EthicalChem

A division of Ethical Solutions LLC

Surfactant Enhanced Remediation Technologies

Dan Socci, CEO

2014

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Green Chemical Solution for Remediation and Oil Industries

ETHICALCHEM BACKGROUND

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- Recently acquired the intellectual property assets of VeruTEK Technologies Inc.
- Provides plant-based, green chemical solutions for remediation and oilfield applications

Remediation Technologies	Oilfield Technologies
• SEPR (*Surfactant Enhanced Product Recovery*) • S-ISCO (*Surfactant-enhanced In Situ Chemical Oxidation)*	• Viscosity reduction • Demulsification • Drilling muds removal • Wellbore cleaning • Oily wastewater separation

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Field Proven Technologies

- ✓ **50+ remediation sites completed**
- ✓ **20+ oil fields**
- ✓ **10 patents**

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Green Chemical Solution for Environmental Remediation

REMEDIATION TECHNOLOGIES

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Remediation Technologies

- Surfactant-enhanced In Situ Chemical Oxidation (S-ISCO)
  - Desorbs and destroys residual contamination in place
  - Simultaneous injection of surfactant and oxidant
- Surfactant Enhanced Product Recovery (SEPR)
  - Desorption and gas generation improves recovery of Non-Aqueous Phase Liquid (NAPL) contamination
  - Implemented first to maximize S-ISCO performance

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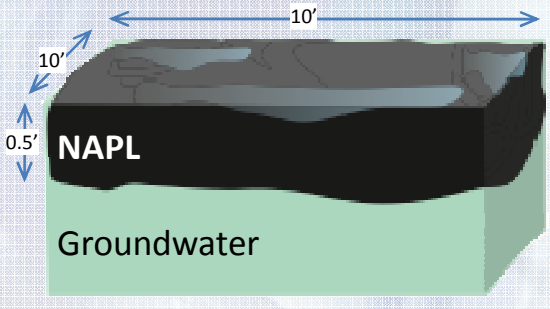
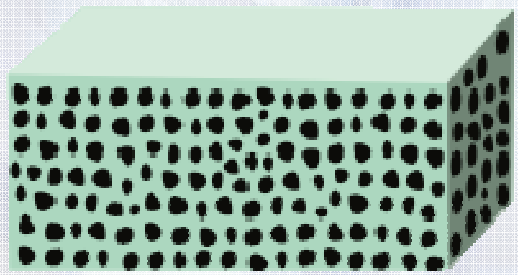
Emulsification and Surface Area

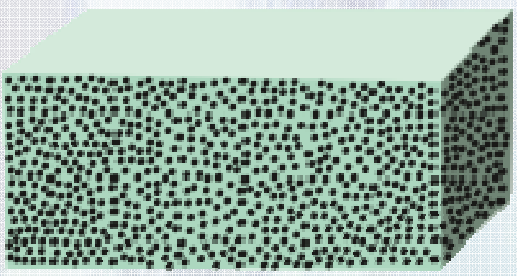
Emulsions increase interface area between oxidant and contaminant by several orders of magnitude



Volume: 50 cubic feet
Surface area: 220 square feet



Volume: 50 cubic feet
Emulsion Diameter: 1 millimeter
Surface area: 91,440 square feet
Approximately 2.5 orders of magnitude higher



Volume: 50 cubic feet
Emulsion Diameter: 1 micrometer
Surface area: 91,493,000 square feet
Approximately 5 orders of magnitude higher

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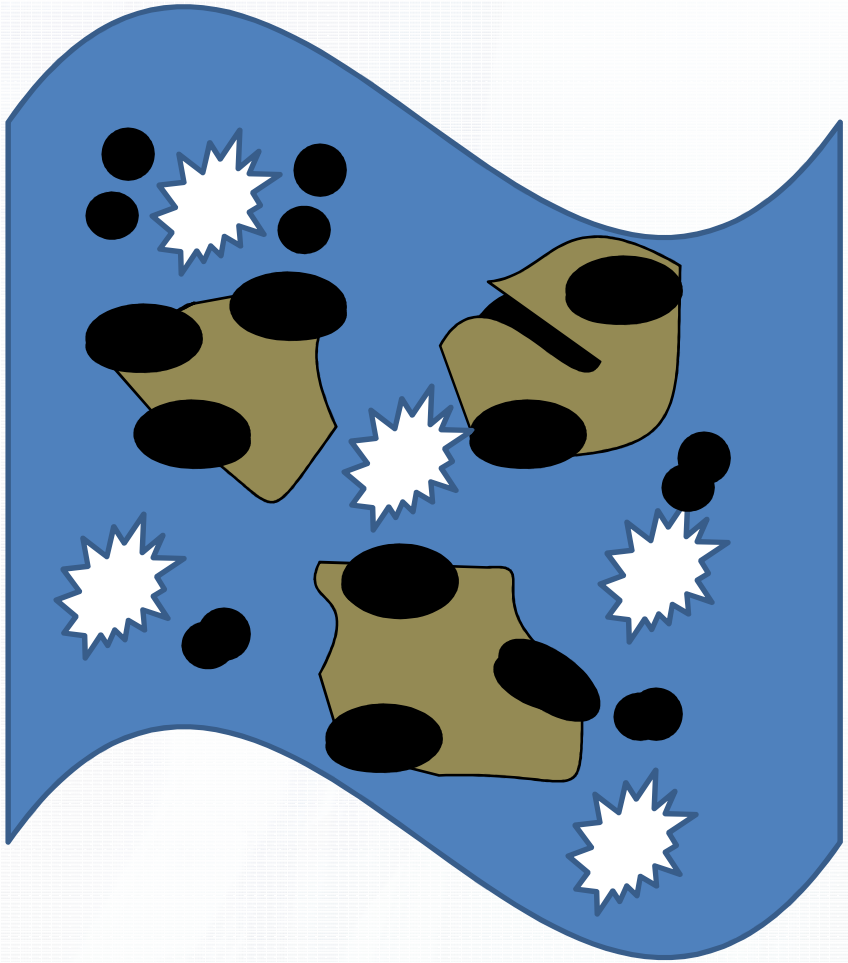
ISCO Performance



