Emulsified Zero-Valent Iron (EZVI): A Combination ISCR Technology for Source Zone Remediation

Presented by:

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EZVI - Introduction

BACKGROUND–

Invention and Commercialization of EZVI

- Scientists at NASA (KSC) and UCF invented EZVI to address TCE DNAPL contamination at the Kennedy Space Center.
- The EZVI technology has been commercially available since 2005. RemQuest has provided EZVI for remediation projects in over 20 states, as well as, Canada and Australia.

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EZVI - Introduction

BACKGROUND – What is EZVI?

- Nano/micrometer sized zero-valent iron particles emplaced within a **surfactant-stabilized, biodegradable, water-in-oil emulsion.**
- EZVI is a remediation DNAPL.
- Highly effective for *in-situ* treatment of DNAPL due to matching physical chemistry and combination remedial technology (abiotic & biotic processes).

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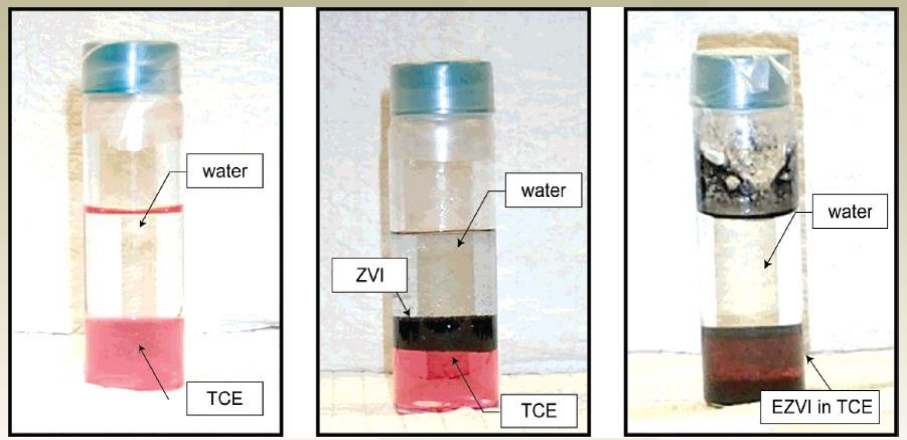
EZVI – Combination Technology

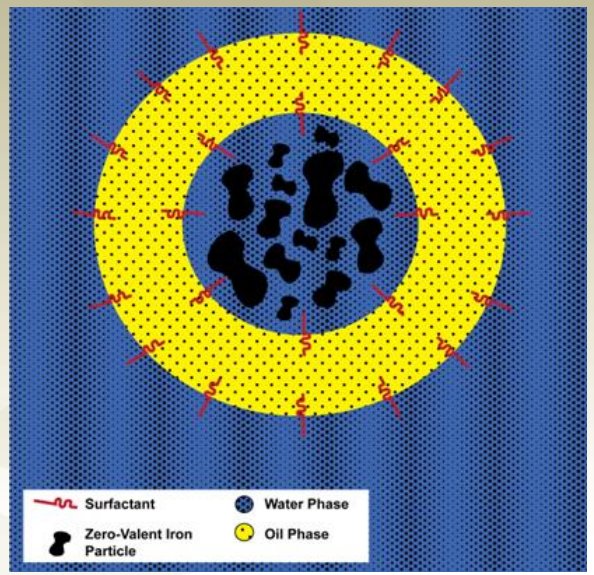
STRUCTURE – What makes EZVI Unique?

- Hydrophobic exterior membrane **mimics DNAPL physical chemistry** characteristics and enables **sequestration of contaminant**
- Utilizes both **ABIOTIC** and **BIOTIC** anaerobic remediation processes
- EZVI is **MISCIBLE with phase or residual DNAPLs *in-situ***



