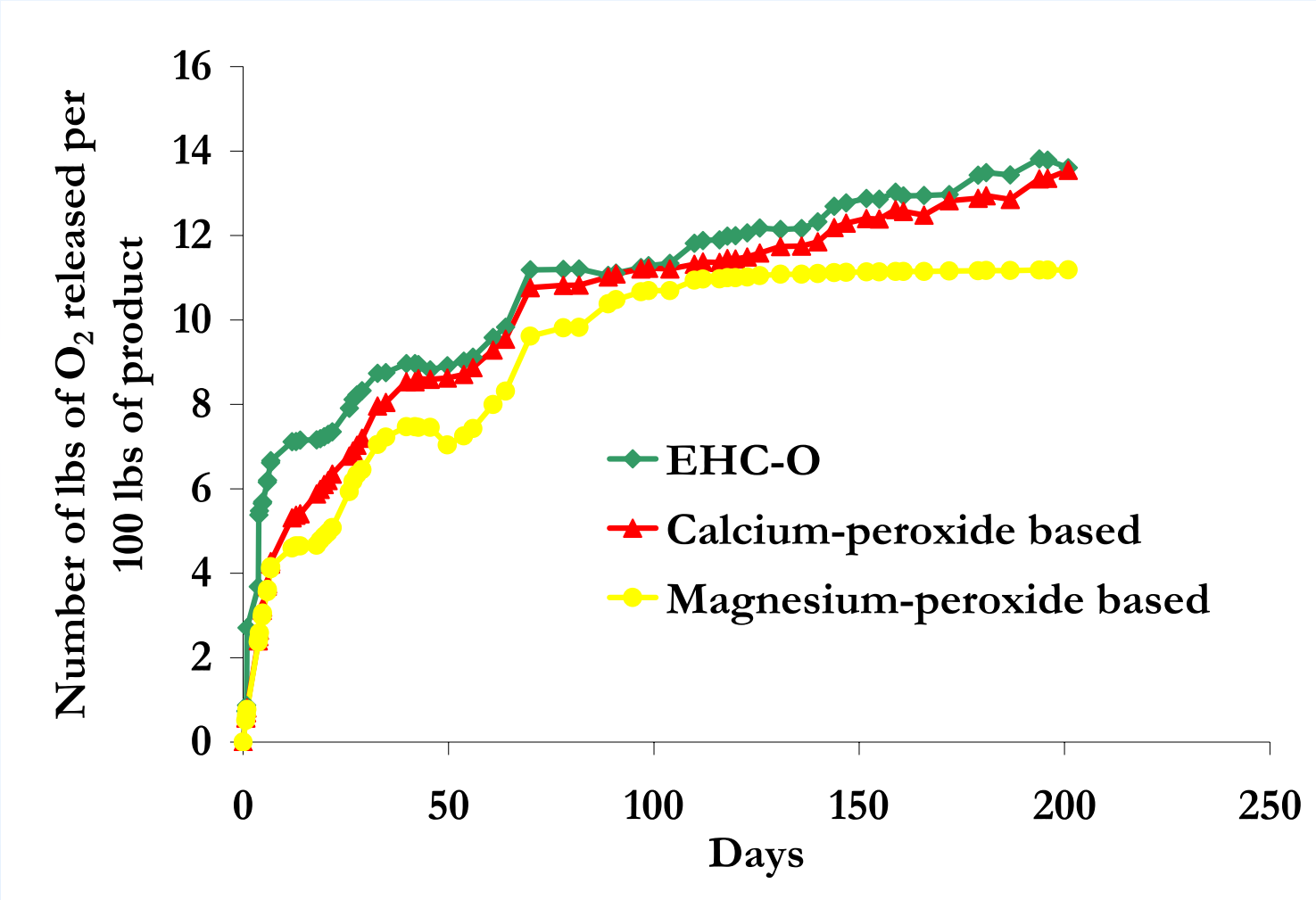
Direct Placement

- Trenching
- Excavations
- Deep soil mixing
- Through existing wells

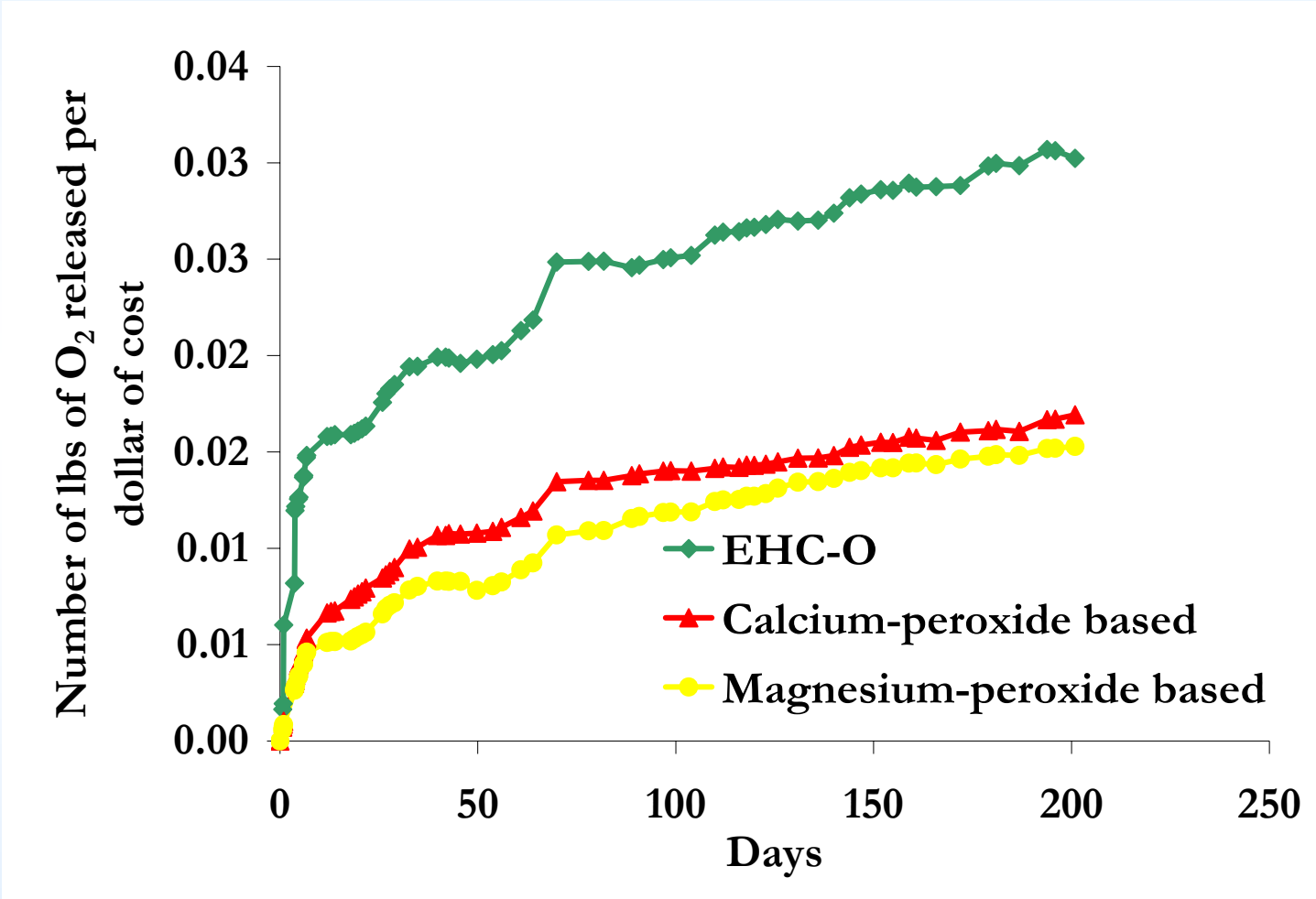
EHC-O™ for aerobic bioremediation

- Oxygen Release Redox Compound
- Stimulation of aerobic biodegradation through controlled-release oxygen and nutrient delivery
- For organic constituents amenable to aerobic biodegradation processes
  - ➥Petroleum Hydrocarbons
  - ➥Light PAHs
  - ➥BTEX
- Significant cost savings realized through the use of EHC-O due to its higher oxygen release rate and lower price

