

# **Area 2 Field Experiment**

## **(PNNL/ORNL/UW)**

**FRC Workshop**  
**October 2005**

# Outline

- ▶ Background
- ▶ Approach
- ▶ Recent progress
- ▶ Future plans

# Outline

## ► Background

- Original focus and hypothesis
- Area 2 characteristics
- Revised hypothesis

## ► Approach

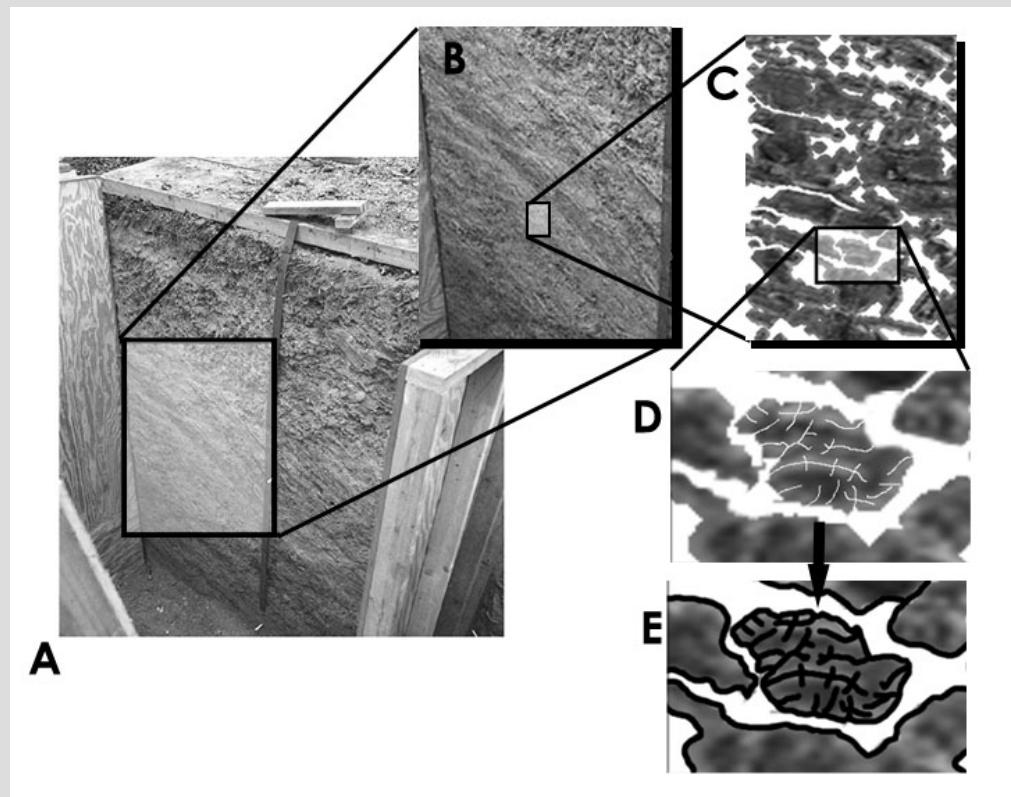
## ► Recent progress

## ► Future plans

# Original Hypothesis

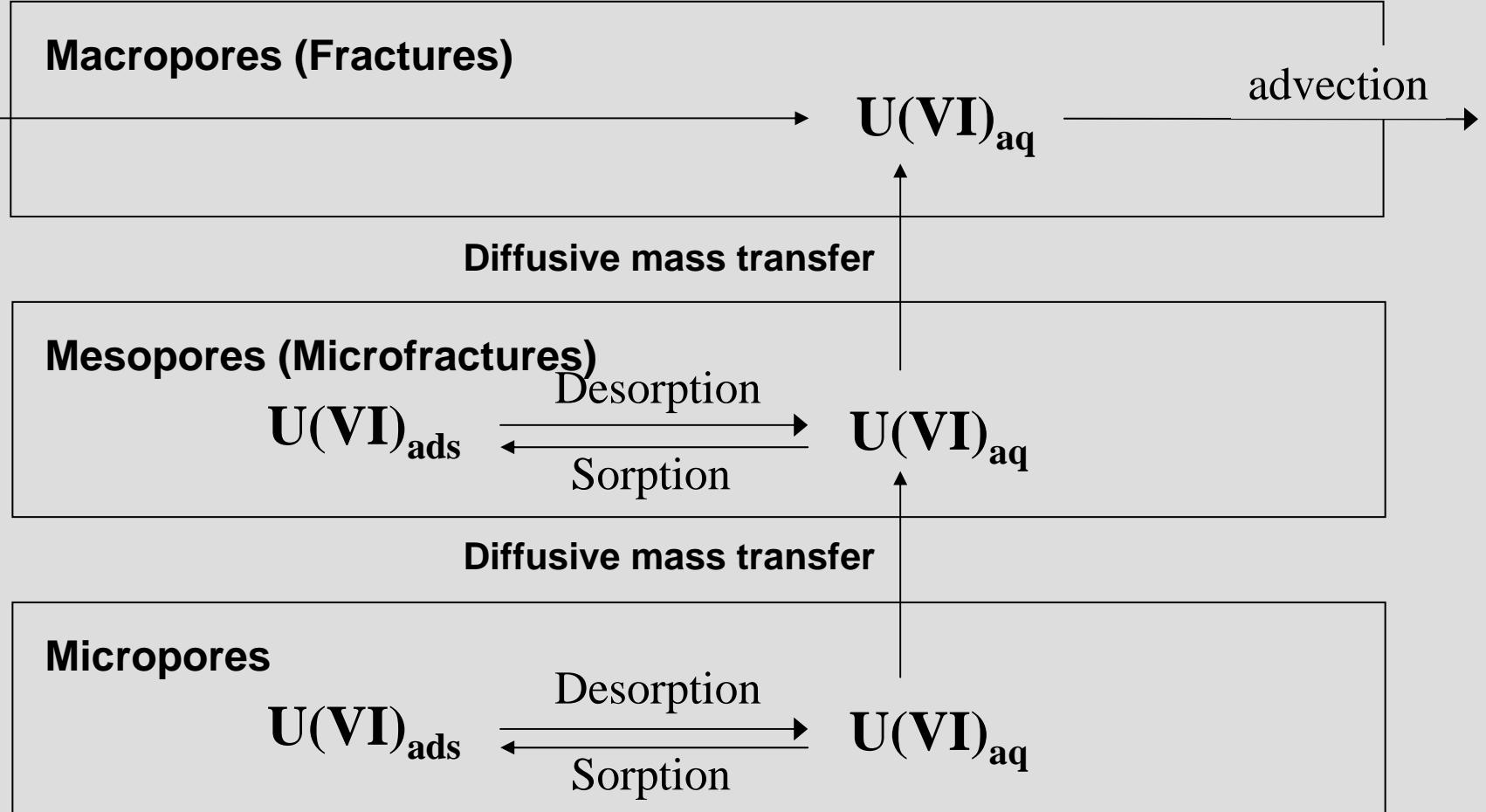
