ZVI APPLIED TO REMEDIATE DoD SUPERFUND SITE

CASE STUDY:
Combined Remedy Effectively Treats 1,2-DCA and TCE at Tinker Air Force Base

REGENESIS®

REGENESIS

OVERVIEW

Built in 1941, Tinker Air Force Base, is a a major United States Air Force base located in Oklahoma City, Oklahoma.

The base, originally known as the Midwest Air Depot, is named in honor of Oklahoma native, Major General Clarence L. Tinker, the first Native American Major General. As part of the Air Force's commitment to preserving and protecting the natural environment, the Air Force underwent a pilot study to remediate dichloroethane (1,2-DCA) and Trichloroethylene (TCE) contaminant levels found as a result of operations on base.

This remediation project was undertaken near former Waste Pit 1 and addressed a co-mingled plume of 1,2-DCA with lesser amounts of TCE. The 1,2-DCA concentrations in the plume were as high as 500 mg/L. The remediation included an application of emulsified vegetable oil (EVO), an aqueous suspension of colloidal zero valent iron (MicroZVI Precursor), with small amounts of fertilizer and B12. Typically, zero valent iron cannot be applied through well systems. However, due to the small particle size of the zero valent iron, this application was successfully applied through the existing wells. At 3 years post-injection, the contaminant levels remain near zero with the presence of ethene indicating continuous biodegradation.

HIGHLIGHTS

- Successful application of colloidal zero valent iron through well system
- At 3 years post-injection, the presence of ethene signals active biodegradation
- Aqueous suspension of colloidal zero valent iron effectively reduced contaminant levels
- Remediation was successfully coordinated in the middle of an active Air Force base

REGENESIS

PROJECT TIMELINE

1941

Tinker Air Force Base Established

1942-1979

Industrial waste dumped into industrial pits 1 and 2

1987

Tinker is placed on the Superfund list

EPA

April 2011-April 2014

Monitoring occurred over the course of three years

April and May 2011

Remedial application of EVO and an earlier formulation of MicroZVI were injected

MicroZVI™

BACKGROUND

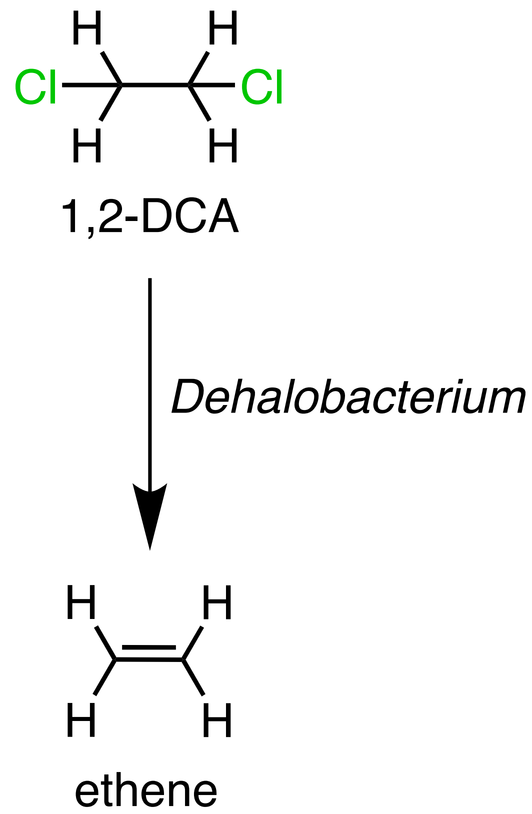
In the middle of the 20th century, it was typical and acceptable for manufacturing wastes to be dumped into pits, landfills, and rivers. These polluting wastes were generated at mills, processing plants, industrial manufacturing sites, as well as at military installations. One of these military installations was the Tinker Air Force Base.

