

Guar for Enhancement of Anaerobic Degradation:

1. Dr. Alan G. Seech, FMC Corporation
2. Guar CAS# 9000-30-0
3. MSDS & Technical Data Sheet - Attached
4. Number of Field-scale Applications to Date: 1,000+ sites.
5. Case Studies – Attached
6. Technical Summary: Guar is a carbohydrate polymer with chemical formula $(C_6H_{10}O_5)_n$ and is most commonly used as food grade thickening agent to improve the injectability of a variety of materials used in groundwater treatment. A prime example is zero valent iron, which is typically injected as a mixture of iron particles + water + guar, in which the iron particles are suspended in aqueous guar slurry. It is fully biodegradable and will therefore not have any long-lived impact on aquifer permeability.



MATERIAL SAFETY DATA SHEET

Guar Gum
08/31/11

1. Product and Company Information

Product Name: Rantec® G150™ Guar Gum

Manufacturer/Supplier: Rantec Corporation
Address: 17 Kukuchka Lane
Ranchester, WY 82839

Phone Number: (307) 655-9565
Fax Number: (307) 655-9528
e-mail: rantec@ranteccorp.com

2. Composition / Information on Ingredients

Ingredient	CAS Number	% Weight	Exposure Limits
Guar Gum	9000-30-0	100	5 mg/m ³ (respirable) PEL-TWA 3 mg/m ³ (respirable) TLV-TWA 10 mg/m ³ (inhalable dust) TLV-TWA
Chemical Family:	Carbohydrate		
Formula:	Approximately (C ₆ H ₁₀ O ₅) _n		

3. Hazards Identification

OSHA Hazardous Material: Yes

OSHA Hazard Categories:

1. Carcinogen – NO
2. Corrosive – NO
3. Highly Toxic – NO
4. Irritant – Yes
5. Sensitizer – Yes
6. Toxic – NO
7. Target Organ Effect Lung and Cutaneous -- Yes

Emergency Overview:

Concentrations of dust suspended in the air present a fire and explosion hazard.

Inhalation of dust may cause respiratory irritation and possible lung injury with symptoms of shortness of breath and reduced lung function.

Guar gum is very slippery when wet.

Acute Health Effects:

Eye Contact: Contact may cause irritation based on studies with laboratory animals.

Skin Contact: Contact may cause dryness.

Inhalation: Inhalation of dust may cause irritation of the nose, throat and respiratory passages. Symptoms include coughing, sore throat, nasal congestion, sneezing wheezing and shortness of breath. Guar gum may cause life-threatening allergic reaction in susceptible individuals.



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3. Hazards Identification (continued)

Ingestion: DO NOT INGEST. While this product is not toxic by ingestion, swallowing small amounts could cause complete blockage of the mouth, pharynx, trachea, esophagus and/or gastrointestinal system which may cause choking, suffocation and/or other life threatening medical conditions. Get medical attention immediately.

Chronic (long-term exposure) Health Effects:

- **Inhalation:** Overexposure to any nuisance dust may cause lung injury. Symptoms include cough, shortness of breath, difficulty breathing and reduced pulmonary function. Repeated exposures may cause allergic sensitization.
- **Carcinogenicity:** None of the components of this product are listed as carcinogens or suspected carcinogens by OSHA, IARC or NTP.
- **Medical Conditions Aggravated by Exposure:** Persons with pre-existing skin and respiratory disorders may be at an increased risk from exposure.

Physical Hazards:

- **Dust:** It is well documented that a dust cloud will fuel an explosion in a confined area with sufficient oxygen and an ignition source. Surface (passive) and airborne (active) dust (fuel) is a potential hazard and the appropriate protective measures should be taken when handling guar outside of the bag in confined work spaces, dust collectors, dryers, mills, sifters, blender, pneumatic conveyance systems, storage tanks, etc. Utilize good housekeeping to remove surface dust from floors, walls, beams, around equipment, etc.
- **Slick Surfaces:** It is possible that an employee will be exposed to guar powder or dust in combination with water on work platform, floor or stair, which will result in a slippery surface.