## ► Focused on Fractured Saprolite

**“Mobile radionuclides in low-permeability porous matrix regions of fractured saprolite can be effectively isolated and immobilized by stimulating localized in-situ biological activity in highly-permeable fractured and microfractured zones within the saprolite.”**



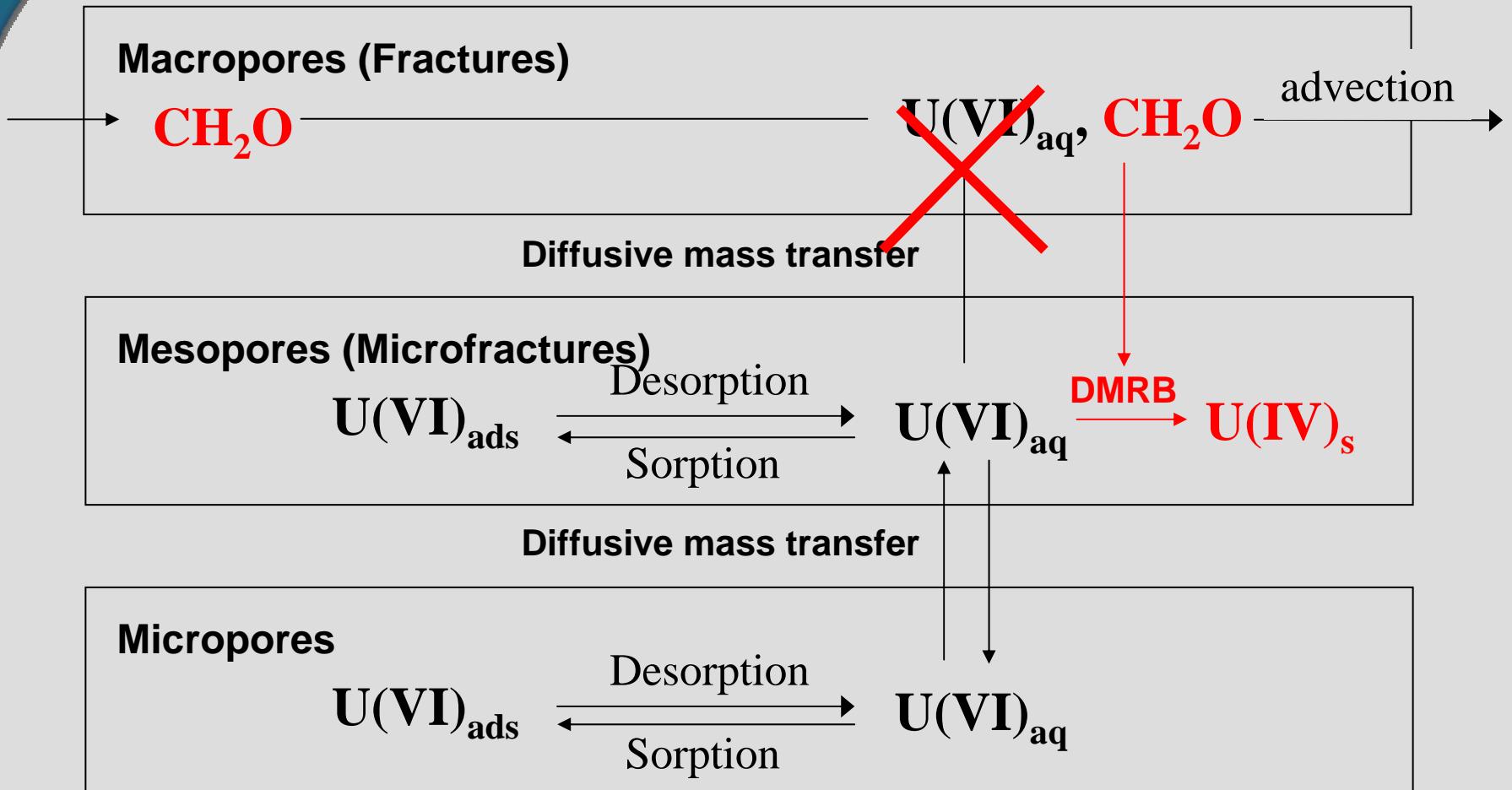
**“Distributed microbarrier”**

# 1-D Multiple Pore Region Model of Bacterial U(VI) Reduction\*



\* Based on Gwo et al. (1996)