- Sorbed contaminants on soil and in soil pores
- Oxidants introduced into groundwater
- Dissolved contaminants oxidized
- Contaminants leach back into groundwater – Rebound
- Repeat treatments

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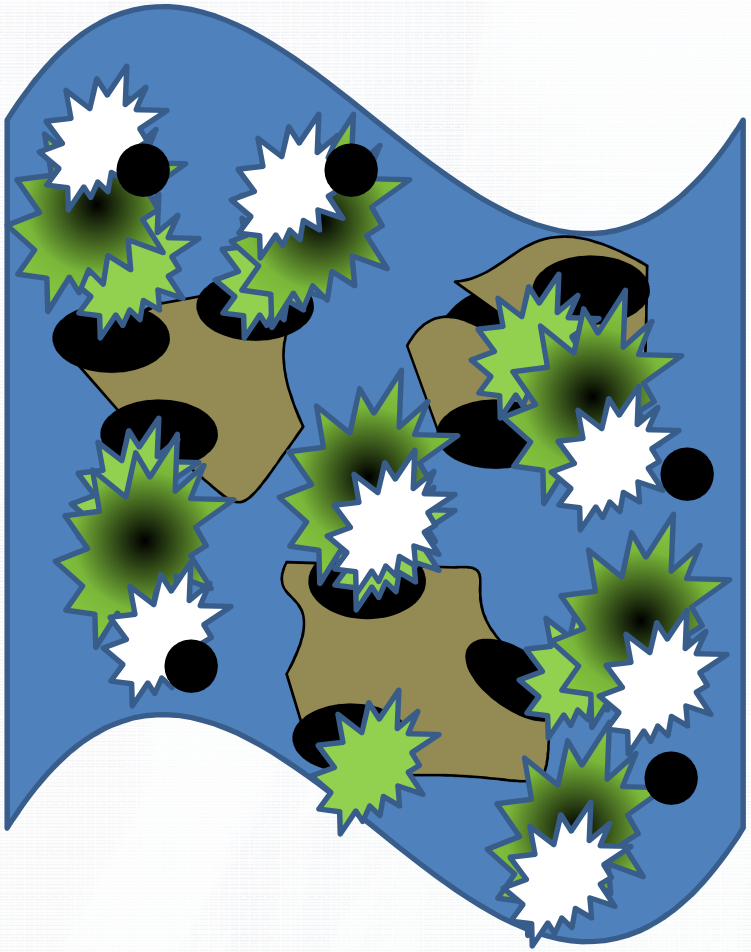
S-ISCO Performance



- Sorbed contaminants on soil and in soil pores
- Surfactant and oxidant introduced into groundwater
- Sorbed contaminants are emulsified into aqueous phase
- Complete removal of contamination – no rebound

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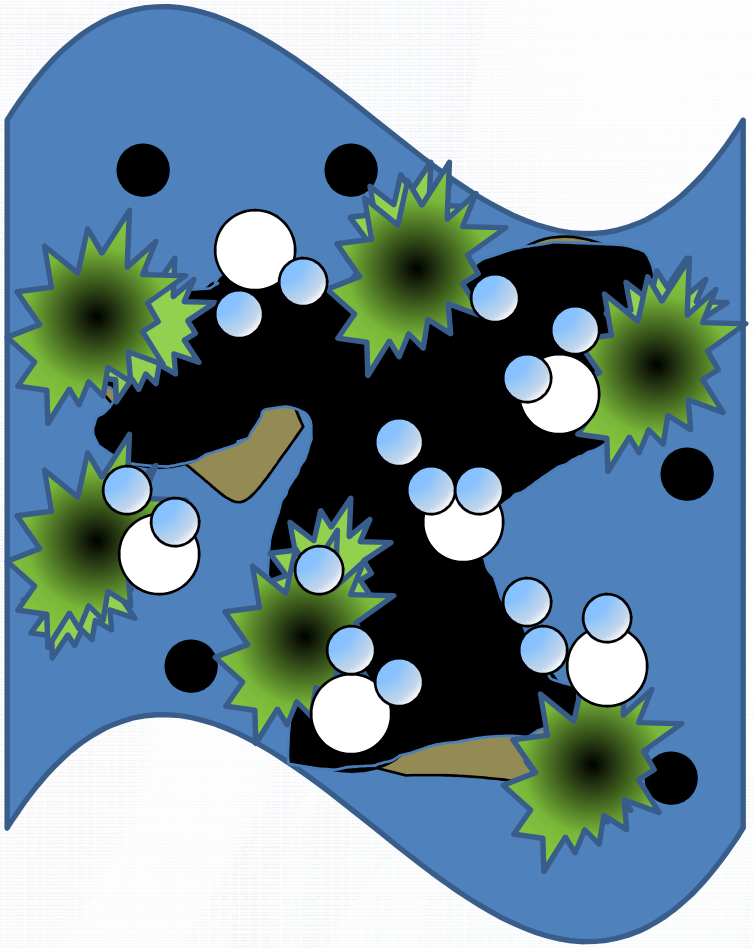
SEPR Performance