Brooks, 2000

Miscible with DNAPL



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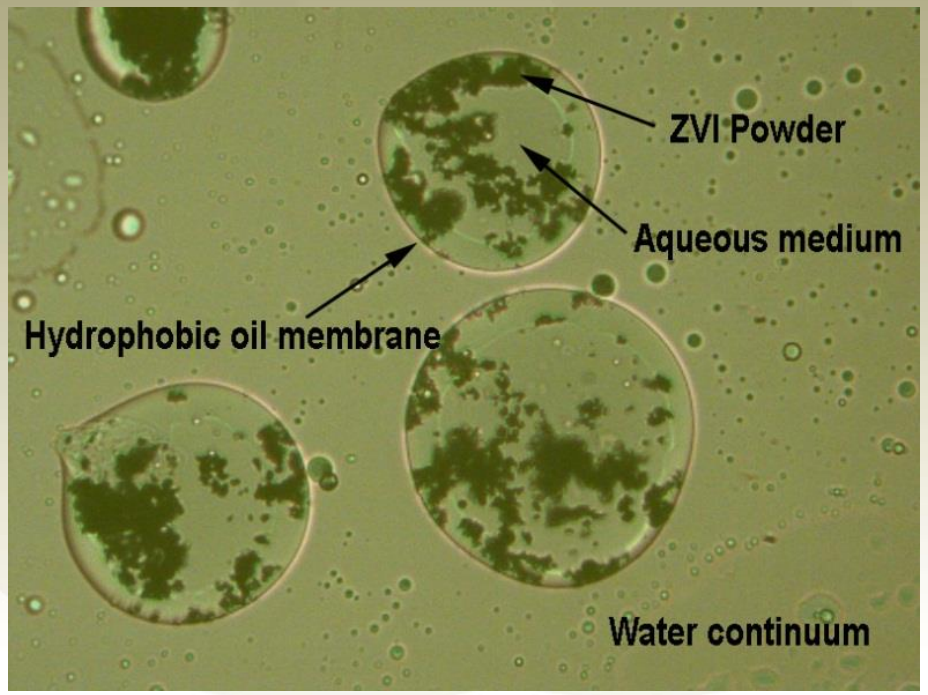
EZVI - Introduction

MECHANISMS – How does it work?

1. Sequestration (phase partitioning of COC into veg. oil membrane)
2. Dissolution (COC diffuses into water/ZVI interior of micelle)
3. Reductive Dehalogenation (abiotic & biotic)



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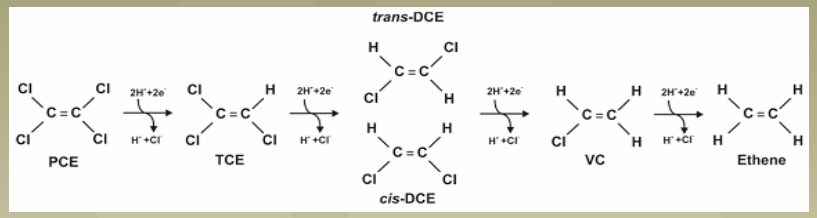
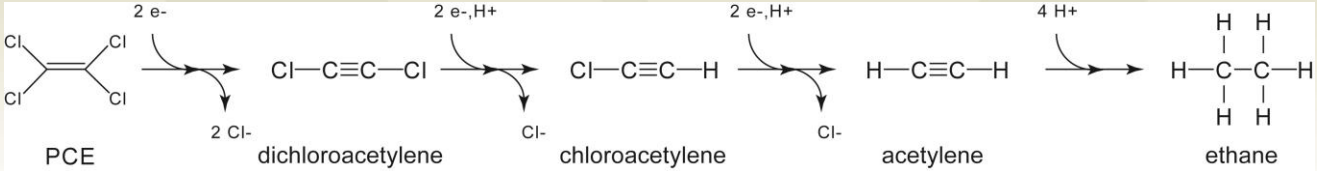
EZVI – Combination Technology

MECHANISMS – How does it work?

- ***Biotic Processes:***
  - Vegetable Oil associated with EZVI is fermented and ultimately provides H2 for biologically mediated reductive dechlorination reactions.



- ***Abiotic Process:***
  - Zero Valent Iron (ZVI) associated with EZVI is emplaced as an aqueous suspension in the interior of the emulsion. Contaminants contact the ZVI via a concentration gradient from the lipophilic membrane into the interior of the micelles.



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EZVI Implementation

- Engineered as an *in-situ* source treatment technology
- Delivered into subsurface soil/groundwater zones that are contaminated with source material(s) (DNAPL)
- Is effective in **vadose soils**, as well as **saline** and **aerobic** saturated environments
- Has been implemented at highly active military and commercial manufacturing sites