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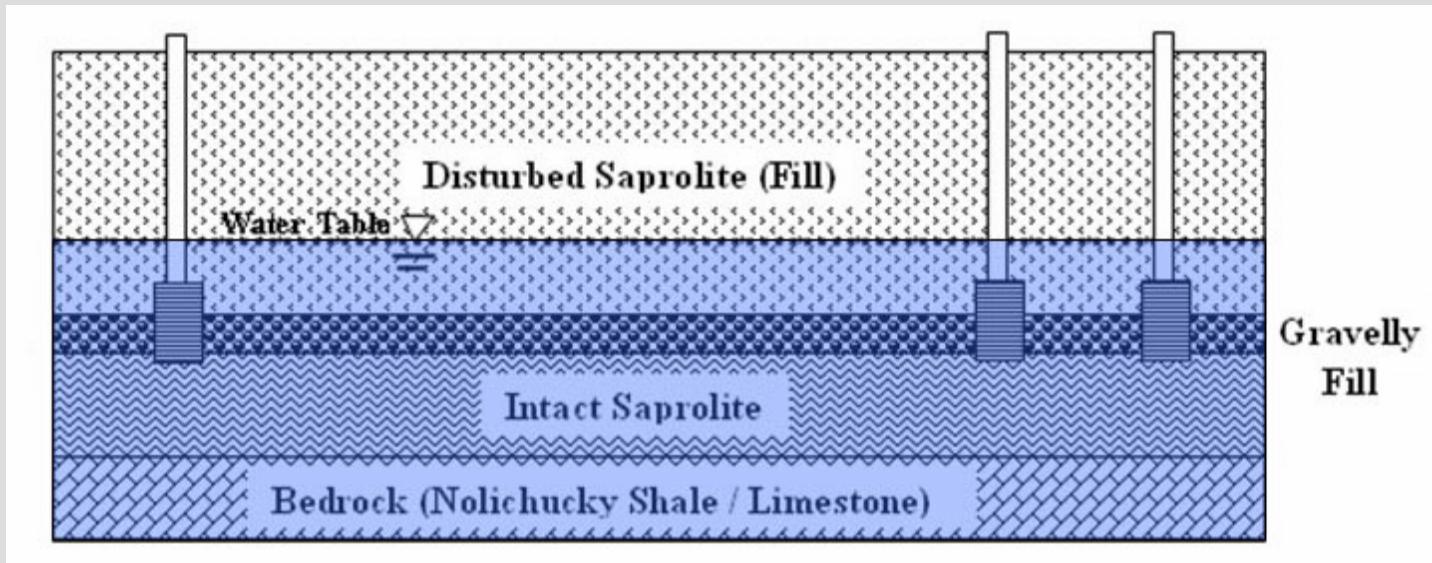
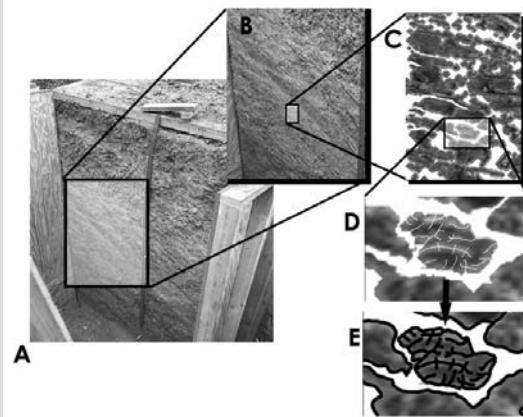
## ► Recent progress