- Bulk, free phase NAPL present in subsurface
- SEPR fluid injected
- Surfactants desorb and emulsify NAPL
- Gas bubbles generated from peroxide
- Help facilitate movement to recovery wells
- Residual contamination remains

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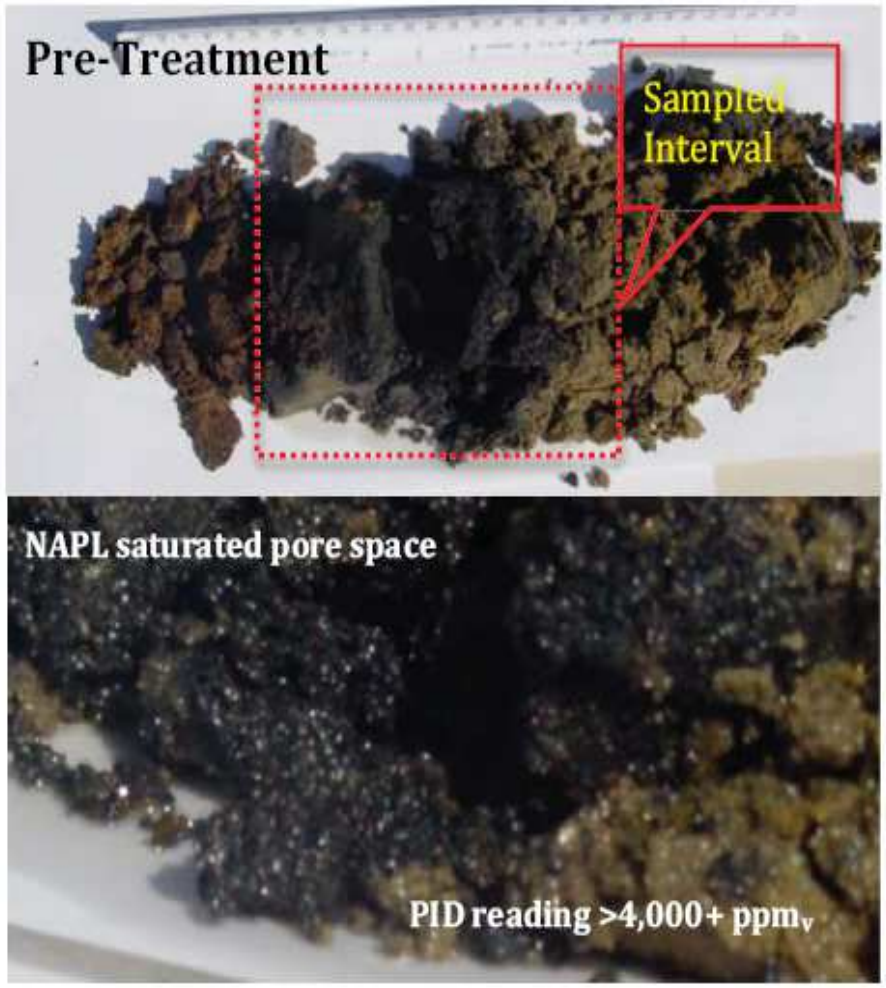
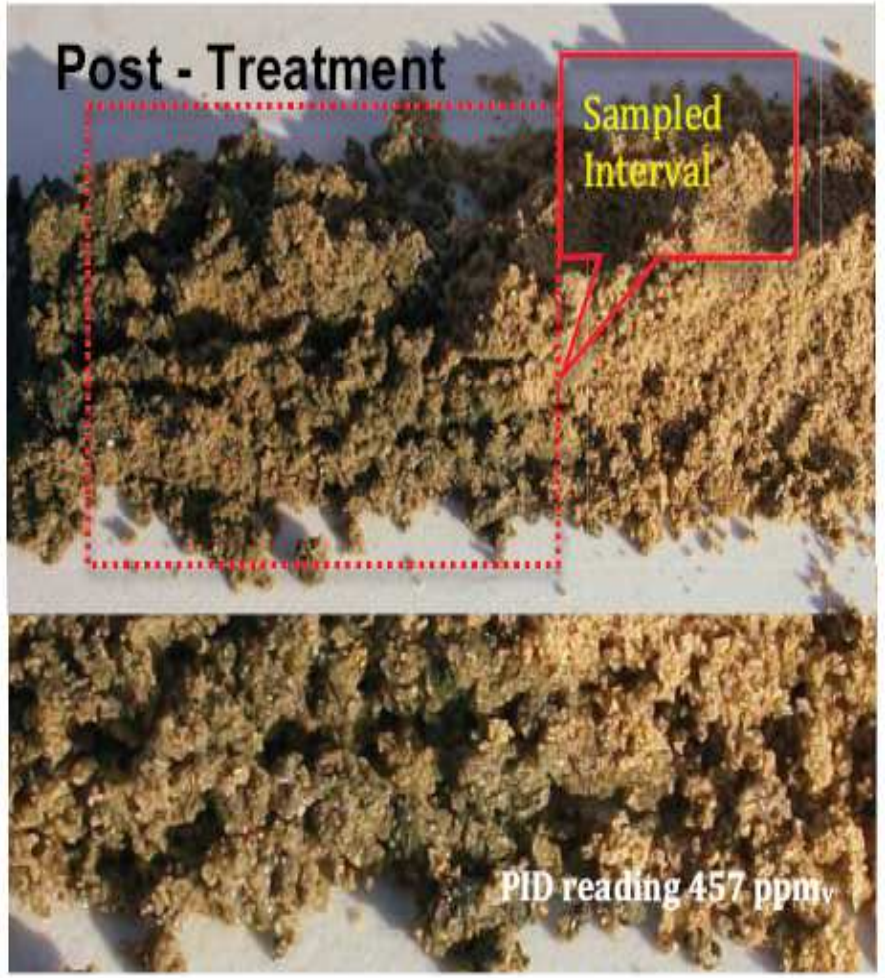
Pre and Post S-ISCO Implementation