4. First Aid Measures

Eye: Flush immediately with large amounts of water. Eyelids should be held away from the eyeball to ensure thorough rinsing. If irritation persists get medical attention.

Skin: First aid is not normally needed. Wash exposed skin with soap and water after use. If irritation or rash develops get medical attention. Use skin lotion if dryness occurs.

Inhalation: If symptoms of irritation or allergy develop, remove person from source of exposure to fresh air. If symptoms persist get medical attention.

Ingestion: Swallowing even small amounts may have serious, life-threatening effects. Get immediate medical attention.

5. Firefighting Measures

Flashpoint: Not Applicable

Auto-ignition Temperature: Not Determined

Lower Explosion Limit: 0.040 oz/cf

Upper Explosion Limit: Not determined

Extinguishing Media: Use water fog, dry chemical, carbon dioxide or foam. Do not use streams of water as dust dispersed by water streams can explode.

Special Fire Fighting Procedures: Wear positive pressure, self-contained breathing apparatus and full protective clothing.

Unusual Fire and Explosion Hazards: Powder has the potential to form explosive mixtures with air. It is well documented that a dust cloud will fuel an explosion hazard. Surface (passive) and airborne (active) dust (fuel) are a potential hazard and the appropriate protective measures should be taken when handling guar gum outside of the original packaging. Avoid creating dust. Keep away from heat, sparks and open flames. As with all dusty materials,



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use preventative measures including spark proof motors and ventilation to control dust. Utilize good housekeeping to remove surface dust from floors, walls, beams, around equipment, etc.

Combustion Products: Oxides of carbon and nitrogen.

6: Accidental Release Measures

Wear appropriate protective clothing and equipment. Caution: Guar gum is **very slippery when wet**. Suspended dust may present a serious dust explosion hazard. Sweep up or vacuum, avoiding the creation of airborne dust. Keep spilled product away from flammable and combustible materials. Use vacuum equipment specifically designed for combustible dusts. Collect into a suitable container for disposal. Wash residual traces with hot water after sweep-up is complete. Test area for residual slippery conditions.

7. Handling and Storage

Handling: Avoid generating and breathing dust. Avoid eye contact. Use with adequate local exhaust ventilation and dust collection to maintain the concentration of airborne dust below the exposure limits. If clothing becomes contaminated, remove and launder before re-use. Wash thoroughly after handling. Keep product away from oxidizers and all sources of ignition including flames, electrical sparks, hot surfaces, pilot lights, etc.

Storage: Keep product dry. Store in a cool, dry area. Keep containers closed to avoid moisture absorption.

8. Exposure Controls / Personal Protection

Engineering Controls: Consult a qualified engineer for evaluation of materials handling and explosion protection system(s).

Personal Protective Equipment (PPE):

- **Eye Protection:** Safety glasses or goggles recommended.
- **Skin Protection:** Rubber, plastic or leather gloves recommended.
- **Respiratory Protection:** If the concentrations exceed the Threshold Value Limit (TLV), a NIOSH approved dust respirator, supplied air respirator or self-contained breathing apparatus is recommended. Select appropriate respiratory protection for respirable particulates based on consideration of the airborne workplace concentrations and duration of exposure. Select and use respirators in accordance with 29 CFR 1910.134 <http://www.access.gpo.gov/nara/cfr/cfr-retrieve.html#page1> , ANSI Z88.2 <http://www.ansi.org/>, the NIOSH Respirator Decision Logic and good industrial hygiene practice <http://www.cdc.gov/niosh/homepage.html>. To simplify selection of the appropriate respirator, OSHA has developed the Advisor Genius. Available online, the advisor genius allows a safety professional to input the conditions under which the respirator will be used and receive a recommendation of the type of respirator to use. The advisor also contains information about types of respirators and factors that affect respirator use. The online advisor contains a set of options as to the use of the respirator (firefighting, welding, escape purposes, confined areas) and then generates a report with the relevant OSHA standard indicated. The advisor is available at http://www.osha.gov/SLTC/etools/respiratory/respirator_selection.html.

