



# SRS<sup>®</sup>-EZVI

## Emulsified Vegetable Oil and Zero Valent Iron Substrate for DNAPL, Freon 113, and Biobarrier Applications

Terra Systems "*injection ready*" **SRS<sup>®</sup>-EZVI** combines iron, biodegradable soybean oil, surfactants, and water, which forms a stable emulsion particle (or micelles) that contain ZVI particles in water surrounded by an oil-liquid layer and is added to the groundwater at complex and challenging remediation sites to rapidly generate reducing conditions. SRS<sup>®</sup>-EZVI provides the necessary carbon and hydrogen to support native or introduced microorganisms (*Dehalococcoides*) for the biodegradation of dense non-aqueous phase liquids (DNAPLs) like tetrachloroethene (PCE) and trichloroethene (TCE) and to support abiotic degradation by the ZVI. The exterior oil layer has similar hydrophobic properties as chlorinated compounds. Therefore, the emulsion attracts the contaminants and pulls them into the interior reactive zone for degradation. Terra Systems, Inc. has licensed the EZVI technology from NASA.

### Key Communication Points

- The SRS<sup>®</sup>-EZVI is manufactured with either 2 or 4  $\mu\text{m}$  ZVI and should be injected via DPT for optimal distribution.
- The smaller ZVI particle size provides very good distribution and contact with the contaminants of concern (COC), easier injectability for the driller and fewer injection points for the consultant, thereby lowering costs.
- Developed/patented by National Aeronautics and Space Administration (NASA)
- Accepted by most state regulators as a qualified product to treat DNAPL
- Provides both abiotic and biotic reductive dechlorination processes.
- Contains ZVI, biodegradable soybean oil, surfactants, and water that form a stable emulsion.
- Also contains a proprietary shear thinning agent, which under pressure thins the SRS<sup>®</sup>-EZVI out for ease of injection and improved radius of influence.
- The exterior oil layer has similar hydrophobic properties as chlorinated compounds. Therefore, the emulsion attracts the contaminants for abiotic degradation.
- Terra Systems, Inc.'s manufacturing facility is configured to allow us to provide our customers with custom blended SRS<sup>®</sup>-EZVI combinations without a cost premium.
- Hydrophobic, dense emulsion absorbs DNAPL, delivering contaminant to iron
- Does not promote mobilization of DNAPL
- It arrives at the site as a homogenous *injection ready substrate* and does not require mixing, which results in lower field labor costs from inefficient field mixing.
- Targeted in-situ source reduction. Proven effective with high concentrations of chlorinated solvents, DNAPL, Biobarriers to prevent migration across property boundaries and Freon 113 treatment. Zero Valent Iron can promote the abiotic dechlorination of solvents including tetrachloroethene (PCE), trichloroethene (TCE), 1,1,1-trichloroethane (1,1,1-TCA), and Freon 113 (1,1,2-trichloro-1,2,2-trifluoroethane).



- Proven effective at military installations, dry cleaners, semiconductor manufacturers, fabricators and manufacturing firms that use and clean metal parts (air conditioners, dishwashers, etc.).

**Table I:** SRS<sup>®</sup> - EZVI Specifications

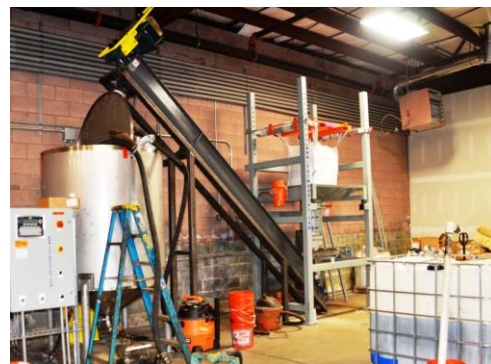
Ingredient	Percent by Weight/ Attributes	Description
Food Grade U.S. Grown Soybean Oil	35 - 37%	Terra Systems operates its own state-of-the-art manufacturing facility for SRS <sup>®</sup> production and can custom blend substrate packages as site conditions require
Zero Valent Iron	10 - 17%	Microscale Iron (2 to 4 μm)
Proprietary Food Grade Emulsifiers	1.0-1.5%	Food grade emulsifiers and nutrients are used.
Water	Difference	
pH	6.0 – 7.5	Neutral pH
Specific Gravity	8.84-9.28 pounds/gallon	Denser than water
Viscosity	270 - 300 centipoises	Moderately viscous

**How it Works**

ZVI is a strong reductant that reacts rapidly with a variety of constituents including chlorinated compounds, nitrate, and oxidized metals such as hexavalent chromium. ZVI reacts directly with the chlorinated compounds and typically generates little daughter products like cis-1,2-dichloroethene or vinyl chloride. In groundwater, iron metal (Fe<sup>0</sup>) will consume oxygen and subsequently corrode to form dissolved hydrogen gas (H<sub>2</sub>) and dissolved ferrous iron (Fe<sup>2+</sup>). The hydrogen generated from the corrosion of ZVI has been shown to serve as an electron donor that stimulates biological reductive dechlorination of chlorinated solvents. The soybean oil is also biodegraded to generate hydrogen to support reductive dechlorination. SRS<sup>®</sup>-EZVI supports both biological and abiotic degradation for the best of both worlds.

