

In Situ Treatment Monitoring: Issues and Best Practices

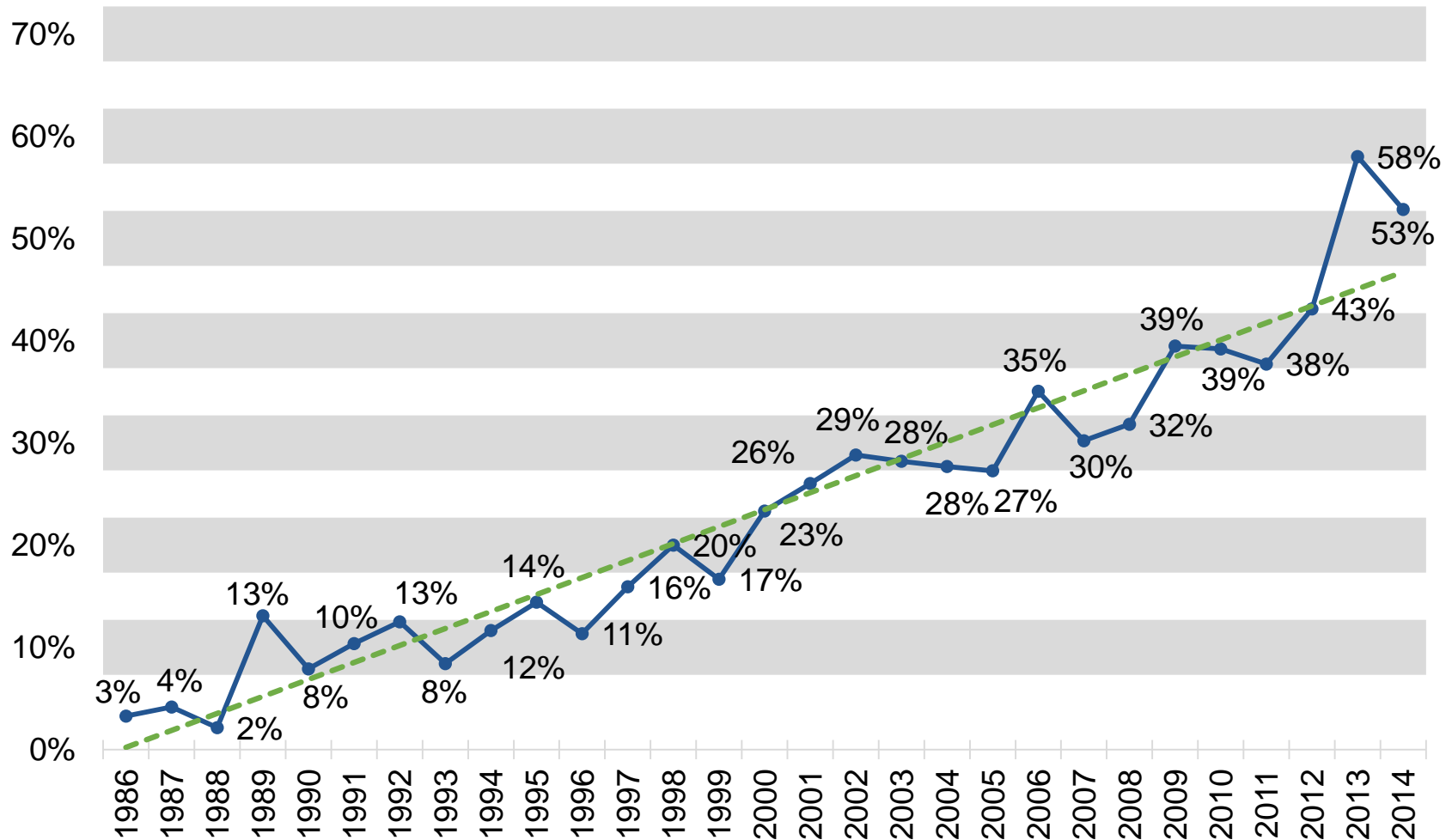
**Linda Fiedler and Jed Costanza, USEPA
Dimin Fan, Oak Ridge Institute of Science
and Education (ORISE) Fellow**

**FRTR Meeting
November 2, 2016**

Problem Statement

- ◆ Site heterogeneity makes accurately characterizing and monitoring groundwater plumes challenging
- ◆ Further challenges associated with designing and implementing performance monitoring for in situ treatment
 - Location of existing groundwater wells often based on preliminary CSM; may not be located or screened optimally for monitoring in situ treatment performance
 - Existing wells often located within treatment zone
 - Samples collected from wells may not be representative of plume concentrations
 - Amendment distribution typically uneven
 - Treatment can impact well integrity and cause sampling artifacts

Selection of Groundwater In Situ Treatment (FY 1986-2014)



Source: USEPA. Superfund Remedies Report, 15th Edition. 2016. Draft.