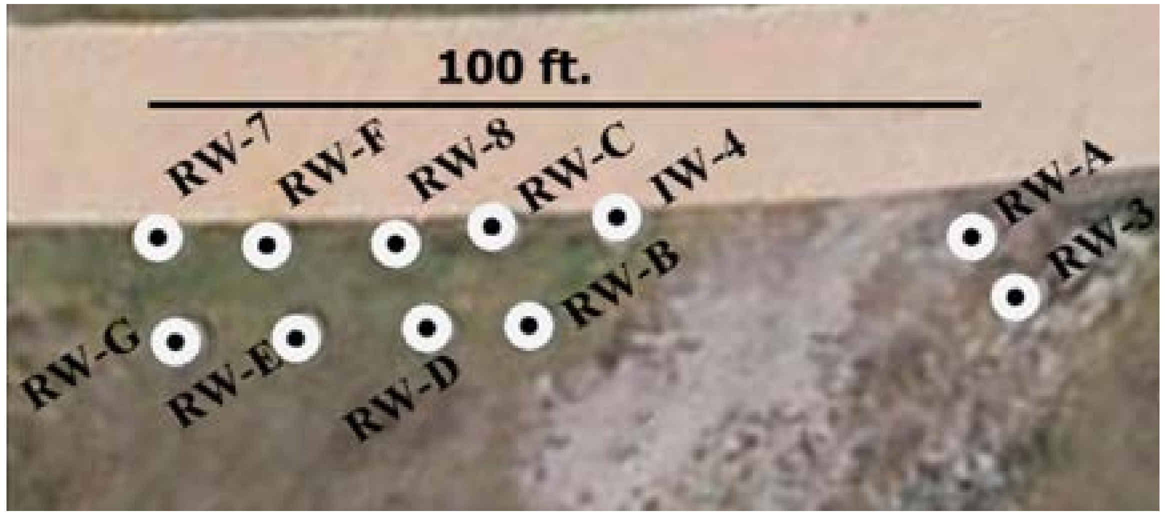
In 1941, Tinker was established as a supply and maintenance depot on the outskirts of Oklahoma City. During World War 2, the base repaired B-24 and B-17 bombers, and today Tinker hosts the largest depot repair complex in the Air Force Material Command. From 1942-1979 manufacturing waste from the Air Force base was dumped into the industrial pits 1 and 2. In 1987, after identifying groundwater and surface contamination, Tinker was added to the list of Superfund sites. The contaminants of concern, 1,2-DCA and TCE, were located in a water bearing zone about 35-45 feet bgs within a complex lithology containing fine silty sand and sandstone. Near the source area, 1,2-DCA concentrations were as high as 500 mg/L and were approximately 10 mg/L in downgradient locations. Water was initially aerobic (ORP =+ 200 mV) and pH neutral with little natural attenuation.

DESIGN EFFORTS

Unlike TCE and other more common halogenated hydrocarbons, 1,2-DCA is resistant to abiotic degradation. As a result, metal-assisted anaerobic bioremediation was used to promote rapid contaminant degradation directly from 1,2-DCA to ethene. The treatment design consisted of eleven 2" diameter PVC injection wells installed in two parallel rows. With a screened section at 35-45 feet bgs, eight wells were used as injection wells and three were used as monitoring wells.

In April and May 2011, an aqueous suspension of the MicroZVI Precursor and EVO with small amounts of fertilizer and B12 was applied to each of the eight injection wells. Pneumatic diaphragm pumps at 15-30 PSI were used to maintain injection rates of 2-4 gallons per minute (gpm); no well clogging, daylighting or similar problems were observed through the screened wells. Subsequently, 15 liters of microbes in total were injected into the eight injection wells.





Placement of the injection wells where MicroZVI precursor was applied shown here

RESULTS

Three months after product application, groundwater reduction potential was measured in 6 injection and 3 monitoring wells. Groundwater, initially at +200 mV, was rapidly rendered deoxygenated and reducing at each well and provided a very favorable environment for anaerobic biodegradation.

1,2-DCA concentrations were measured in three monitoring wells. In the downgradient monitoring wells, 1,2-DCA concentrations decreased by more than 50% within two months of product application and continued to decline, remaining at near-zero after three years. For the upgradient monitoring wells, concentrations peaked at 112 mg/L two months after product application and trended downward throughout the next three years.