Pilot Scale

Full Scale

EZVI staged for field implementation

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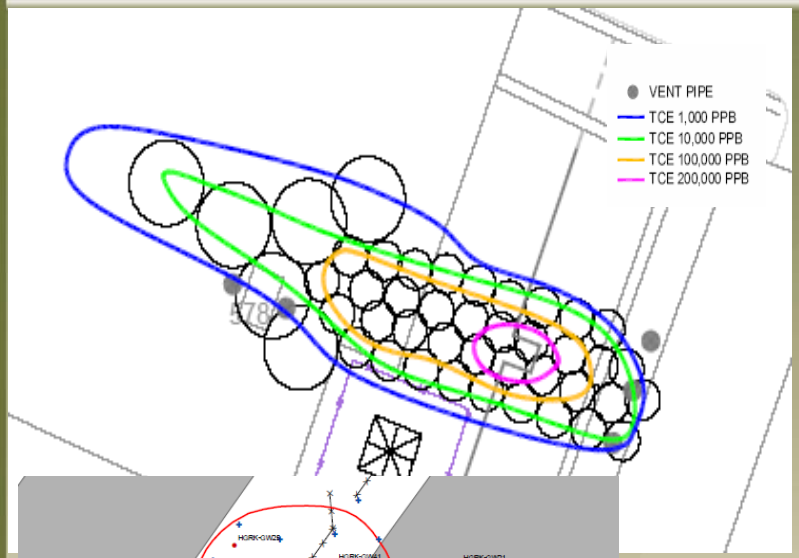
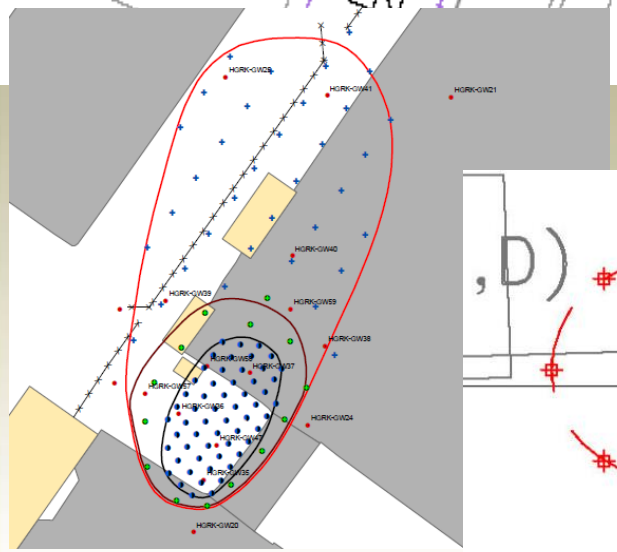
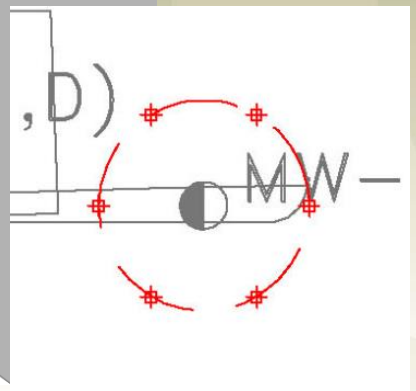
EZVI Delivery







- EZVI injections performed using:
  - Fracturing methods
  - Pneumatic Enhanced IDS
  - KAPSDIDS (or Badger System)
  - Soil Mixing (LDA method)
- Injection pattern typically "outside-in" and "bottom-up" in highly permeable soils to minimize the potential for DNAPL mobilization.

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Implementations

Pneumatic Enhanced Injection

Hybrid Direct Push Injection

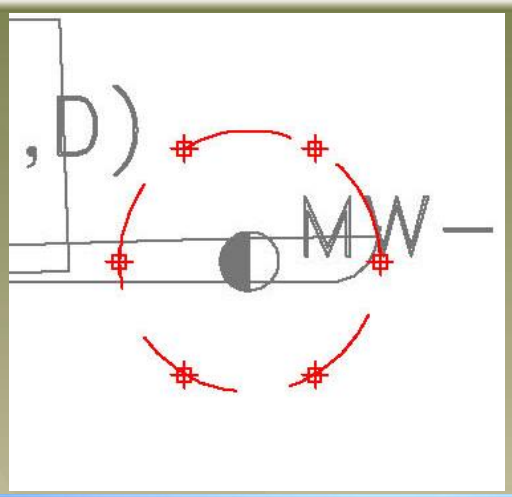
Hydraulic Fracturing/Injection
& Direct Push Injection

Hydraulic Fracturing/Injection

Case Study #1-Pilot Scale

Private Client in Central Florida

- Trichloroethylene (TCE), cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride
- 3,000 gallons of 10% EZVI was injected in a 40 ft. radius around a former UST/sump location.
- Injections targeted a 10-ft. thick subsurface zone.
- Electron donor material was injected above the area treated with EZVI and down gradient of the former source area to stimulate naturally-occurring biodegradation of the dissolved phase plume.