Scope of Effort

- ◆ Identify in situ technologies that may present challenges to performance monitoring
- ◆ Define issues that impact performance monitoring
- ◆ Describe how to monitor for these impacts and suggest how to prevent or address

Technologies Addressed

In Situ Technology	
ISB	In Situ Bioremediation
ISCO	In Situ Chemical Oxidation
CBI	Activated Carbon-Based Injectate
ZVI	Zero-Valent Iron
ISTT	In Situ Thermal Treatment
ISS	In Situ Stabilization/Solidification

Some Technical Challenges Addressed

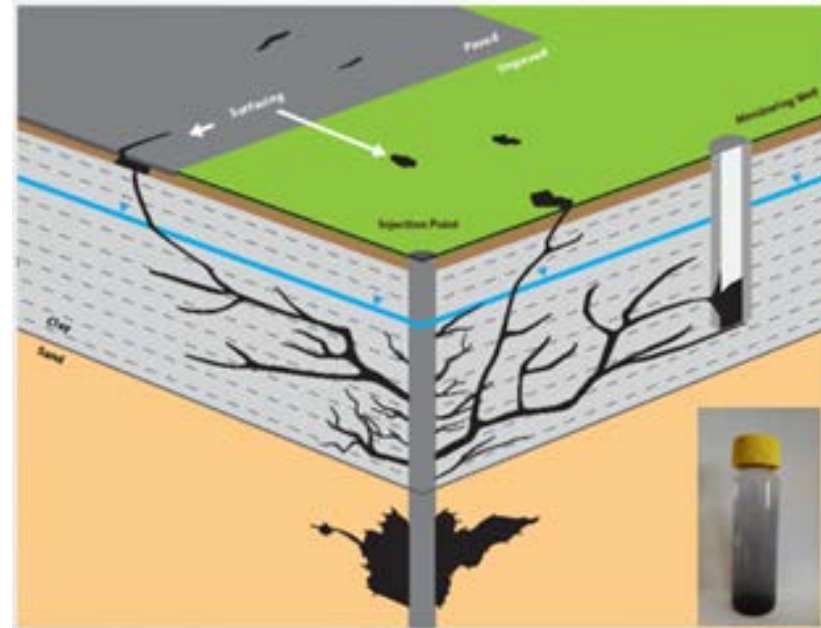
- ◆ Do groundwater samples represent plume concentrations when:
 - Amendments are in monitoring wells
 - Amendments interact with well screen material

- ◆ How can contaminant loss or degradation after sample collection be minimized, such as:
 - Degradation of contaminants in samples containing reactive amendments
 - Loss of volatiles when sampling regions at elevated temperatures

Amendments in Monitoring Wells

Technologies Affected					
ISB	ISCO	CBI	ZVI	ISTT	ISS
✓	✓	✓	✓		?

- ◆ Amendments may be injected near monitoring wells or at high pressures
- ◆ Amendment injection wells sometimes used for performance monitoring
- ◆ Impact
 - Amendment concentration in well might be higher than in aquifer
 - Therefore, contaminant concentrations may be lower than in aquifer



Source: Tom Fox, Colorado Division of Oil and Public Safety, Tank Conference, 2015

Amendments in Monitoring Well (cont'd)

◆ Monitoring for Impacts

- Test for amendments in monitoring wells
- Monitor geochemical indicator parameters (e.g., pH, DO, total dissolved solids, ORP) for secondary evidence of amendment

◆ Best Practices for Preventing and Addressing

- Locate injections such that monitoring wells outside ROI
- Install new monitoring wells in appropriate locations
- If amendments found in well or if using injection wells for performance monitoring:
 - Delay sample collection or analyzing for contaminants until amendment (e.g., persulfate) no longer reactive or present
 - Continue to sample and analyze, but flag results to indicate amendment is present
 - Evaluate results against wells where injection not conducted or amendment not found
- For persistent amendments (i.e., carbon, permanganate), longer term monitoring and downgradient wells become more important

Amendment Interacts with Well Screen

Technologies Affected					
ISB	ISCO	CBI	ZVI	ISTT	ISS
✓	✓	?	✓	✓	

- ◆ Oxidation or reduction of metals causes precipitation or mobilization, corrosion
- ◆ Can occur when pH or temperature high, under oxidizing or reducing conditions
- ◆ Amendments enhance microbial activity, cause biofouling
- ◆ Impact
 - Reduces groundwater flow to well
 - Causes releases or adsorptions of contaminants
 - Samples not representative of plume



Well Screen with Metal Precipitates

Source: Scherer, T. Care and Maintenance of Irrigation Wells. North Dakota State University. AE-97 (Revised). May, 2013.