## ► Future plans

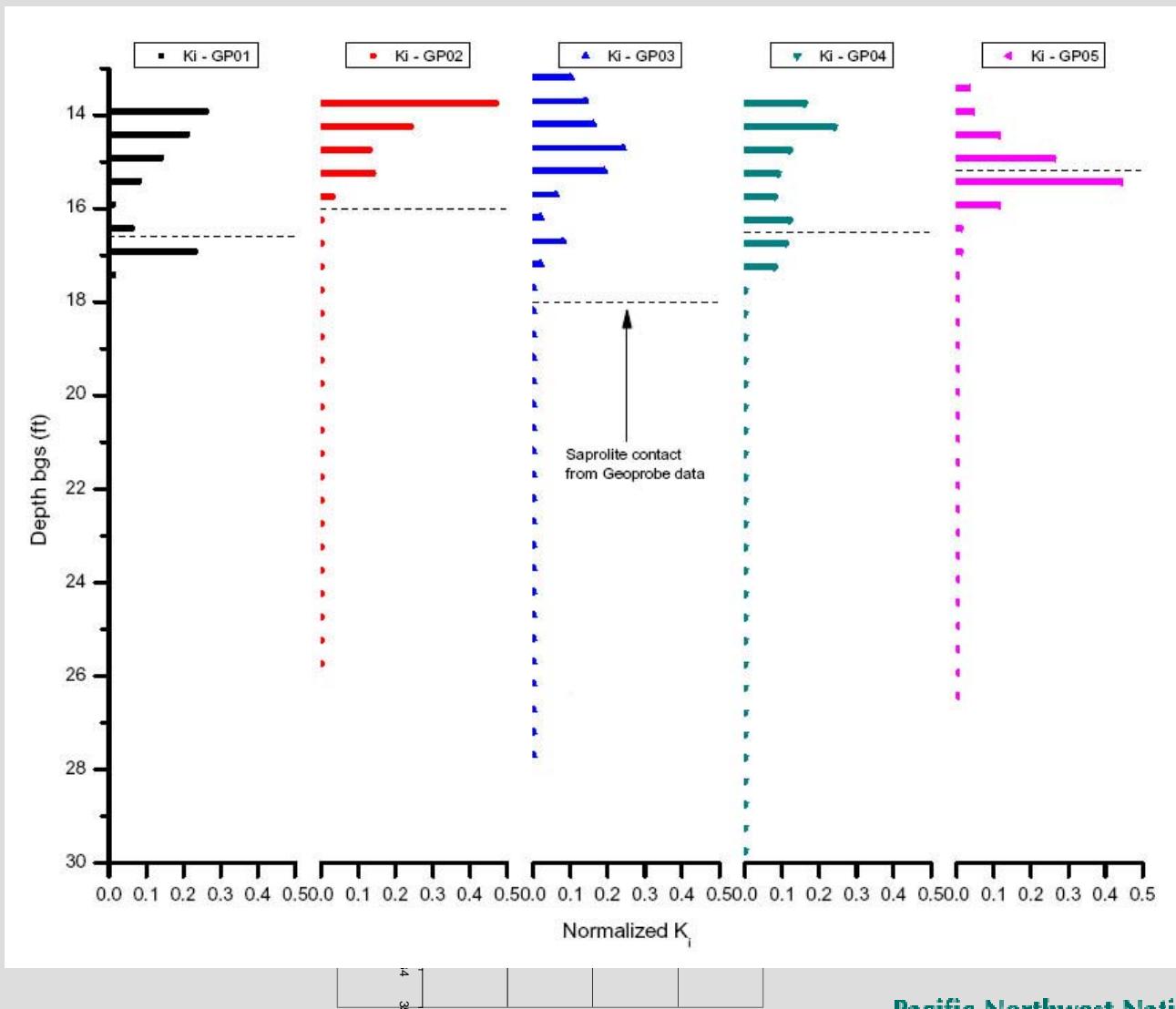
# Area 2 Characteristics

## ► Issues

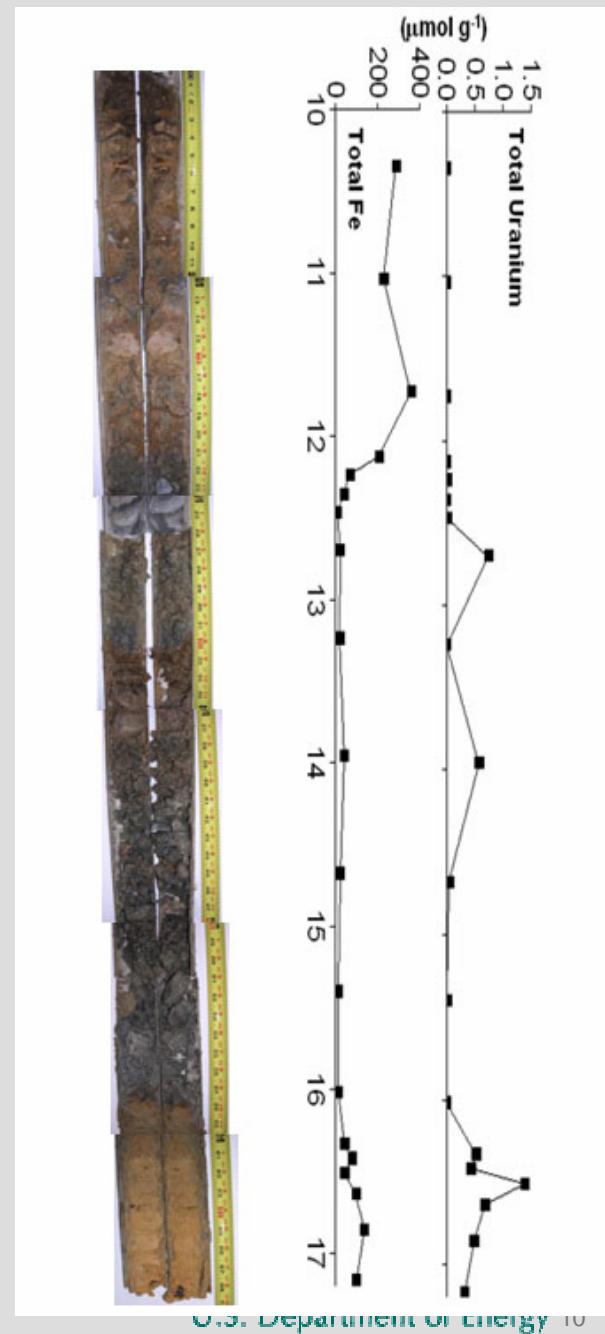
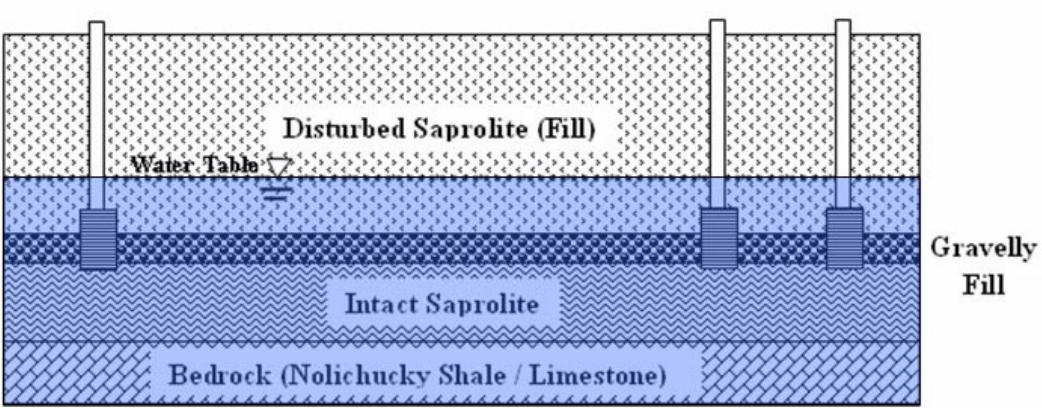
- Low uranium and high nitrate in deep saprolite
- Dominant flow feature at Area 2 is a (man-made) gravel layer



# Area 2 Characteristics



# Area 2 Characteristics



# Outline

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- Original focus and hypothesis
- Area 2 characteristics
- **Revised hypothesis**

## ► Approach

## ► Recent progress

## ► Future plans

# What are the Central Issues?

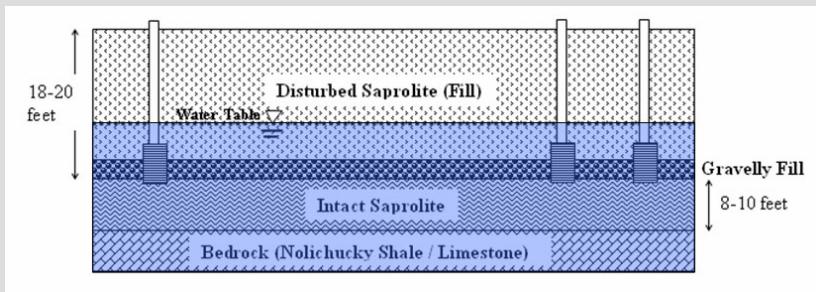
- ▶ Impact of preferential flow and mass transfer on bioreduction strategy and effectiveness

Are there preferential  
flow and mass  
transfer issues in the  
fill zone?