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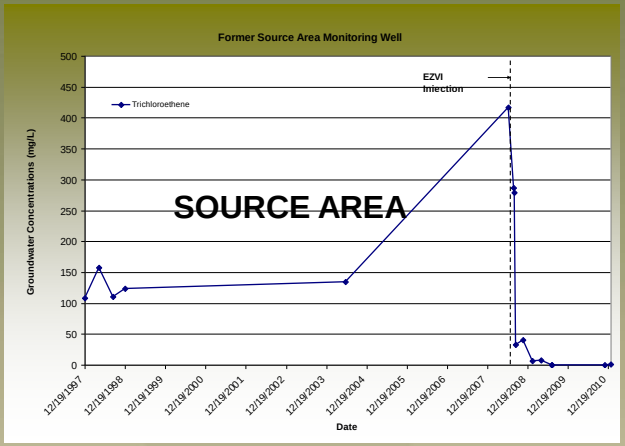
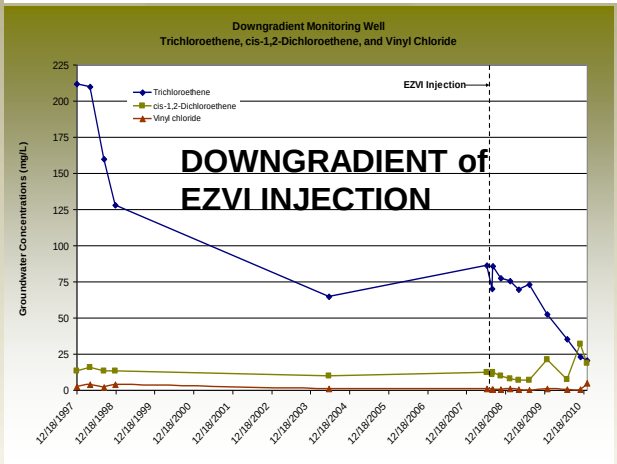
Results of Case Study #1

- Source area results: TCE groundwater concentrations from 417 mg/L (baseline results) to 6.88 mg/L after six months and non-detect within twelve months.
- Dissolved TCE concentrations adjacent to and above the EZVI injection zone decreased from 3.25 mg/L (baseline results) to <0.002 mg/L.
- Source Area [TCE] remained at non-detect levels for ~ 3 years post EZVI injection.





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Case Study #2-Pilot Scale

Private Client in Western U.S.

- PCE/CT source area beneath a tank farm in an active chemical facility, with a depth of contamination to 85ft bgs
- **MIP survey** conducted to identify location/depths of injection points
- 30,000 gallons of 10% EZVI were injected using the **KAPSDIDS technology**
- Injection design and monitoring program limited due to active tank farm