**Terra Systems Flexible Manufacturing Capability**

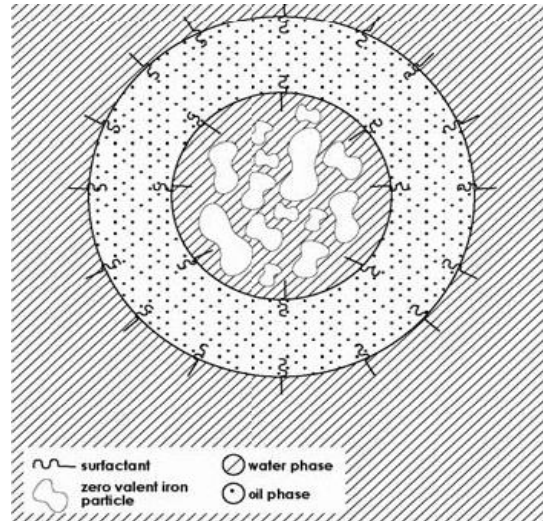
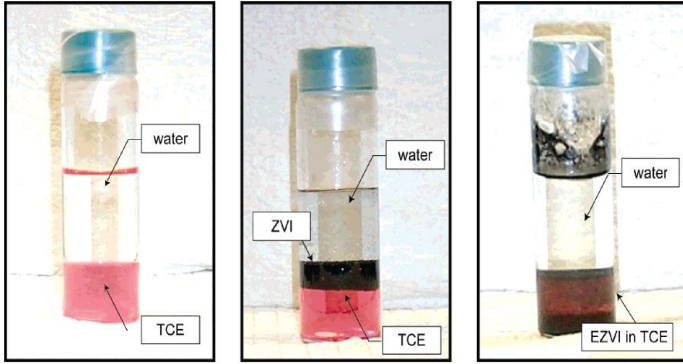
Terra Systems, Inc.’s manufacturing facility is configured to allow us to provide our customers with custom blended SRS<sup>®</sup>-EZVI packages without a cost premium. In general, the smaller the average ZVI particle, the more expensive the product.





**2 µm ZVI:** Can be injected via DPT. Easiest to inject with improved radius of influence.

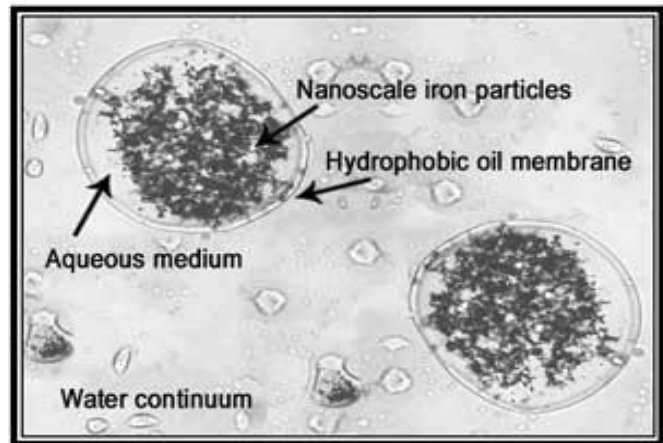
**4 µm ZVI:** Can be injected via DPT.



**Figure 1: Miscible with DNAPL (Brooks, 2000)**

Figure 1 shows a dyed DNAPL TCE sample to the left. The middle picture shows the EZVI added to the DNAPL TCE. On the right, the EZVI has reacted with the TCE.

Figure 2 show a generalized depiction of the ZVI particles within an oil droplet. Figure 3 is a microscope picture showing the ZVI particles surrounded by an hydrophobic oil membrane in an aqueous medium.



**Figure 2 & 3 (Quinn et. al., 2005)**

**Packaging:** Terra Systems patented SRS<sup>®</sup> - EZVI is shipped in 330-gallon IBC totes with 250 gallons in each tote.

**Delivered Injection Ready:** Terra Systems patented SRS<sup>®</sup> - EZVI is shipped ready-to-inject.