1,2-DCA was converted directly to ethene which appeared in each monitoring well shortly after bioaugmentation. In the downgradient wells, ethene peaked a few months after product application and trended downward as the 1,2-DCA was consumed. In the source zone well, ethene peaked one year after product application and was still being generated three years later, indicating active biodegradation.

1,2-DCA Concentrations at Monitoring Wells

Date:	Description:	**RW-E** Downgradient	**RW-F** Downgradient	**RW-C** Source Influx
April 2011	pre-program	12.5 mg/L	11.7 mg/L	13.6 mg/L
August 2011	2 months post	3.0 mg/L	5.8 mg/L	108 mg/L
March 2012	1 year post	0.0 mg/L	2.0 mg/L	93.6 mg/L
May 2013	2 years post	0.0 mg/L	0.0 mg/L	67.4 mg/L
April 2014	3 years post	0.0 mg/L	0.0 mg/L	7.2 mg/L

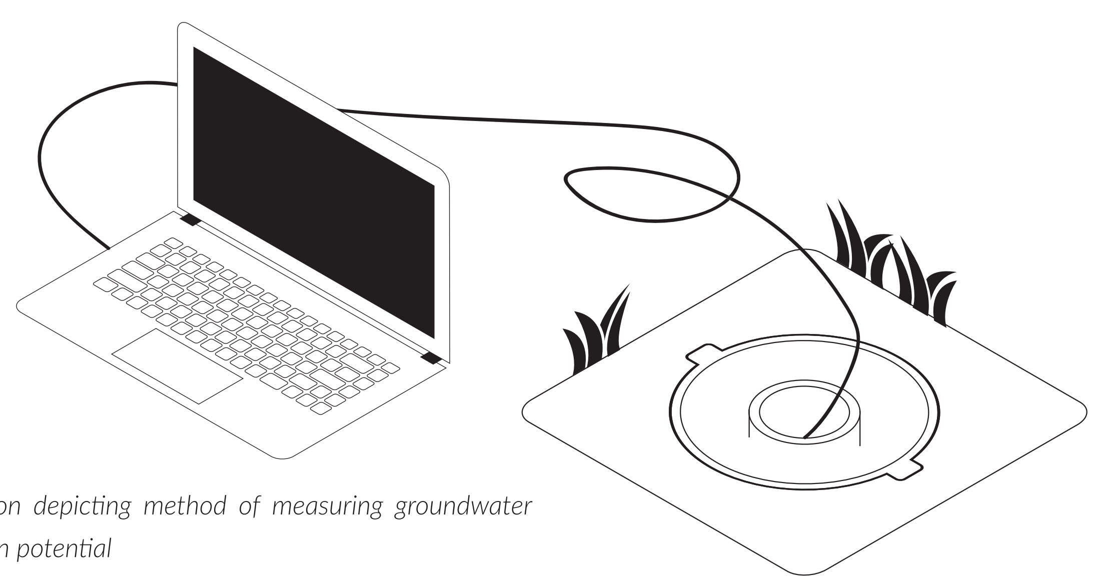


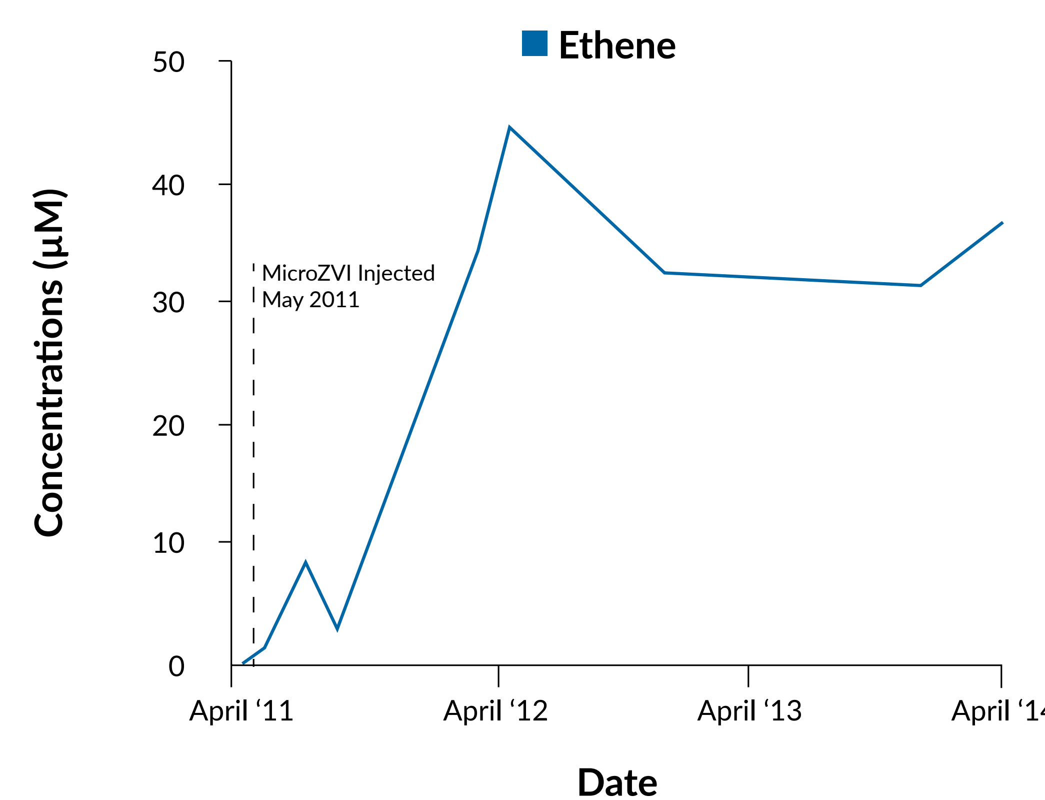
Illustration depicting method of measuring groundwater reduction potential

REGENESIS®

Ethene Concentrations at Monitoring Wells

Date:	Description:	**RW-E** Downgradient	**RW-F** Downgradient	**RW-C** Source Influx
April 2011	pre-program	0.0 mg/L	0.0 mg/L	0.0 mg/L
August 2011	2 months post	3.9 mg/L	4.0 mg/L	0.1 mg/L
March 2012	1 year post	1.1 mg/L	1.4 mg/L	1.0 mg/L
May 2013	2 years post	3.0 mg/L	0.1 mg/L	0.9 mg/L
April 2014	3 years post	0.0 mg/L	0.2 mg/L	1.0 mg/L

Ethene Concentrations Vs. Time RW-C



TECHNOLOGY

MicroZVI™

MicroZVI consists of highly dispersible colloidal ZVI (cZVI) particles (<5 µm) suspended in glycerol and proprietary dispersants. This combination results in unsurpassed distribution, reactivity and longevity compared to other ZVI products. As a result, treatment is more efficient, saving time and cost onsite.

It destroys contamination through:

- ISCR-enhanced anaerobic biological degradation: creating a strongly reducing and hydrogen rich environment for reductive dechlorination
- Direct abiotic chemical reaction