Amendment Interacts with Well Screen (cont'd)

◆ Monitoring for Impacts

- Assess metals precipitation or mobilization through baseline, interim, and post-application groundwater monitoring
- Monitor for changes in well hydraulic performance and physiochemical water quality parameters
- Inspect monitoring wells, submerged equipment, and purge water for precipitates

◆ Best Practices for Preventing and Addressing

- Perform geochemical modeling to assess impact of amendments on metal precipitation and mobilization
- Apply cleaning processes
 - Physical processes (e.g., over-pumping, surging, brushing, jetting, air injection)
 - Chemical processes (e.g., cleaning with acid)

Sample Artifacts

Technologies Affected					
ISB	ISCO	CBI	ZVI	ISTT	ISS
✓	✓	?	✓	✓	

- ◆ Unreacted amendments or active microbes in collected samples
- ◆ Samples from ISTT treatment are at elevated temperature
- ◆ Impact
 - Degradation or volatilization of contaminants between sample collection and analysis
 - Samples not representative of plume

Sample Artifacts (cont'd)

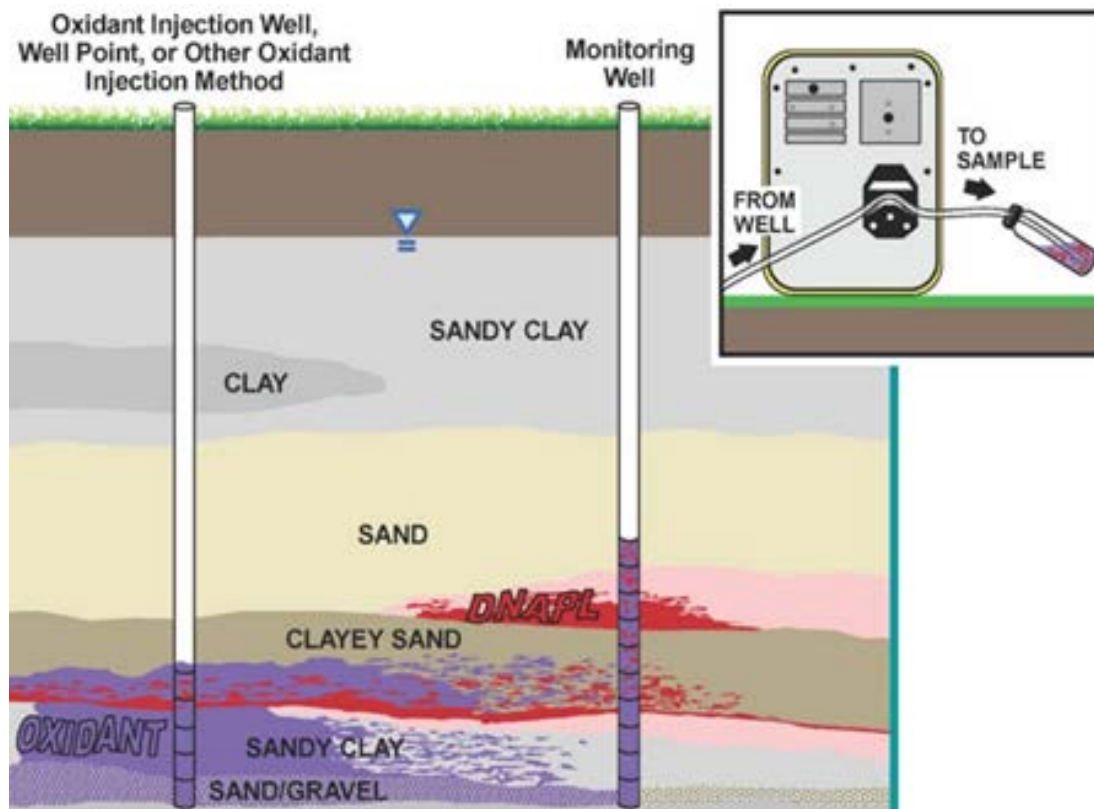


Illustration of Unreacted Oxidant and Contaminant Introduced into Sample

Source: Ko, S. Huling, S.G. and B. Pivetz. Ground Water Sample Preservation at In-Situ Chemical Oxidation Sites – Recommended Guidelines. EPA National Risk Management Research Laboratory. EPA/600/R-12/049. August, 2012.

Sample Artifacts (cont'd)

◆ Monitoring for Impact

- Check for presence of oxidants in sample
- Monitor temperature of groundwater in well

◆ Best Practices for Preventing and Addressing

- Preserve samples
 - Neutralize amendments
 - Cool samples to reduce reaction rate
 - Quench biological activity
- Sample in cooler areas of ISTT treated area

Summary and Conclusions

- ◆ Design an effective performance monitoring plan based on CSM and anticipated ROI
- ◆ Amendments likely to be in monitoring wells after injection
 - Samples likely to be impacted by amendment and not represent plume
 - However, does not mean well removal or abandonment necessary
- ◆ If amendments found in well or if using injection wells for performance monitoring:
 - Delay sample collection until amendment no longer reactive or present
 - Continue to sample and flag results to indicate amendment present and evaluate considering other well data
- ◆ If amendments or microbes found or thought to be in samples, neutralize or preserve, if methods available
- ◆ Consider temperature of sample for ISTT



Contacts

Linda Fiedler

OSRTI/TIFSD/TAB

(703) 603-7194

fiedler.linda@epa.gov

Jed Costanza

OSRTI/TIFSD/TAB

(703) 603-8724

costanza.jed@epa.gov