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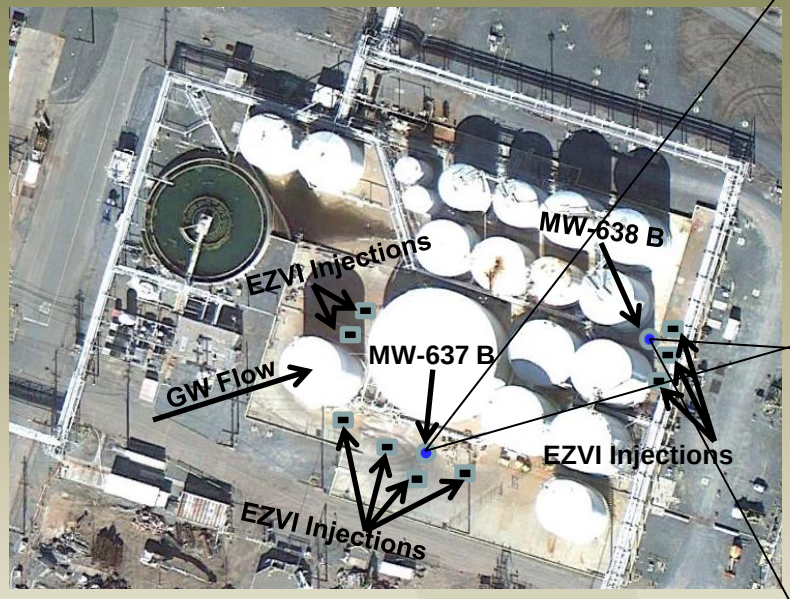
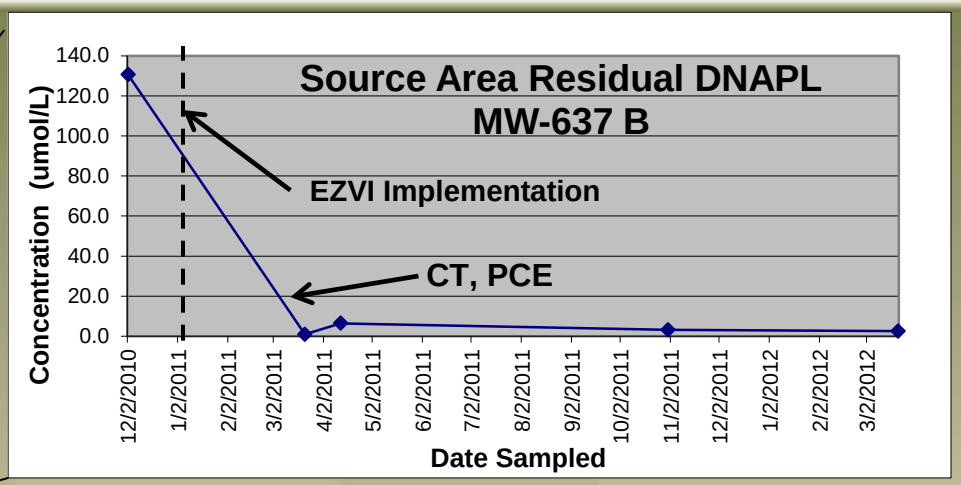
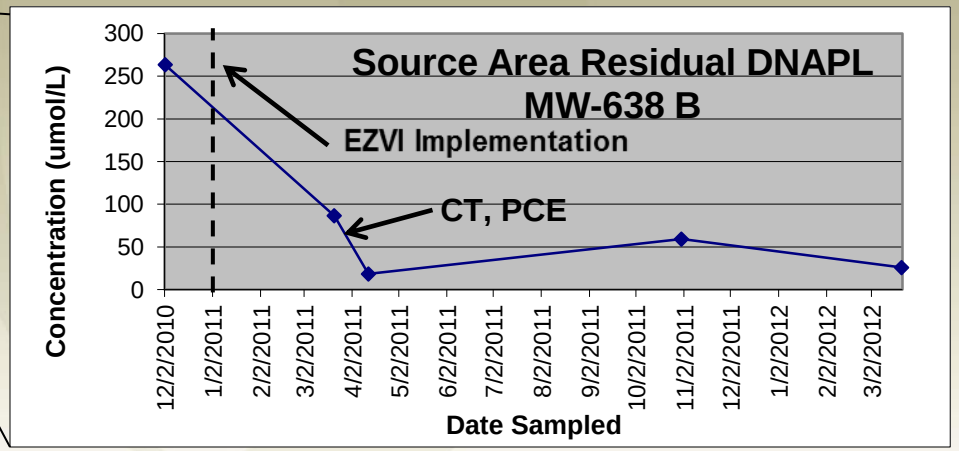
Results of Case Study #2







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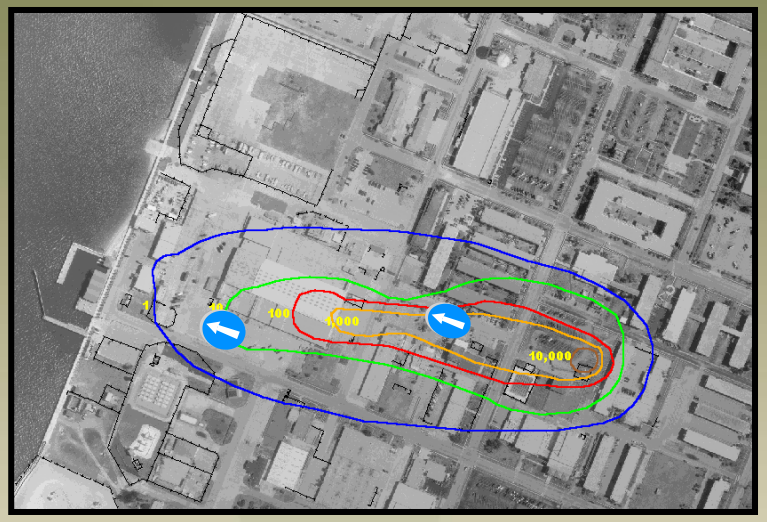
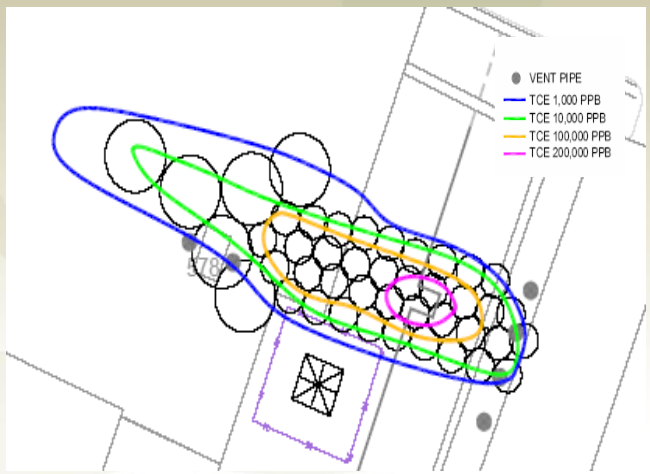
Case Study #3-Full Scale