Oxygen Release Compounds – Comparative Rates of Oxygen Delivery



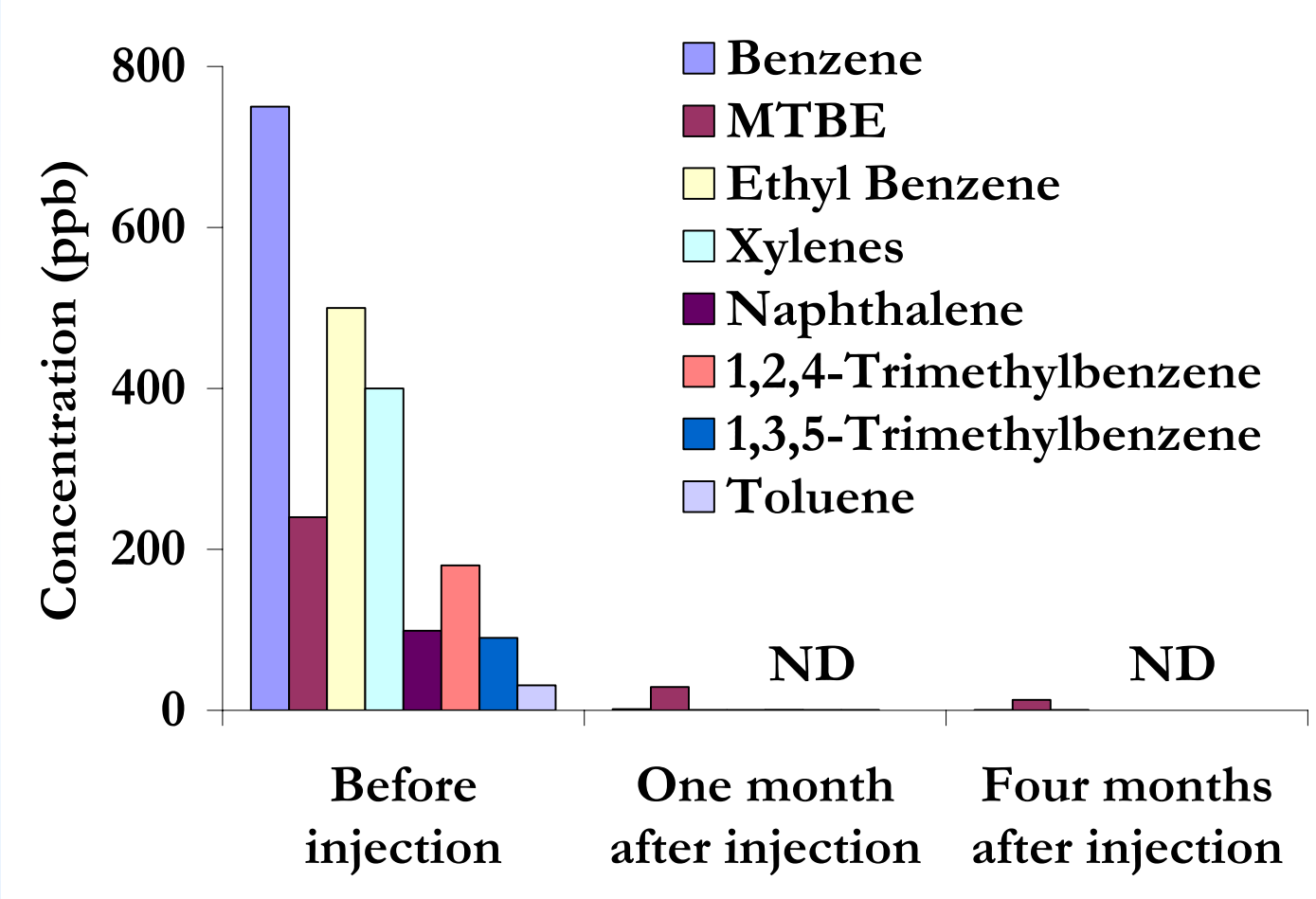
Oxygen Release Compounds – Cost Efficiency Comparison



EHC-O Installation Methods

- Injection methods (direct injection, fracturing, etc.)
- Open excavations
- Socks or canisters for well applications

EHC-O Case Study – Treatment of PVOCs, Wisconsin



Mixed Plume Remediation

- A variety of mixed plumes exist:
  - VOCs and metals
  - VOCs and BTEX, TPH
  - BTEX and PAHs
  - Etc. etc.
- Field scale PRB systems in place since the mid-1990's
- If both oxidative and reductive processes needed, the requisite EHC materials can be installed with the same equipment
- Although several proposals and lab studies have incorporated both EHC and EHC-O, our experience to date involves the use of only one material to treat multiple types of contaminants in a mixed plume