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S-ISCO and SEPR Implementation

CASE STUDY EXAMPLES

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Case Studies

1. S-ISCO treatment of VOCs in NY State
2. SEPR Creosote Recovery in a U.S. Gulf State
3. SEPR & S-ISCO MGP remediation in Sydney, AU
4. S-ISCO treatment of New York City Brownfield site

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S-ISCO Treatment of VOCs at NY Site

Site
Textile Manufacturing Company

Contaminants of Concern
TCA, Volatile Organic Compounds

Objectives
Achieve NYSEC Commercial Use Soil Cleanup Criteria

Remedial Implementation
S-ISCO

Consultant
Fleming Lee Shue

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S-ISCO Treatment of VOCs at NY Site

S-ISCO

- Combined surfactant/oxidant desorb & destroy treatment for hydrophobic contaminants

RemMetrik

- Calculates the mass and 3D location of subsurface contamination
- Targets the contamination for treatment with S-ISCO and subsurface pressure waves
- Assesses the effectiveness of treatment

Wavefront Primawave

- Generates subsurface pressure waves that open soil pore spaces.

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S-ISCO Treatment of VOCs at NY Site

Treatment Details:

- 50 ft x 50 ft treatment area
- Saturated treatment of 10 - 15 ft bgs
- Treatment Adjacent to creak flowing into Hudson River
- S-ISCO chemical delivery
  - 3 permanent injection wells
  -5 Geoprobe points
- 6 days of S-ISCO injections

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S-ISCO Treatment of VOCs at NY Site

S-ISCO injections

Alkaline activated Klozur (persulfate) and EthicalChem proprietary plant based surfactant VeruSOL.