9. Physical and Chemical Properties

Boiling Point: Not Applicable
Melting Point: Decomposes
Vapor Pressure: Not Applicable
Vapor Density (Air=1): Not Applicable
% Solubility in Water: Complete

Specific Gravity: Not applicable
% Volatile: Not applicable
Evaporation Rate (Butyl Acetate=1): Not Applicable
pH: 5-8
Octanol/Water Partition Coefficient: Not Applicable



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Odor/Appearance: Creamy white powder with a bean-like odor.

10. Stability and Reactivity

Stability: Material is stable.

Incompatibility: Avoid high temperatures, sparks, open flames and moisture. Avoid contact with strong oxidizing agents.

Hazardous Reactions-Decomposition Products: Combustion may produce carbon dioxide, carbon monoxide and oxides of nitrogen.

Hazardous Polymerization: Will not occur.

11. Toxicological Information

Guar Gum: Oral rat LD50: 9.4g/kg

Guar gum is a natural food additive, although direct use in powder or pill form is banned by the FDA due to the risk of respiratory or gastrointestinal blockage

12. Ecological Information

No ecotoxicity data is available at this time.

13. Disposal Considerations

Dispose in compliance with all applicable federal, state and local regulations. Do not dump down sewers or drains as this may cause blockage.

14. Transport Information

U.S. Department of Transportation (DOT)

Proper Shipping Name: Not Regulated

Hazard Class: N/A

UN/NA Code: N/A

Packing Group: N/A

Labels Required: N/A

IMDG CODE

Proper Shipping Name: NOT REGULATED

Hazard Class: N/A

UN/NA Code: N/A

Packaging Group: N/A

Labels Required: N/A

15. Regulatory Information

Regulatory Information

The United States Food and Drug Administration, the European Economic Community and the World Health Organization accept guar gum as a food additive/ingredient providing it meets specified purity standards and dosage limitations. Maximum usage levels permitted may vary from country to country. Guar gum has been affirmed as GRAS by the United States Food & Drug Administration under title 21, CFR, part 184.1339; it is listed



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as item G.3 of Table IV, Division 16, of the Canadian Food and Drug Regulations and is referenced E-412 under the EEC Council Directives.

Comprehensive Environmental Response and Liability Act of 1980 (CERCLA) Reportable Quantity:

This product is not subject to CERCLA reporting requirements as it is sold.

OSHA Hazard Categories: Irritant, Sensitizer, Target Organ Effect.

Superfund Amendments and Reauthorization Act (SARA) Title III Information:

SARA Section 311/312 Hazard Categories: Fire Hazard, Acute Health

This product contains the following toxic chemical(s) subject to reporting requirements of SARA

Section 313: None

15. Regulatory Information (continued)

California Proposition 65: Guar gum is not a chemical known to the State of California to cause cancer or reproductive toxicity under the "Safe Drinking Water and Toxic Enforcement Act of 1986".

Toxic Substances Control Act (TSCA): All components of this product are listed on the TSCA inventory or exempt from notification requirements.

Canadian Environmental Protection Act: All of the components of this product are listed on the Canadian Domestic Substances List or exempt from notification requirements.

European Inventory of Existing Commercial Chemical Substances (EINECS): All of the components of this product are listed on the EINECS Inventory or exempt from notification requirements.

Japan MITI: All of the components of this product are existing chemical substances as defined in the Chemical Substance Control Law.

Australian Inventory of Chemical Substances: All of the components of this product are listed on the AICS Inventory or exempt from notification requirements.

Canadian WHMIS Classification: Class B, Division 4 (Flammable Solid)

16. Other Information

NFPA Hazard Ratings:

NFPA® Flammable (combustible dust) with representative diameter less than 420 microns (40 mesh).