# Preferential Flow / Mass Transfer

## ► Multiple points of interest:

- Intact saprolite immediately below gravel layer
- Intragranular porosity within gravel layer
- Secondary porosity within saprolitic fill above gravel
- Large-scale mass transfer between gravel layer (highly preferential flow) and adjacent layer(s).



# Revised (Generalized) Hypothesis

- ▶ In heterogeneous porous media, microbial activity can be stimulated at interfaces between zones of high and low groundwater flow rates in such a manner as to create a local, distributed redox barrier. Such a barrier will inhibit the transfer of contaminants from the low-flow zones that serve as long-term contaminant sources into the high-flow zones that transport contaminants to receptors.

# Outline

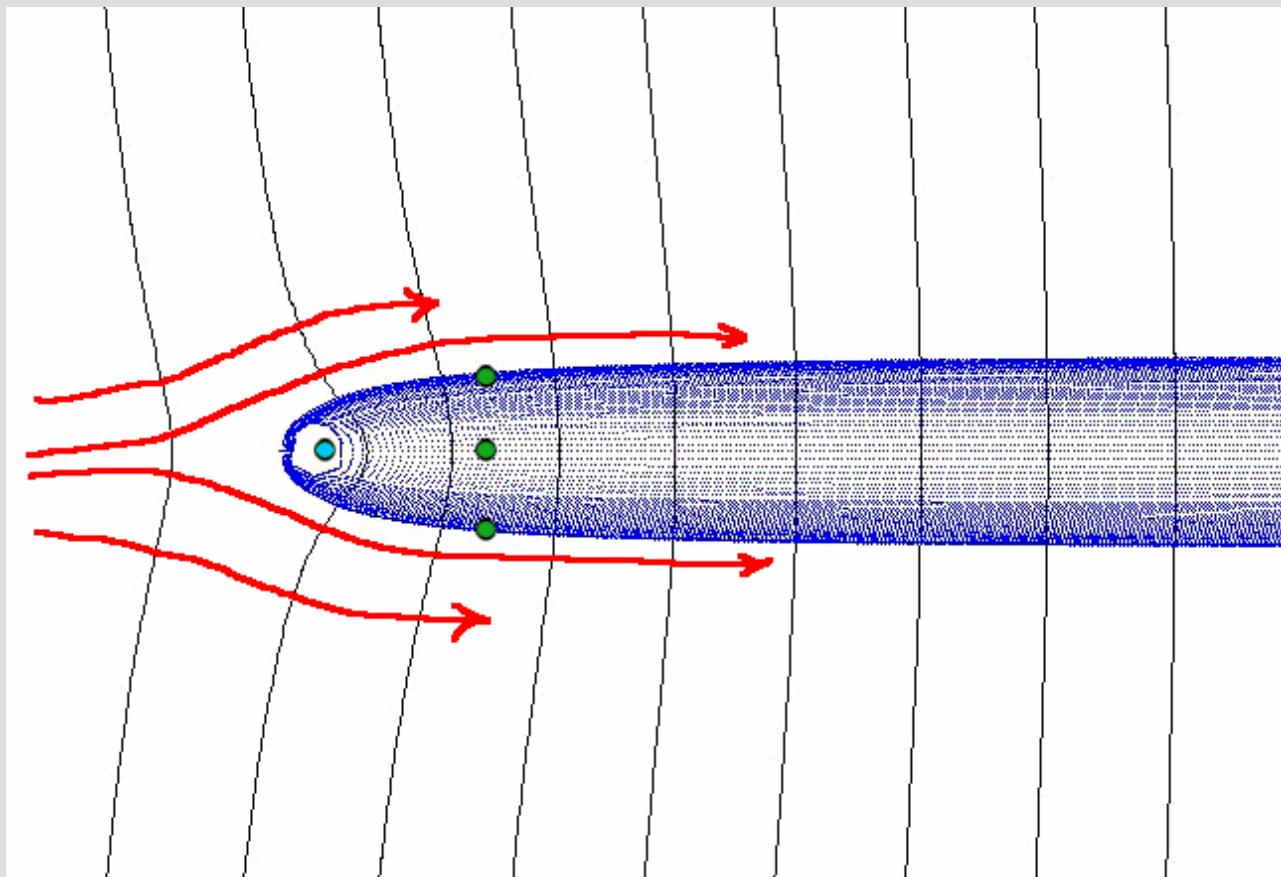
- ▶ Background
- ▶ Approach
  - **Biostimulation with tracer flush experiments**
- ▶ Recent progress
- ▶ Future plans