Approximately 14,200 gallons of total fluids consisting of

- Klozur, 15 – 50 g/L
- Sodium hydroxide, 12 – 50 g/L
- VeruSOL 5– 15 g/L

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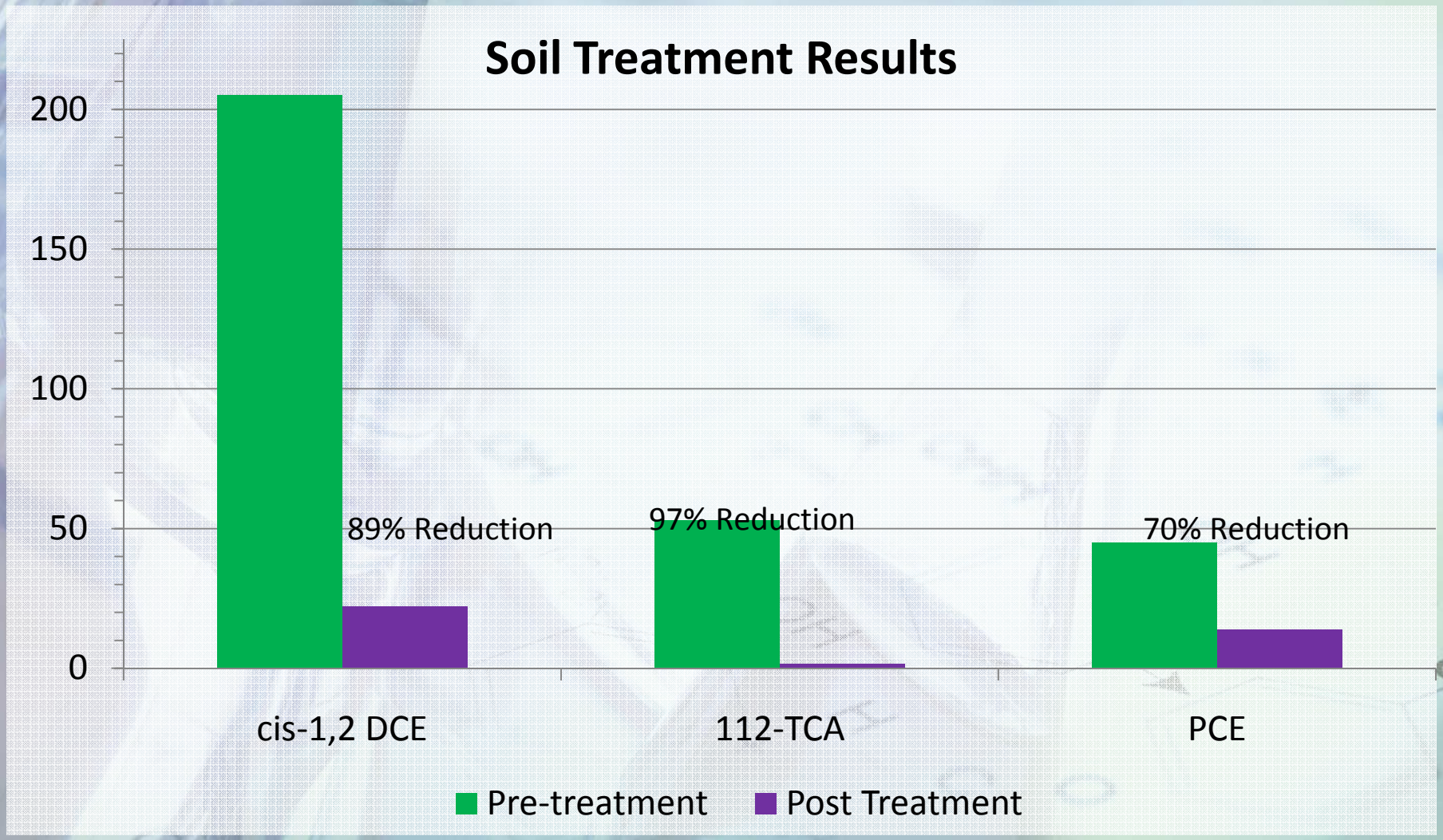
S-ISCO Treatment of VOCs at NY Site



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S-ISCO Treatment of VOCs at NY Site

All GW Concentrations below site cleanup criteria

Groundwater Treatment Results			
VOC	Pre-treat Max. Conc. µg/L	Post-treat Max. Conc. µg/L	Percent Reduction
Total VOCs	86,530	11,706	86%
TCA	48,300	8,630	82%
112-TCA	34.5	2.3	93%
1,1-DCA	36,100	2,540	93%
Chloroethane	1,280	334	74%

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S-ISCO Treatment of VOCs at NY Site

Current Site Status:

Based on the post treatment results consultant has recommended site closure.

The site is currently under review for closure by the NYSDEC.

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Creosote Remediation with SEPR Technology

U.S. Gulf State

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Superfund Creosote Site in U.S. Gulf State

Site

- 34 acre Former Wood Treating Facility,

Contaminants of Concern

- Creosote DNAPL

Objectives

- Enhance well yield of the existing recovery system in saturated zone
- Reduce soil concentrations of TPH in vadose zone

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Superfund Creosote Site in U.S. Gulf State

Treatment Details:

- **3 stage treatment approach**
  - Well rehabilitation
  - Vadose zone NAPL removal
  - Saturated zone NAPL removal
- **SEPR Chemistry**
  - Up to 8% hydrogen peroxide
  - 1-5% VeruSOL Creosote formula

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Superfund Creosote Site in U.S. Gulf State

Saturated Recovery Well Performance			
Well	**Pre SEPR Average Yield (gpm)**	**Post SEPR Average Yield (gpm)**	**% Increase**
R5	0.82	2.40	193%
R9	0.16	1.11	594%
R10	0.11	0.23	109%
R12	0.24	1.27	429%
R15	0.31	0.67	116%
R17	0.04	0.54	1250%
R18	0.15	0.45	200%

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Superfund Creosote Site in U.S. Gulf State

Frac Tank Containing Extracted Fluid

Samples of Extracted Fluid

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Superfund Creosote Site in U.S. Gulf State

Results:

- Enhanced recovery rates by up to 1200% in saturated zone
- Achieved 84% TPH mass reduction in the vadose zone
- Enhanced the removal of free phase creosote NAPL from the vadose and the saturated zone

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SEPR & S-ISCO Remediation of MGP Contamination

Sydney, AU

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MGP Remediation in Sydney, AU

Site
Former Gasworks Plant

Contaminants of Concern
BTEX, PAHs, TPH

Objectives
Demonstrate effectiveness of SEPR & S-ISCO technology at the site

Remedial Implementation
SEPR & S-ISCO

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MGP Remediation in Sydney, AU

Treatment Details:

- **3 Stage Approach**
  - SEPR Implementation – 2.5 weeks
    - 20 – 40 g/L VeruSOL with 0.5 – 1.0% peroxide
  - S-ISCO Implementation with persulfate – 4.5 weeks
    - 5 – 15 g/L VeruSOL with 100 – 200 g/L persulfate
  - S-ISCO Implementation with peroxide – 2.5 weeks
    - 5 – 10 g/L VeruSOL with 0.5 – 4% peroxide

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MGP Remediation in Sydney, AU