Health: 1 Flammability: 2 Reactivity: 0

HMIS Hazard Ratings:

Health: 1 Flammability: 1 Reactivity: 0

Abbreviations:

ACGIH American Conference Of Governmental Industrial Hygienists
ANSI American National Standards Institute

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CAS	Chemical Abstracts Service
CDC	Centers for Disease Control and Prevention
CFR	The Code of Federal Regulations
EEC	European Economic Community
EINECS	European Inventory of Existing Commercial Chemical Substances
EPA	United States Environmental Protection Agency
FDA	United States Food and Drug Administration
HMIS	Hazardous Materials Identification System
IARC	International Agency for Research on Cancer
IMDG	International Maritime Dangerous Goods
LD50	Lethal Dose expected to cause death in 50% of the test animals
MITI	Ministry of International Trade and Industry
NFPA	National Fire Protection Association
NIOSH	CDC - National Institute for Occupational Safety
NTP	National Toxicological Program

16. Other Information -- Abbreviations (continued)

OSHA	U.S. Department of Labor, Occupational safety and health administration
PEL	OSHA - permissible exposure limit
TLV	ACGIH - threshold limit value
TWA	Time weighted average
UN/NA	United Nations / North America
US	United States
WHMIS	Workplace Hazardous Materials Information System

NOTICE:

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08/31/11

Quality Polymers from



RANTEC CORPORATION

PO Box 729
Ranchester, WY 82839

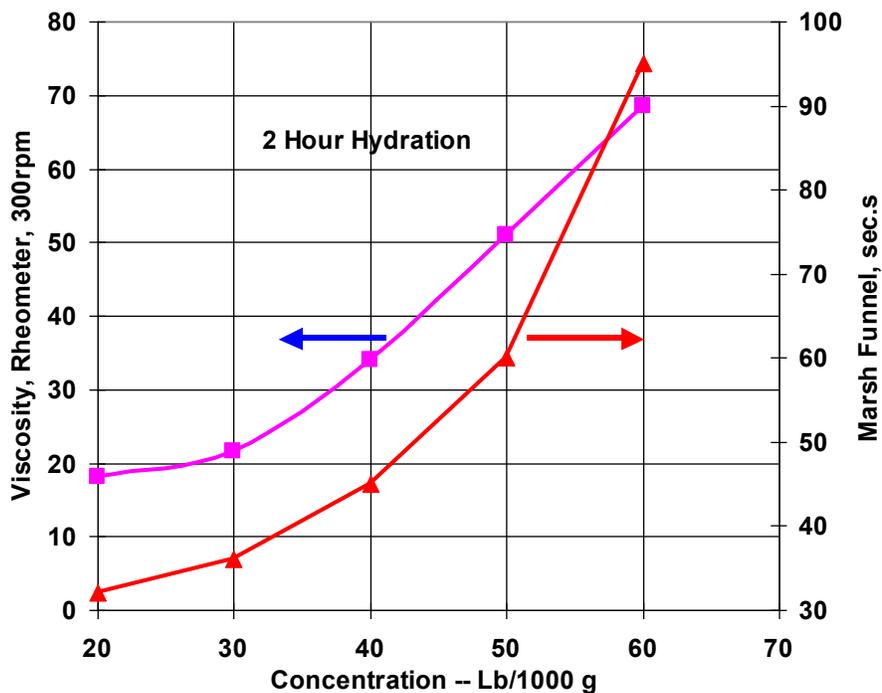
Phone (307) 655-9565
www.ranteccorp.com
Email: rantec@ranteccorp.com

28 Years of Innovation

Rantec G150™ BioPolymer

DESCRIPTION

G150 is Rantec's guar gum-based natural polymer (galacto-mannan) for biopolymer liquid shoring fluids (BLSF) and drilling muds. Molecular weight is in the range of 1.5 to 2.0 million. **G150** BLSF has been used extensively for geo-technical stabilization of extraction trenches during excavation and construction and well bores during drilling. **G150** is biodegradable and can be broken down completely thus maintaining the permeability of those soils and producing formations. Rantec has more than 16 years of experience in supplying **G150** for use in liquid shoring and drilling applications. As part of Rantec's continued improvement program **G150** is now easier to mix, less dusty and produces more viscosity per pound.



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Figure 1: Viscosity with Concentration shows fresh water viscosity for a range of concentrations of Rantec **G150** biopolymer.