# Is This Hypothesis Testable?

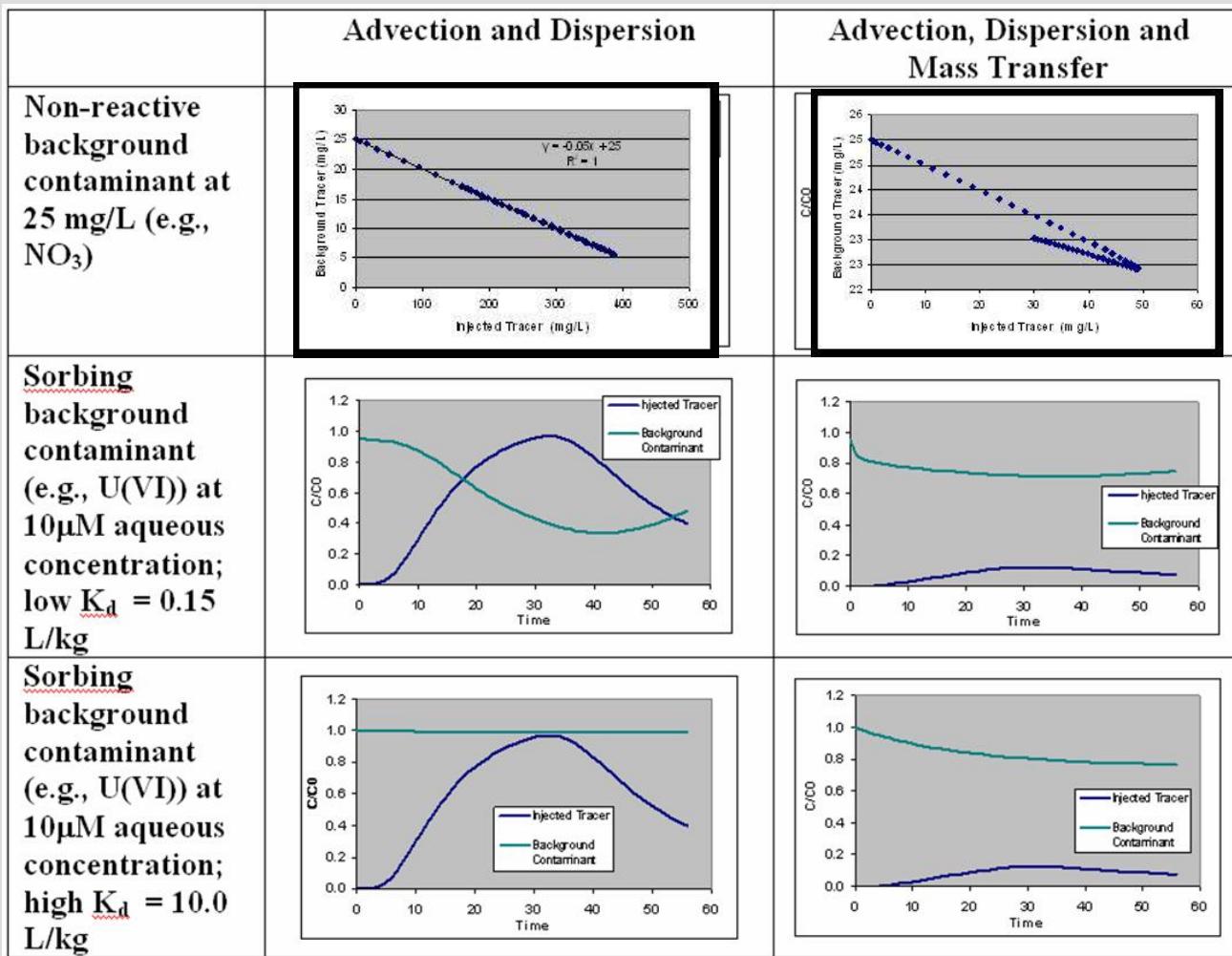
- ▶ At local scale, same approach as before (focuses on laboratory column experiments and post-stimulation sediment characterization)
- ▶ At larger scale, tracer flush experiment was devised to directly interrogate mass transfer

# Tracer Flush Experiment

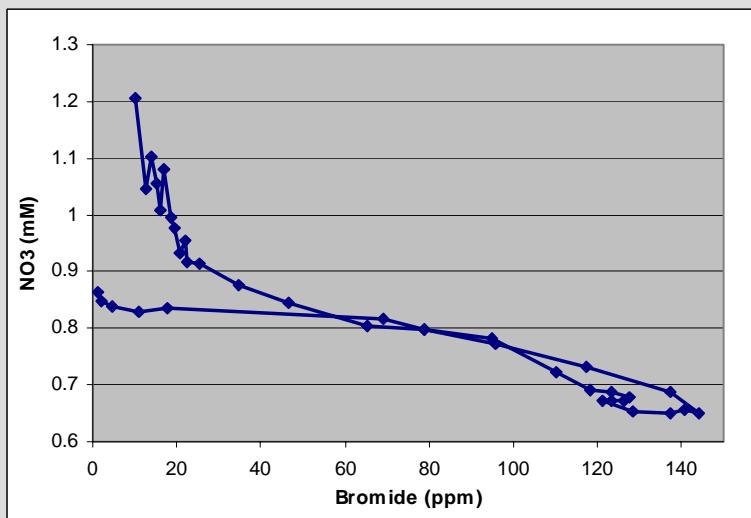
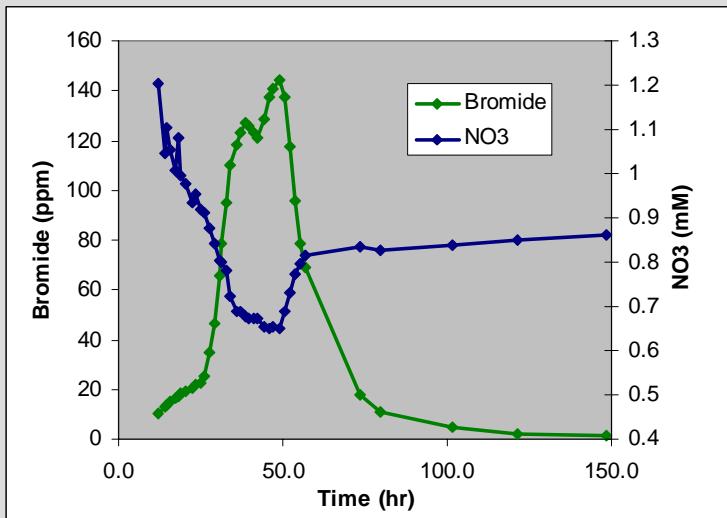
- ▶ Conceptual idea:



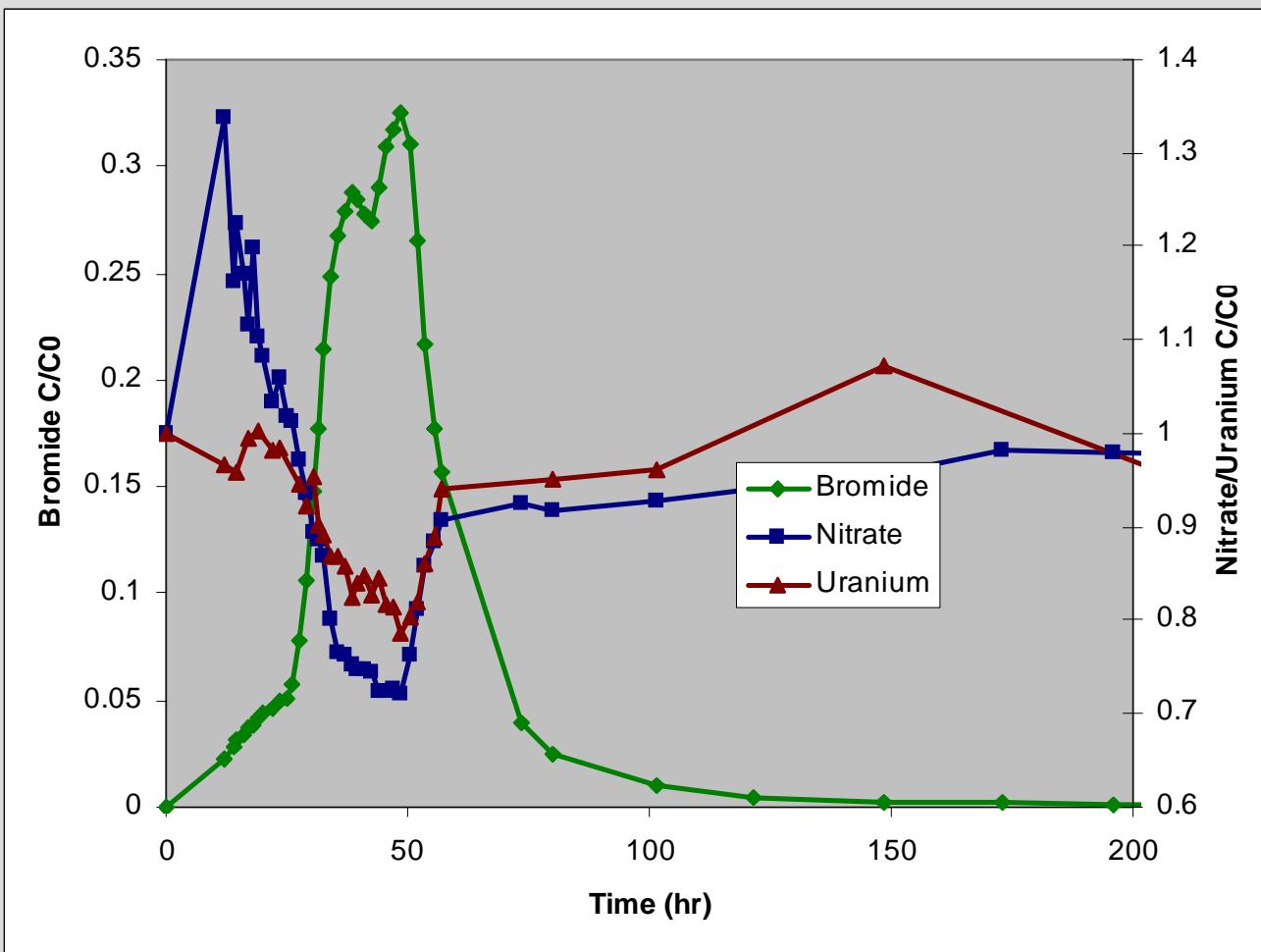
# Tracer Test Revisited



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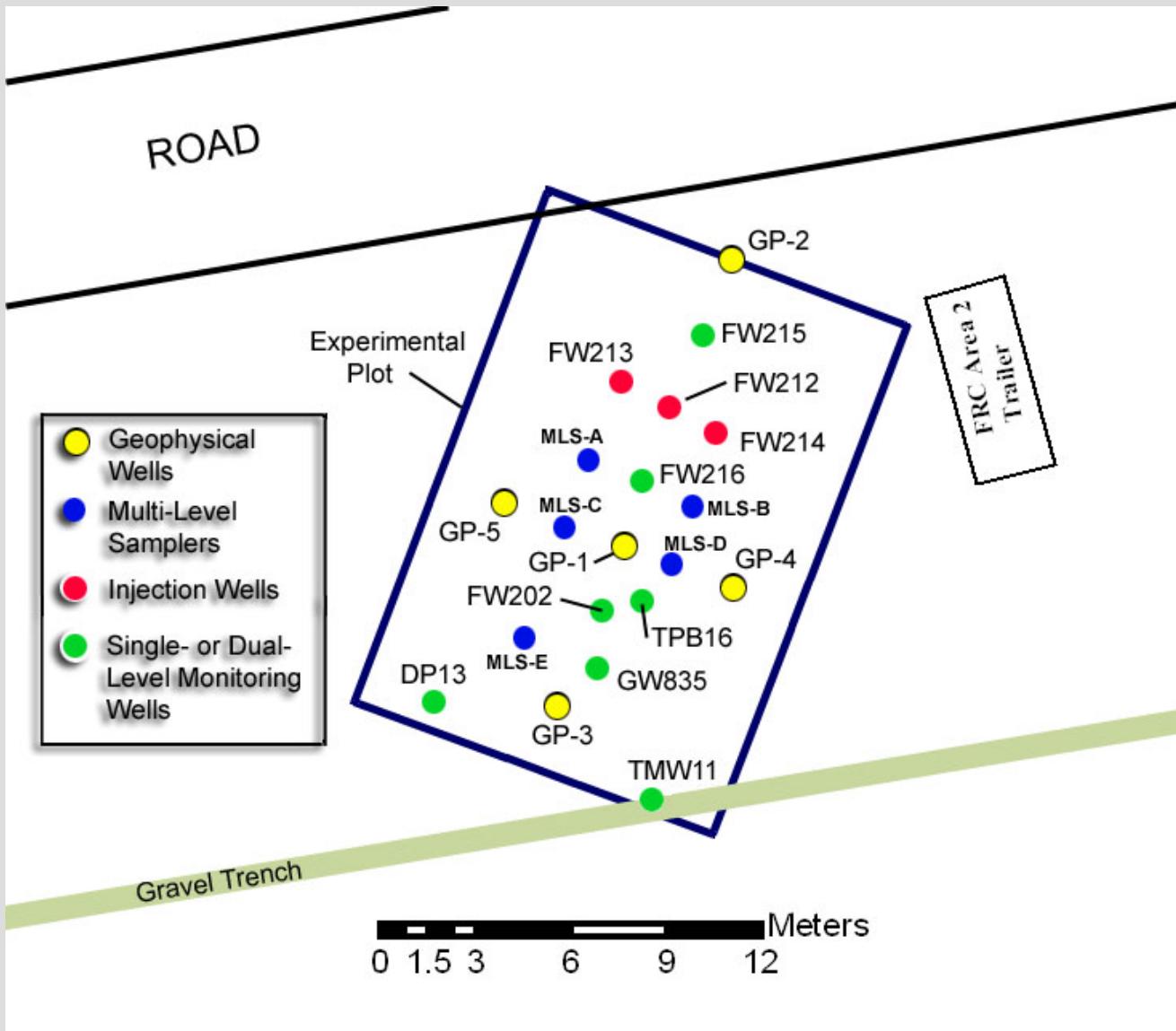
# Tracer Test Revisited