Results

- 31 soil samples were analyzed post treatment
- Majority of samples reached criteria levels

Post Injection Samples Below Criteria	
Contaminant	**Percent of Samples Below Criteria (out of 31)**
C10-C14	31
C15-C28	30
C29-C36	30
cPAHs	20
Benzene	31
B(a)P	26
Total PAHs	24

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MGP Remediation in Sydney, AU

Project Outcome & Current Status

- **SEPR and S-ISCO technology was deemed effective for removal and destruction of site contaminants**
- **EthicalChem is currently engaged in submitting plans for full scale work**
- **Full scale is planned for March 2015**

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S-ISCO Remediation of MGP Coal Tar

NYC Brownfield Site

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MGP Coal Tar Remediation in NYC

Site
Former Roofing Products Manufacturer

Contaminants of Concern
BTEX, PAHs, & naphthalene

Objectives
Reduce contaminant mass to enable issuance of Certificate of Completion

Remedial Implementation
S-ISCO

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MGP Coal Tar Remediation in NYC

- **Site Conditions**:
  - Former roofing manufacture site
  - ~50,000 lb contamination
  - BTEX, PAHs, naphthalene
  - NAPL
  - Heterogeneous subsurface

- **Challenges:**
  - Adjacent to East River
  - Dense urban neighborhood
  - Weather
  - NAPL

Northern edge of site boundary ~ 100 ft from high-rise, luxury residential building

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MGP Coal Tar Remediation in NYC

Treatment Details:

- **S-ISCO Implementation**
  - 5 g/L VeruSOL
  - 25 – 50 g/L Sodium Persulfate
  - 20 g/L Sodium Hydroxide
  - Total injected volume = 1,201,900 gal
  - 100 days of injections
- **RemMetrik™** process to quantify & target contamination
- Wavefront Technology's **Primawave** Pressure-Pulsing Sidewinder

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MGP Coal Tar Remediation in NYC

Implementation Monitoring:

Weekly Monitoring Showed:

- No NAPL mobilization beyond site boundaries
  - Controlled process
- No vapor pressure increases
- Reduced soil gas concentrations
- No nuisance complaints

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MGP Coal Tar Remediation in NYC

Results

- ***Soil:*** *ACHIEVED OBJECTIVE*
  - Destroyed **> 90%** Contaminant Mass (PAHs + BTEX)
- ***Groundwater:*** *ACHIEVED OBJECTIVE*
  - Reduced GW Concentrations; Achieved Asymptotic Decreases
    - *91% BTEX*
- ***Soil Gas:*** *REDUCED SOIL GAS CONTAMINANTS*
  - *100% of benzene, ethylbenzene, naphthalene*

➢ *Certificate of Completion*, New York State DEC, Dec. 2011

➢ Public Library & Park Ranger Station

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MGP Coal Tar Remediation in NYC

On-going Quarterly Groundwater Monitoring Confirmed:

- ***No rebound***
- ***Continuing asymptotic decreases***
- ***Concentrations approaching Ambient Groundwater Quality Standards***

"In samples collected 11 months following the end of injections the continuing overall decline instead of rebound suggests that the source contamination has been effectively treated."

Fleming Lee Shue report

- ***BTEX:*** *all wells exhibit overall decreasing or asymptotic trend*
- ***Naphthalene:*** *most wells show decreasing or asymptotic trend*
- ***Toluene:*** *3 more wells met TOGS AWQS*