Federal Client in Central Florida

- TCE source area was 75 feet wide and 150 feet long with a depth of contamination to 45 feet.
- 20 acre dissolved plume
- 62,000 gallons of 10% EZVI were injected using pneumatic fracturing technology
- Vegetable oil and KB-1 were also injected in the downgradient plume areas.





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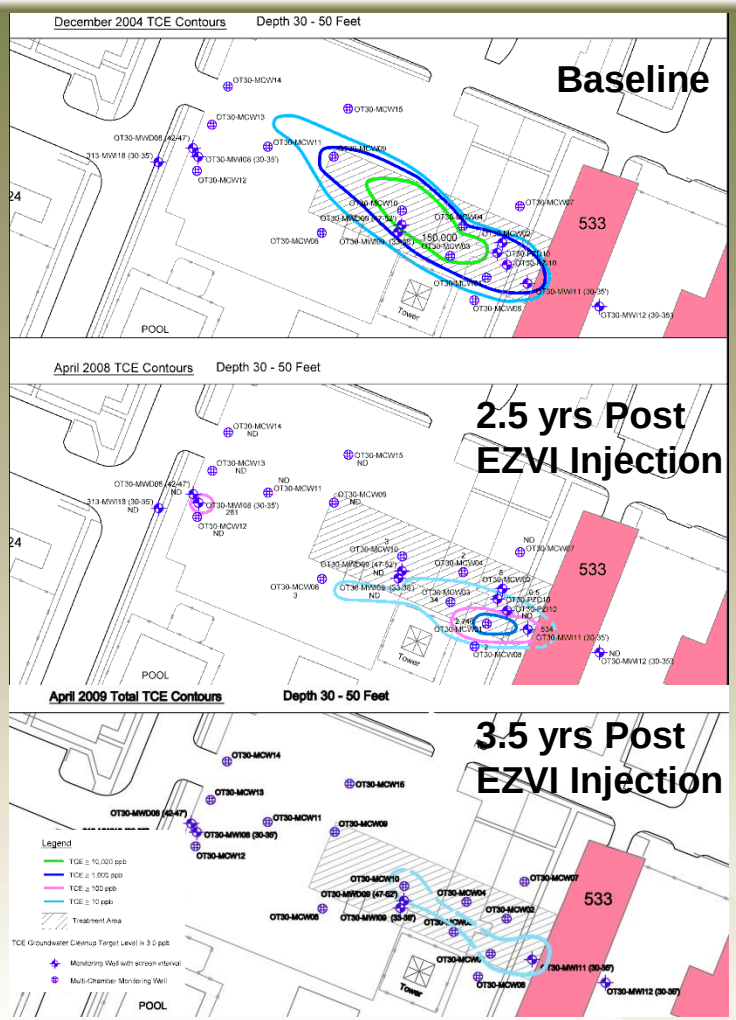
SOURCE AREA Results
Case Study #3



- Baseline samples from TCE source zone up to **350 ppm** in groundwater samples
- One EZVI injection event
- ~90% destruction of source area TCE within one year
- >99% destruction of source area TCE to date
- **Prior to EZVI injection-** Estimated to take ~**200 yrs**. to remediate site via MNA
- **Post EZVI injection-** Estimated to attain remediation goals within **50 yrs**.