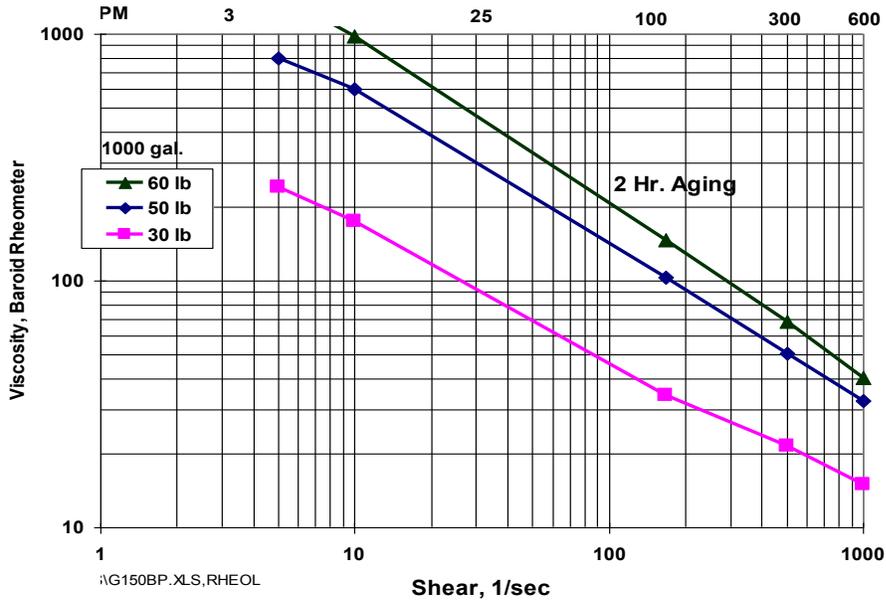


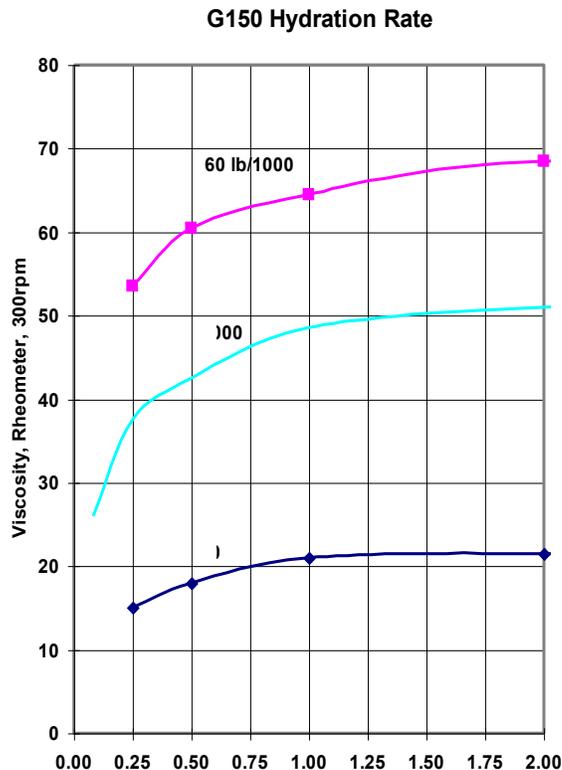
Figure 2: Rheology

Rantec **G150** BLSF is a non-Newtonian "shear-thinning" fluid. At low shear rates a gel is apparent, while under high shear, viscosity is very low.

Figure 2: Rheology demonstrates these rheological characteristics of the fluid.

High viscosity in the gel state or low shear condition is important for prevention of soil or water movement, while low viscosity is important under higher shear conditions such as mixing and pumping.

G150 fluids immediately recover original viscosity as soon as shear is relieved. High shear will not destroy the **G150** polymer molecule as can occur with many synthetic polymers.