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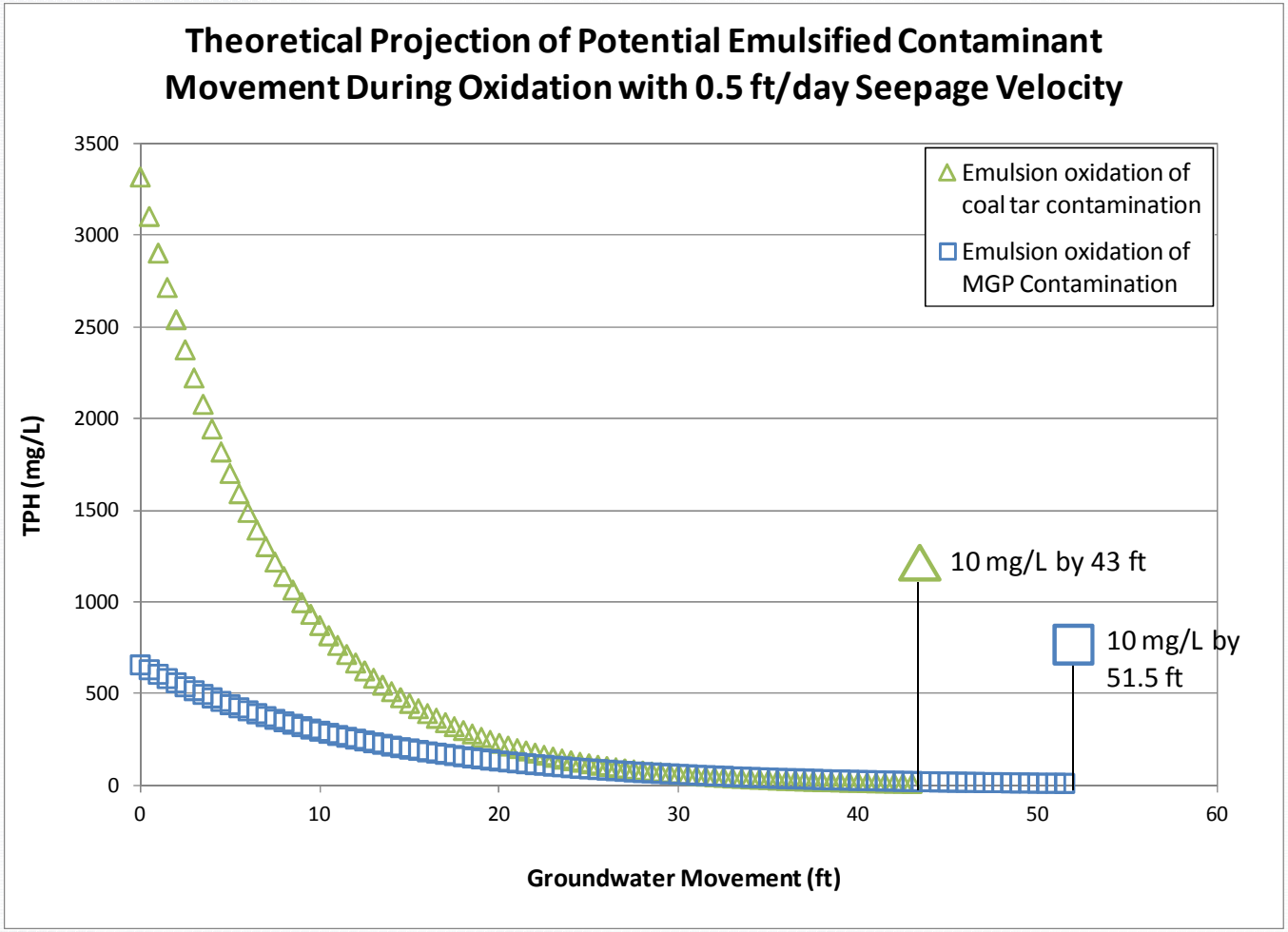
FAQs: Mobilization

Q: Will surfactant use cause undesirable contaminant mobilization?

- Surfactant and oxidant are injected together as a homogeneous solution
    - Injected chemistry travels together through subsurface
- Emulsification and oxidation take place simultaneously over time
- VeruSOL typically remains in the soil about a month due to biodegradation and oxidation
- Groundwater speeds typically do not carry emulsion offsite prior to destruction