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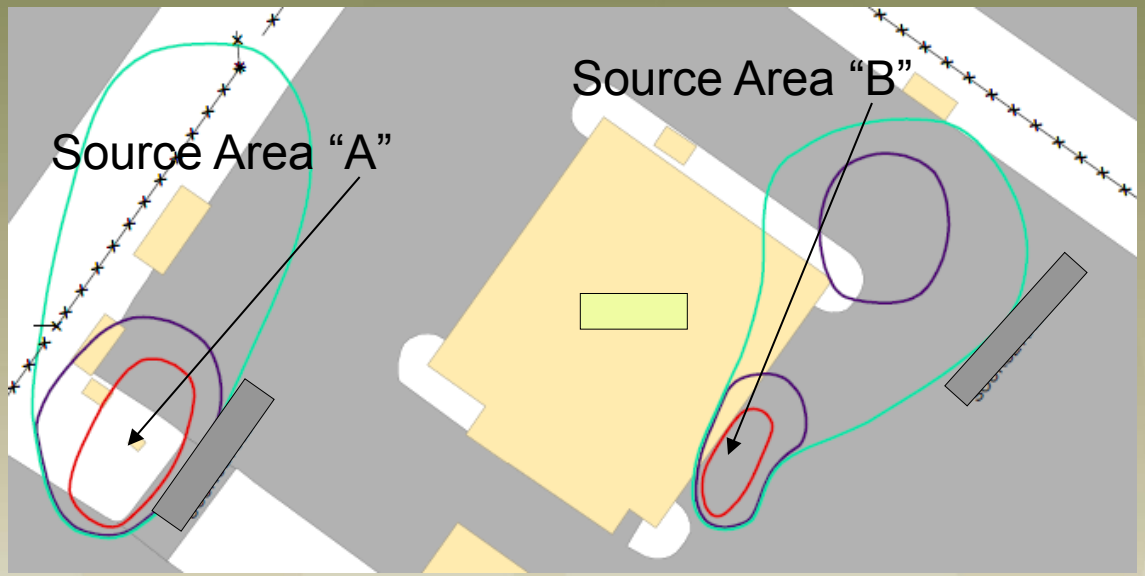
Case Study #4-Full Scale

Federal Client in Central Florida



- TCE source area "A" was ~ 50 ft. wide and 100 ft. long; while source area "B" was ~ 20 ft. wide and 60 ft. long; both with a depth of contamination to 40 feet.
- 37,500 gallons of 10% EZVI were injected into the two source areas using the KAPSDIDS technology

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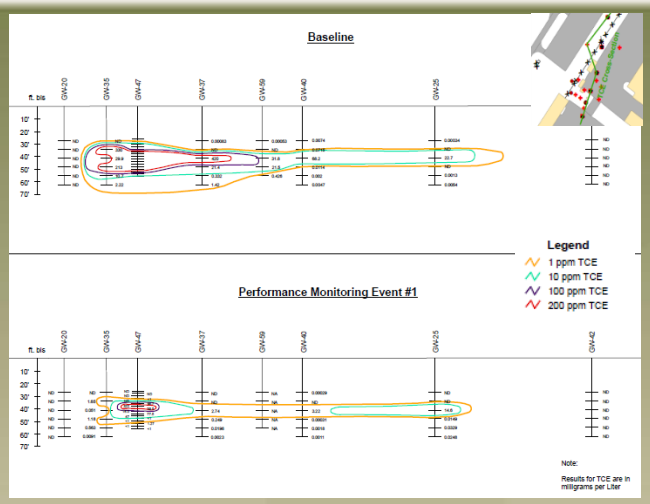
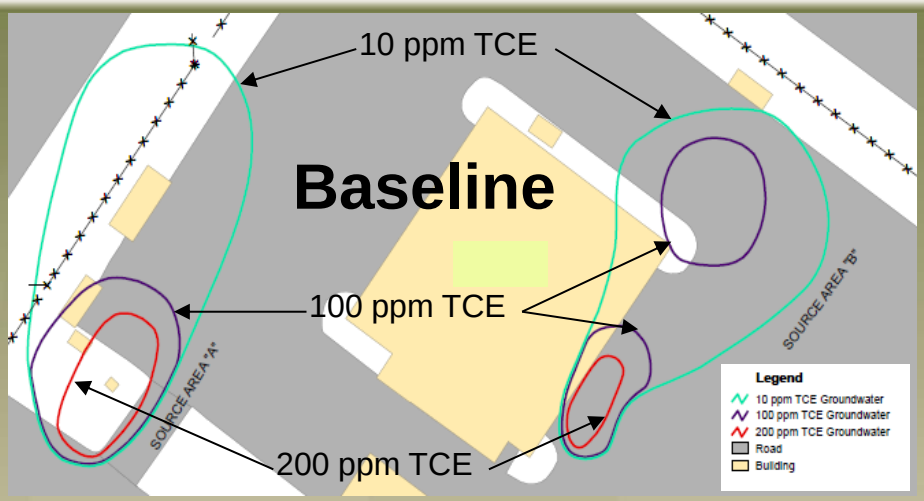
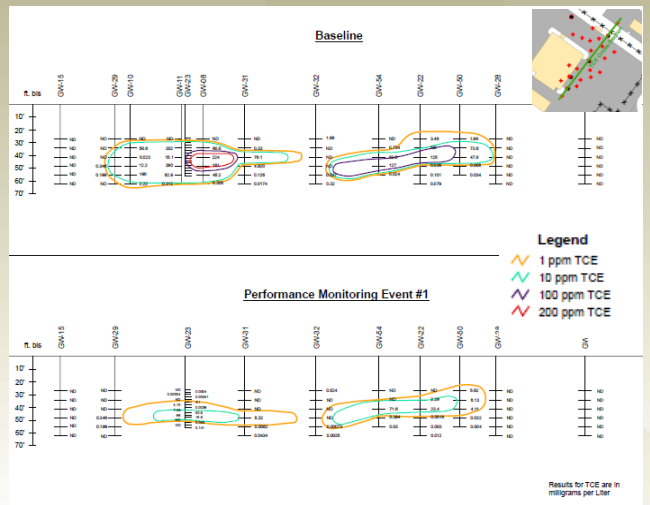
SOURCE AREA Results
Case Study #4