Mixed Plume Remediation Projects

- Solvents and OCPs, SE USA, 2006 (EHC)
- TCE and Cr, WA, 2006 (EHC)
- TCE,DCE,VC and BTEX, Birmingham UK, 2007 (EHC)
- PCE,Cr,As, AZ, (Pilot 2007, 2008), (EHC and EHC-A)
- BTEX,MTBE,naphthalene, CA, 2008 (EHC-O)

*does not include a number of iron PRBs treating combined VOC and trace metal plumes

EHC-M Case Study
Cr(VI) and TCE in Groundwater Plume

Case Description	
Location	Northwestern US
Type of Site	Industrial facility
Description of Impacts	Cr(VI) and TCE in groundwater; 75 to 85 ft bgs
Objective and Approach	Injection of EHC-M for treatment of isolated hot-spot.

EHC-M Injection Layout

Treatment Area Dimensions:

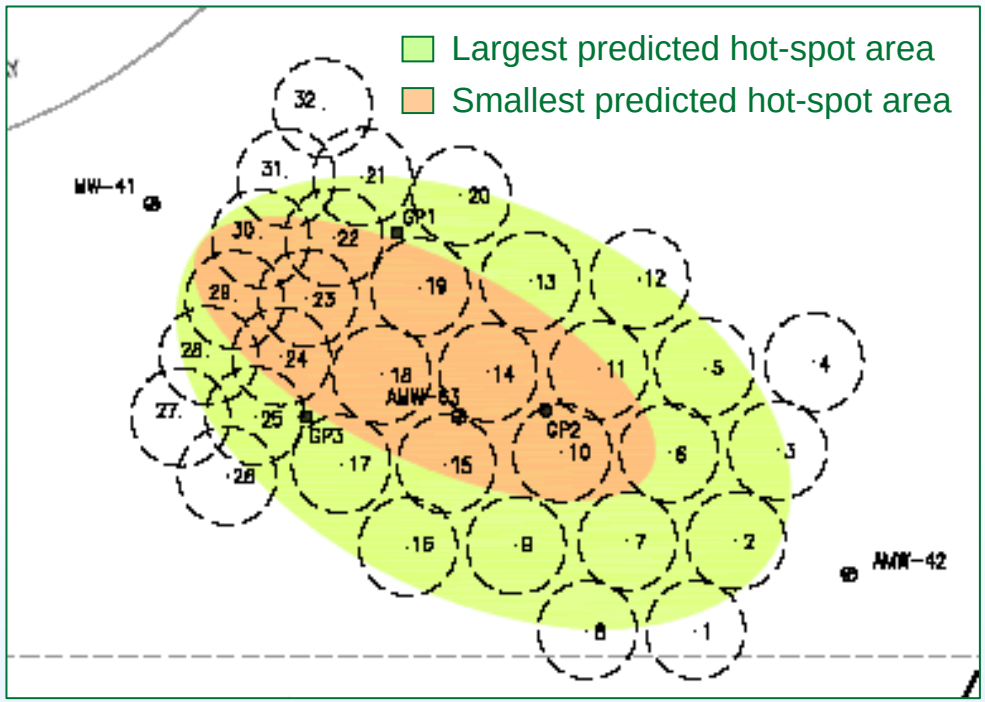
- 100 ft long x 60 ft wide x 10 ft deep (from 75 to 85 ft.

EHC-M Application Rate:

- 0.15% wt/wt
- 9,600 lbs injected

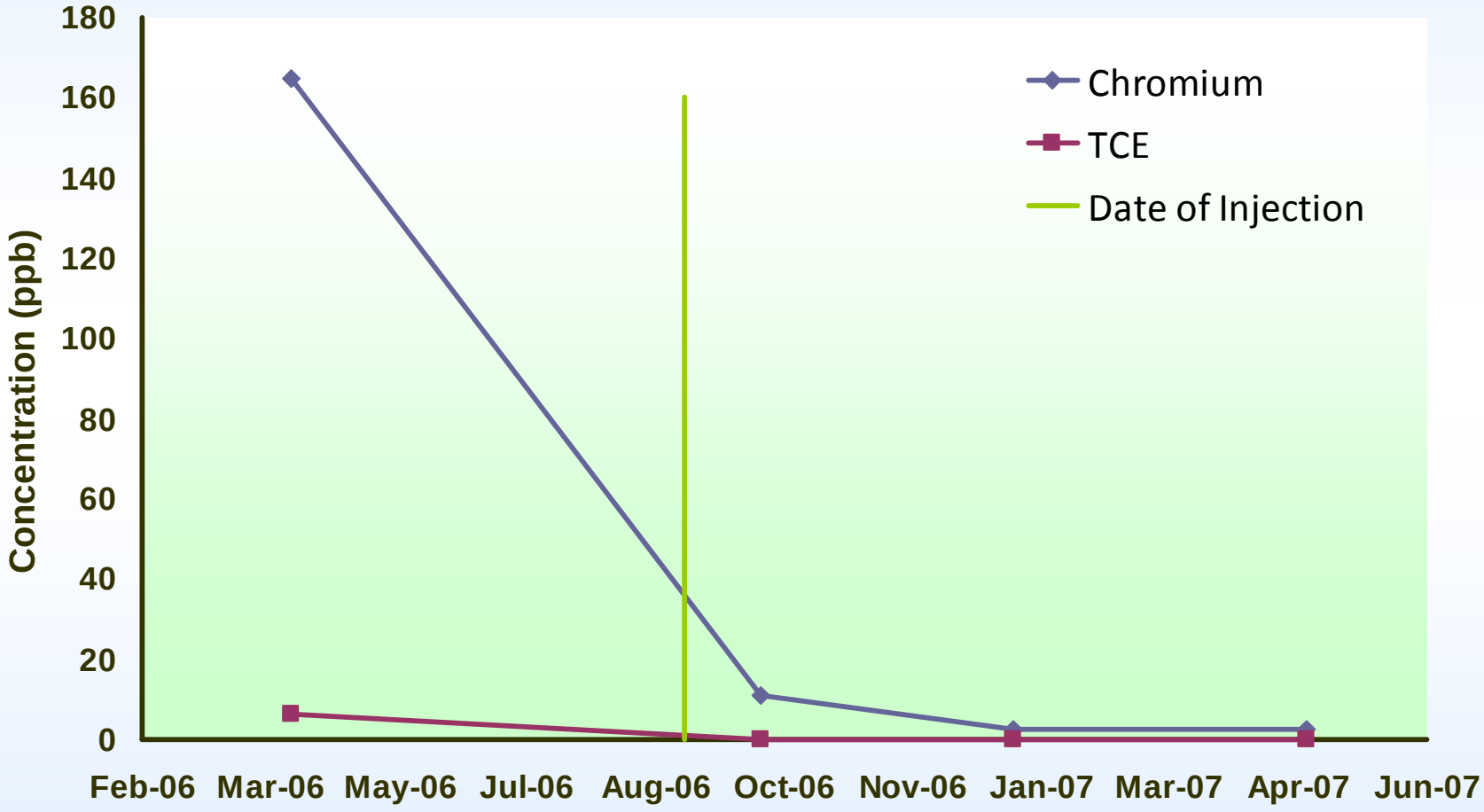
Direct Injection:

- 32 direct push points
- 10 to 15 ft spacing

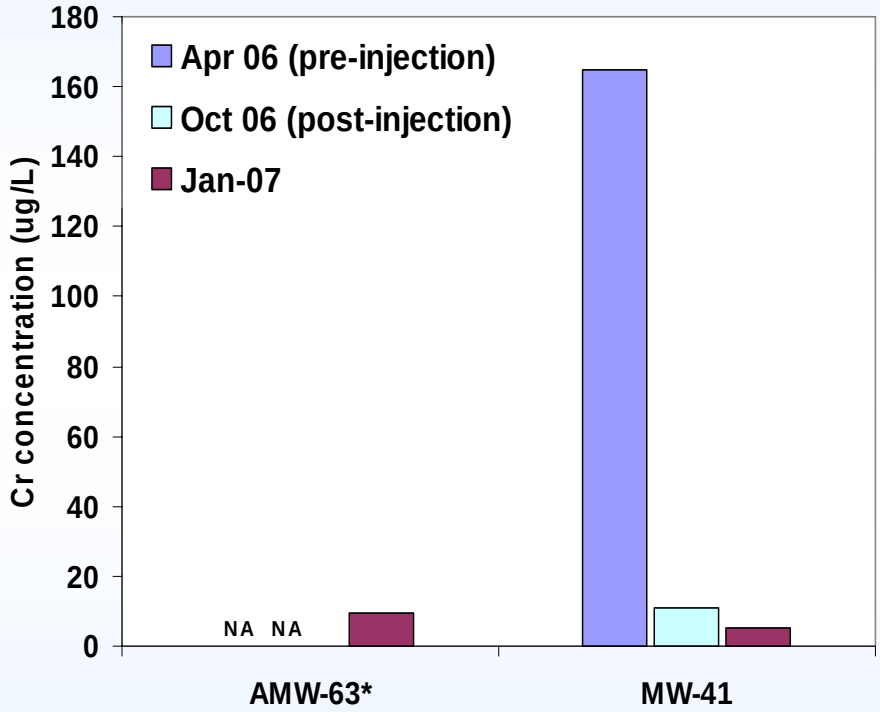


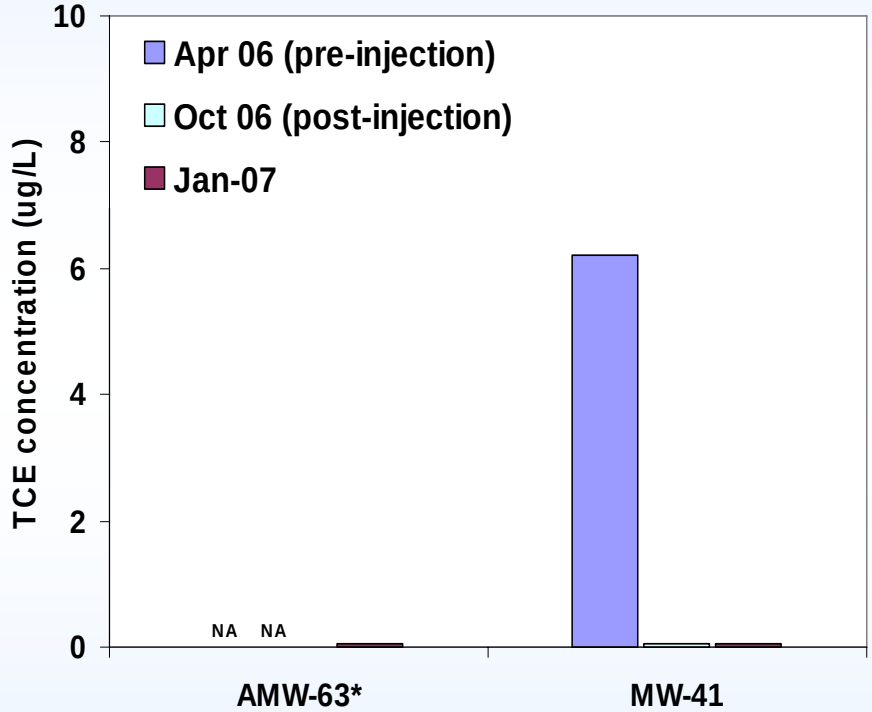
Field Injection

Influence of EHC-M™ on TCE and Cr(VI) Concentrations in Groundwater



EHC-M Case Study – Field Results





AMW-63 - New well installed in November 2006

(Courtesy of EA Engineering, Science and Technology, Inc.)

EHC® Installations in Canada

EHC

- Commercial Facility, AB – July 07
- DND facility, QC – June 06 (pilot)
- Commercial Facility, ON – May 06
- Industrial Facility, ON – April 06
- Industrial Facility, ON – Feb 06
- Industrial Facility, ON – Feb 06

*10 Daramend, 7 iron PRB applications in Canada

Select EHC-M, EHC-A Installations in Canada

EHC-M

- Commercial Facility, ON – Oct 06
- Industrial Facility, ON – Sept 06
- Industrial Facility, ON – Aug 06

EHC-A

- Commerical Facility, ON – June 06

Select EHC-O Installations in Canada

- Industrial Facility, ON – June 08
- Industrial Facility, ON– June 08
- Commercial Facility, ON– Mar 08
- Industrial Facility, ON – Sept 07
- Industrial Facility, AB – Nov 07
- Industrial Facility, ON – May 07
- Industrial facility, SK- Nov 06
- Industrial Facility, AB – Aug 06

Over 35 applications in Canada