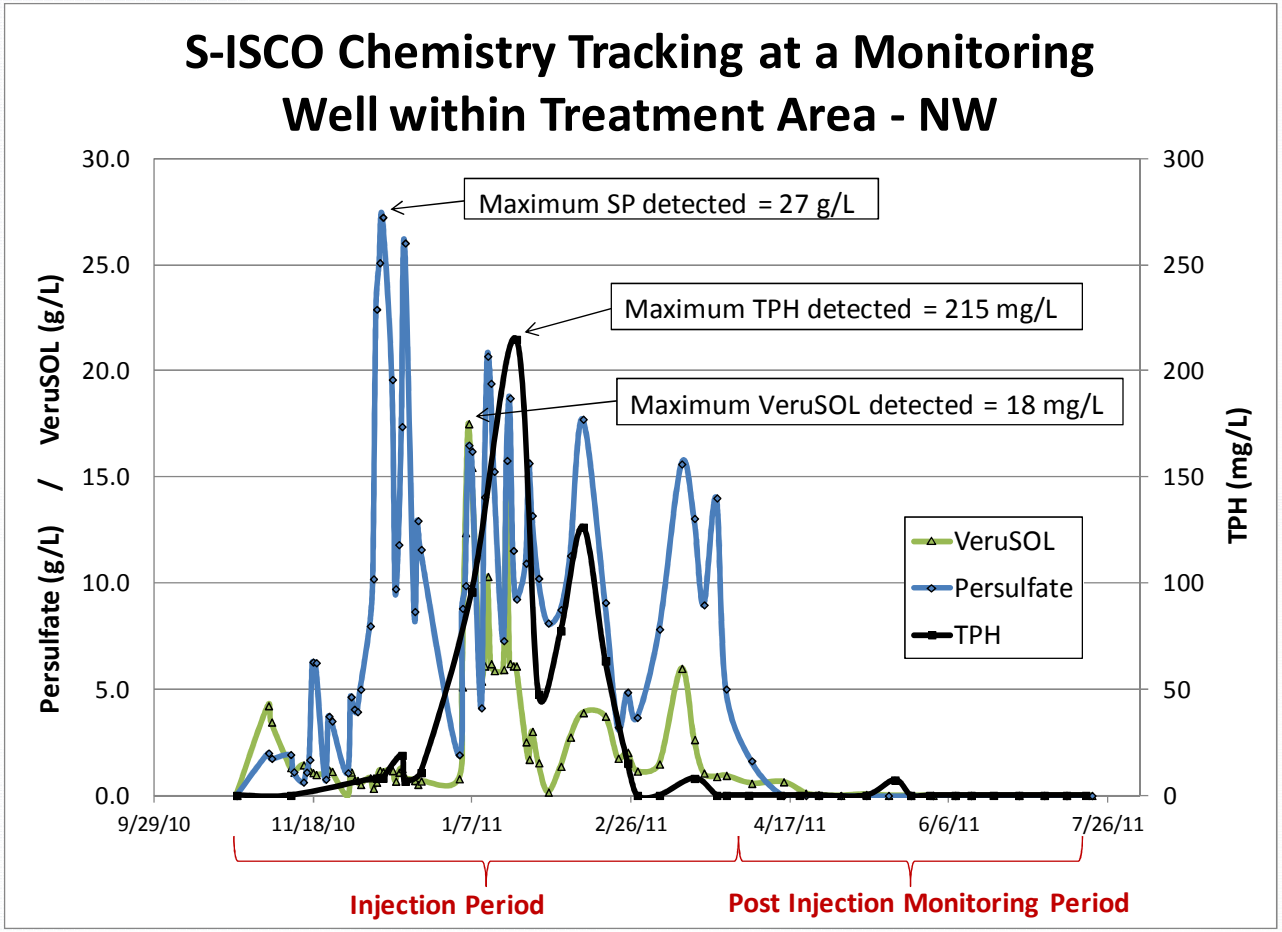
FAQs: Mobilization

Field and lab projection of two emulsions, traveling vs. destruction



FAQs: Mobilization

- S-ISCO chemistry traveling together – data from an on site monitoring well during and after injections

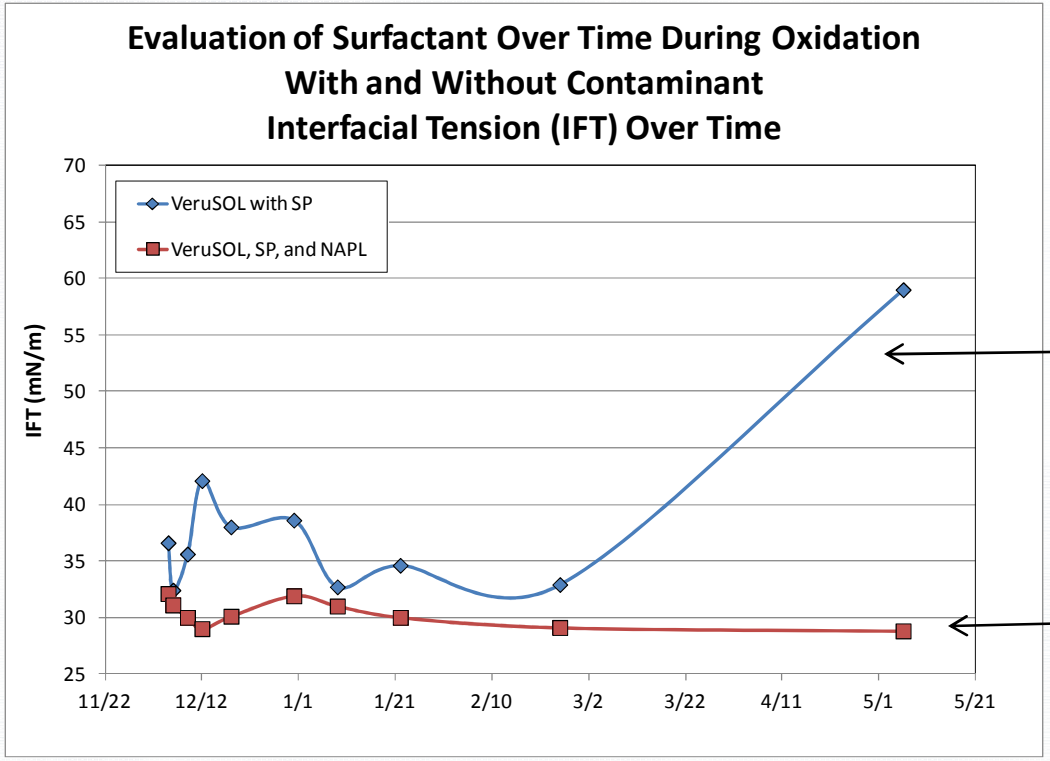


FAQs: Surfactant Consumption by Oxidant

Q: Will the surfactant be consumed by the oxidant

Contaminants are more susceptible to oxidation than surfactant

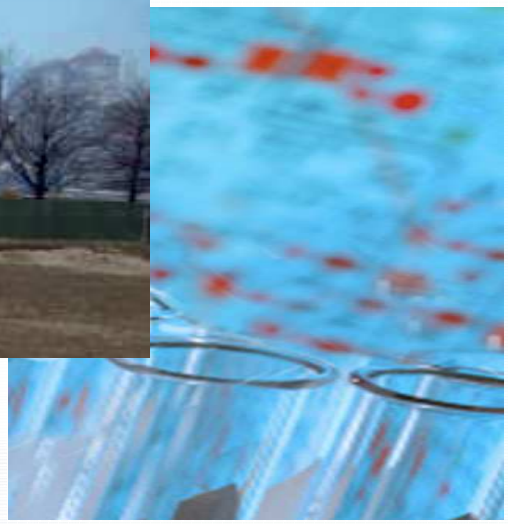
- Contaminants will be oxidized first



Increase in IFT indicates destruction of surfactant

Stable, low IFT indicates stable presence of surfactant

Thank you.



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