YIELD AND MIXING

Typical design mix for G150 in difficult conditions would be:

G150	50 to 70 lb/1000 gallons
Busan 1059WS	1.2 to 2.0 lb/1000 gallons
Soda Ash	5 to 8 lb/1000 gallons to maintain pH 10
Lime	1 to 3 lb/1000 gallons if required to maintain pH 10

Rantec **G150** is designed to provide easy mixing and good yield of viscosity. **G150** yields workable viscosity in about 1 hour and is fully yielded in about 4 hours. **Figure 3: Viscosity Development** demonstrates the development of viscosity through a period of 24 hours. In 1 hour **G150** has yielded 90% of its viscosity. **G150** responds well to high shear mixing. Additional shear will accelerate the rate of viscosity yield.

Rantec will provide assistance in choosing equipment suited for good mixing of **G150** fluid. Systems can be engineered for a wide range of capabilities from manual addition to fully automated systems.

IN USE CHARACTERISTICS

Typical Use Rate – 60 lb/1000 gallons (0.72% w/w)

Odor of Broken Slurry – Not noticeable under aerobic conditions. May become putrid under anaerobic conditions.

BOD of Broken Slurry – Typically approximately 1200 ppm.

Useful Life of Slurry – 3 to 10 days depending upon temperature, soil conditions and additives

Degradability – Approximately 10 to 12% insoluble residue after enzyme break

PACKAGING

Rantec **G150** is available in packaging from 20 lb pails to 2000 lb super sacks. The most common packaging is 50 lb multi-wall paper bags. All packages are loaded on pallets and stretch wrapped to protect the product. For outside storage pallet covers can be provided on request.

SAFETY

G150 is a natural organic polymer often used in food ingredients as well as industrial applications. It is non-polluting and non-toxic. It is totally biodegradable, so disposal problems are reduced. Preservative can be used for long term applications. **G150** is non-mineral: therefore, it does not contaminate trenches, surroundings or assays.

RANTEC CORPORATION
17 KUKUCHKA LANE
RANCHESTER, WY 82839

Phone 307-655-9565

Fax 307-655-9528

email rantec@ranteccorp.com

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ZVI Permeable Reactive Barrier

San Francisco Bay Area, CA

Client Profile: National Consulting Firm

Project Profile: DPT injection of ZVI suspended in guar gum

Contaminants of Concern: Chlorinated VOCs

Impacted Matrix: Silts with sand lenses. The project focused on an area between the downgradient border of the disposal cells and a local waterway. Groundwater migrating from the landfill is known to be impacted with chlorinated VOCs.

Project Summary: The purpose of this project was to construct an abiotic permeable reactive barrier that would abate the concentration of chlorinated VOCs in the groundwater migrating across the area. The injection project was conducted in two phases. A pilot injection program was first implemented to assess the subsurface response to ZVI injection and develop an injection approach suitable for local lithology. A 64% wt/wt paste of H2OMET-ZVI (of less than 150-micron particle size) was pre-mixed using guar gum powder as a suspending agent. In June 2009, Vironex conducted a 59-point full scale PRB injection, distributing more than 8,000 lbs of ZVI into the subsurface between 10-11 feet bgs and 19-20 feet bgs within anticipated groundwater flow paths.

Project Results: Continuous cores collected near injection points confirmed the formation of subsurface fractures filled with ZVI. Initial post-injection groundwater monitoring results indicated that Oxidation-Reduction Potential had dropped significantly in area downgradient from the PRB.