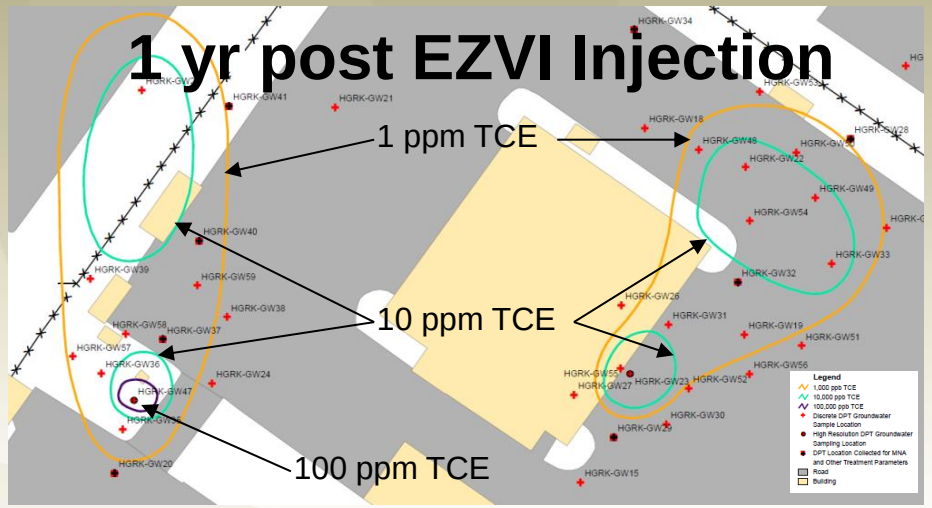
Source Area A





Source Area B





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EZVI Performance Highlights

- **Contaminant Reduction**
  - Typical source area VOC concentration reduction of 80 - 95% within <1 year
- **Timeframe of Reactivity**
  - EZVI has been shown to be effective in the subsurface for periods exceeding 2.5 years
- **Source Area Effects**
  - Directly destroys source material
- **Plume Effects**
  - *Adjacent to source area:* Fermentation reactions provide hydrogen for biotic transformations or "polishing" adjacent to injection area
  - *Downgradient:* Eliminates on-going source for downgradient areas

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FAQ's

- How much EZVI will I need at my site?
- How is EZVI packaged for site delivery?
- How much do you dilute the product for injection delivery?
- Can you inject EZVI through wells?
- What are typical reduction results?
- How long is EZVI reactive?
- How much does EZVI cost?
- What is the difference between EZVI and any of the other ZVI and carbon products that are available?

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Contact Information

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