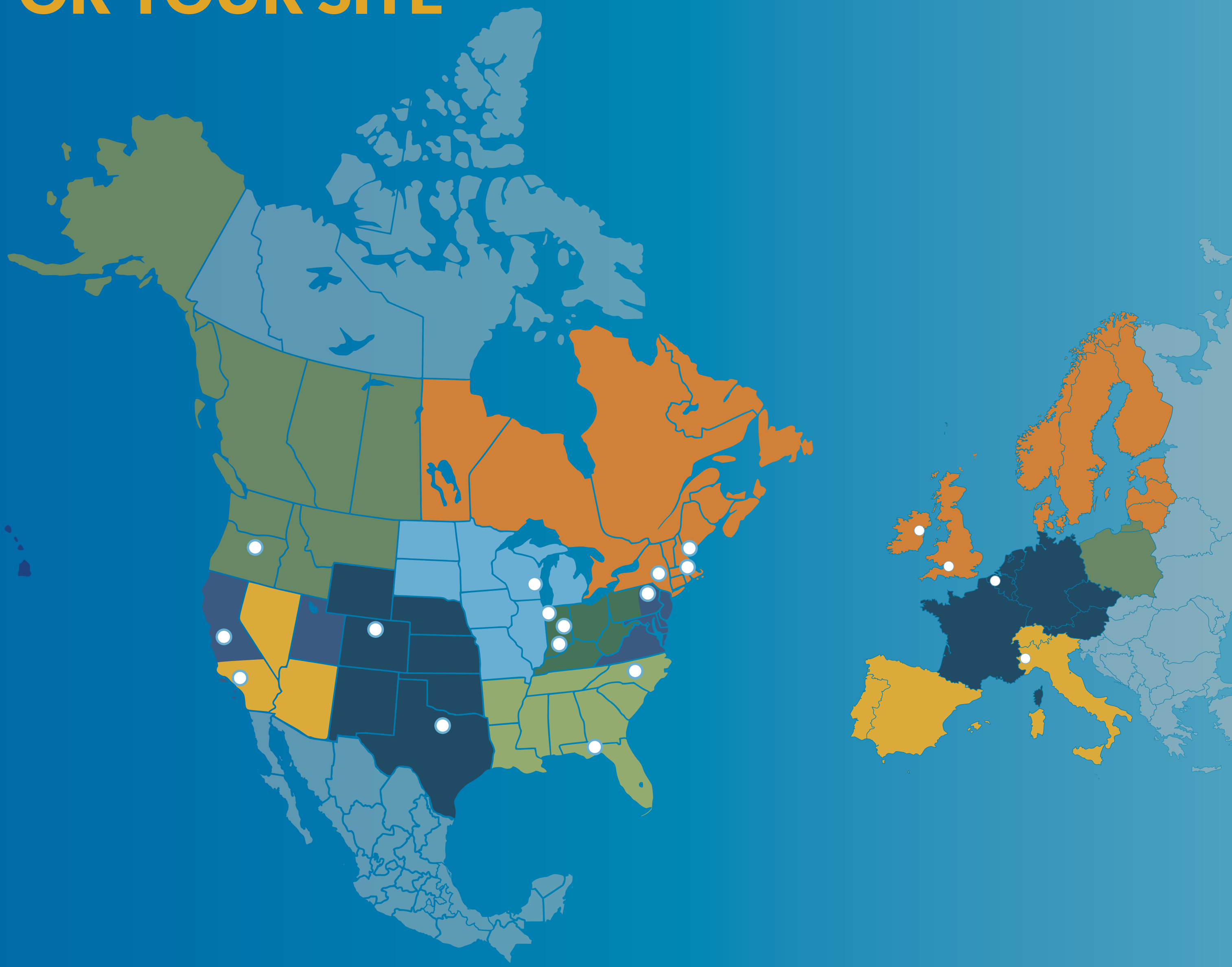
MicroZVI can be used in conjunction with 3-D Microemulsion® to provide the necessary iron to activate abiotic chemical reduction (including the β-elimination pathway) of chlorinated organic groundwater contaminants like perchloroethene (PCE), trichloroethene (TCE), dichloroethene (DCE), and vinyl chloride (VC). The end products of these biogeochemical reductions are ethene and ethane. MicroZVI can also be co-injected with Bio-Dechlor Inoculum Plus® (BDI+).

Key Benefits:

- Superior, wide-area distribution into groundwater
- Easy application
- Long-lasting, powerful *In Situ* Chemical Reduction (ISCR)

WE'RE READY TO HELP YOU

FIND THE RIGHT SOLUTION FOR YOUR SITE



Global Headquarters

1011 Calle Sombra
San Clemente, CA 92673 USA
Ph: (949) 366-8000
Fax: (949) 366-8090

European Offices

Bath, United Kingdom
Ph: +44 (0) 1225 731 447

Dublin, Ireland
Ph: +353 (0) 1 9059 663

Torino, Italia
Ph: +39 (0) 11 19781549

Ieper, België
Ph: +32 (0) 57 35 97 28

www.REGENESIS.com
1011 Calle Sombra, San Clemente, CA 92673 | T: 949.481.8118