Figure 1 – DPT Core Showing ZVI Distribution
10 to 11 feet bgs



Figure 2 – DPT Core Showing ZVI Throughout Core

ZVI and Emulsified Oil Source Zone Injection Chlorinated Methanes Charleston, WV

Client Profile: National Consulting Firm

Project Profile: DPT injection of ZVI suspended in guar gum and EVO

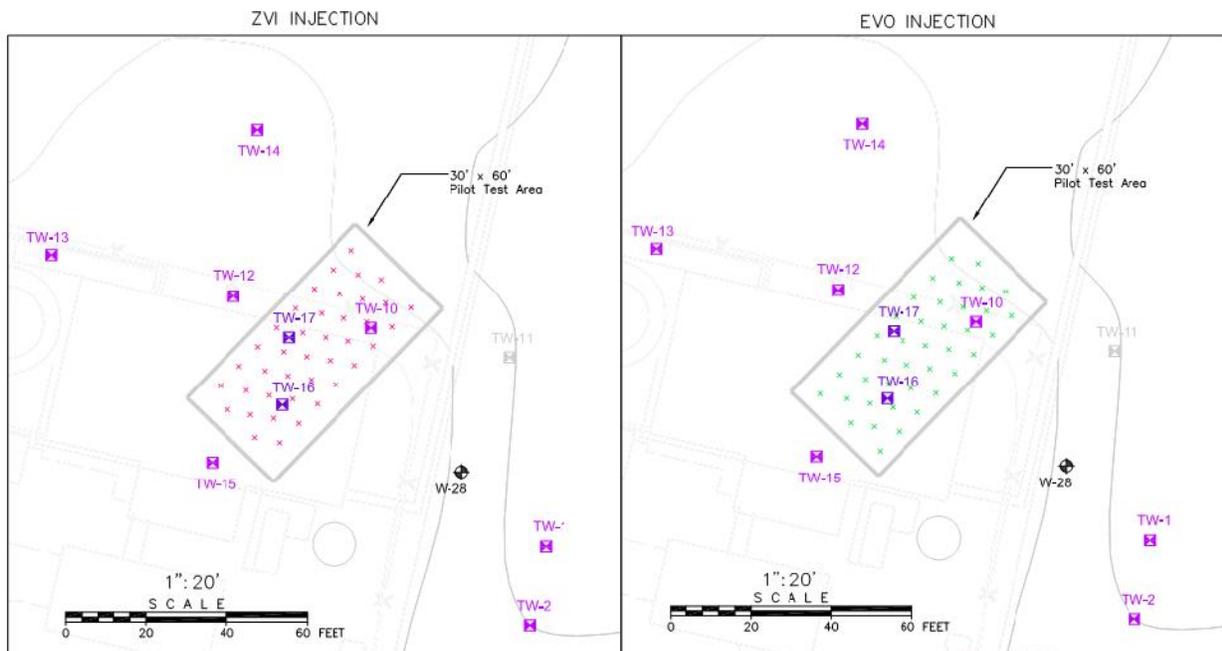
Contaminants of Concern: Chlorinated Methane VOCs

Impacted Matrix: Heterogeneous sands to clays .The project focused on a source area primarily impacted by chlorinated methanes.

Project Summary: During April, 2012, ZVI was injected into the saturated zone in an area of about 1800 square feet. The scope of injection involved mixing 14,400 gallons of water with 8,100 lbs of micro-scale ZVI and 900 lbs of guar gum. DPT injection occurred in the saturated zone from 35’ and 60 feet bgs at 40 locations (See Figure below).

Each location also received on a subsequent injection event of 210 gallons EVO per location which was 3 feet SE of each ZVI location

Project Results: Confidential results not provided to Vironex.



ZVI and Emulsified Oil Source Zone Injection

San Francisco Bay Area, CA

Client Profile:	National Consulting Firm
Project Profile:	DPT injection of ZVI suspended in guar gum and emulsified oils field demonstration
Contaminants of Concern:	Chlorinated VOCs
Impacted Matrix:	Heterogeneous sands to clays .The project focused on a source area contributing to a down gradient plume.

Project Summary: The purpose of this project was to construct an abiotic and biotic treatment zone that would abate the concentration of chlorinated VOCs in the groundwater migrating across the area. Less than 300 micron ZVI (20% by weight) was pre-mixed with anoxic water using guar gum (See Figure 1) as a suspending agent. In October 2013, Vironex conducted a 6 location injection, distributing more than 6,000 lbs of ZVI into the subsurface between 45 feet and 95 feet bgs. ZVI was supplemented with emulsified oil and a bioaugmentation culture.

Project Results: Distribution was verified by monitoring for ZVI in the injection well (See Figure 1.)



Figure 1 – Magnet recovering ZVI from target monitoring well 15' from injection location



Figure 2 – Shear pump used to create a uniform guar mixture to adequately suspend ZVI