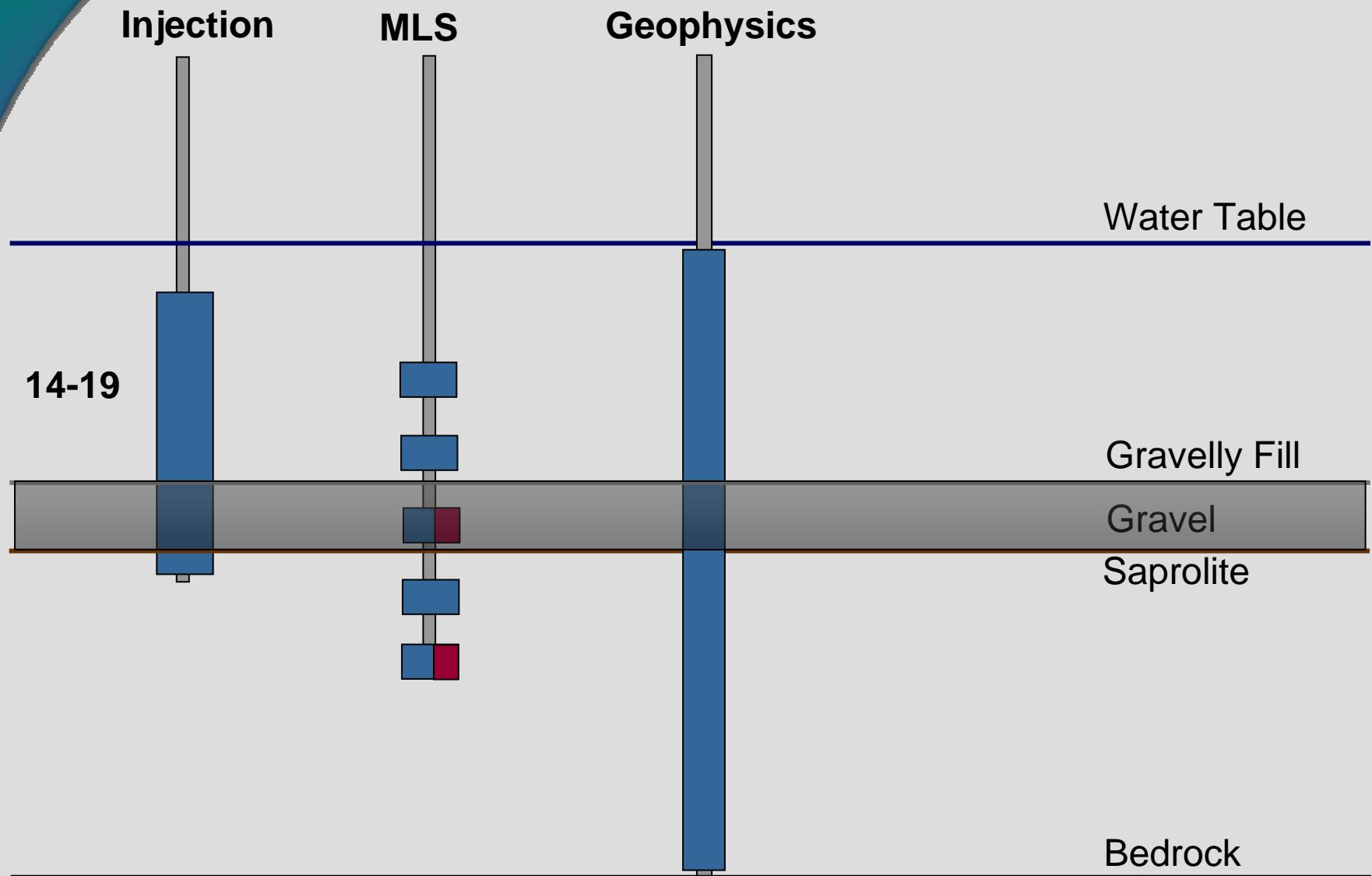
# Outline

- ▶ Background
- ▶ Approach
- ▶ Recent progress
  - Completed flow cell installation (MLS / Geophysical wells)
  - Initiated biostimulation in late September
- ▶ Future plans

# Experimental Cell Configuration



# Well Screen Intervals

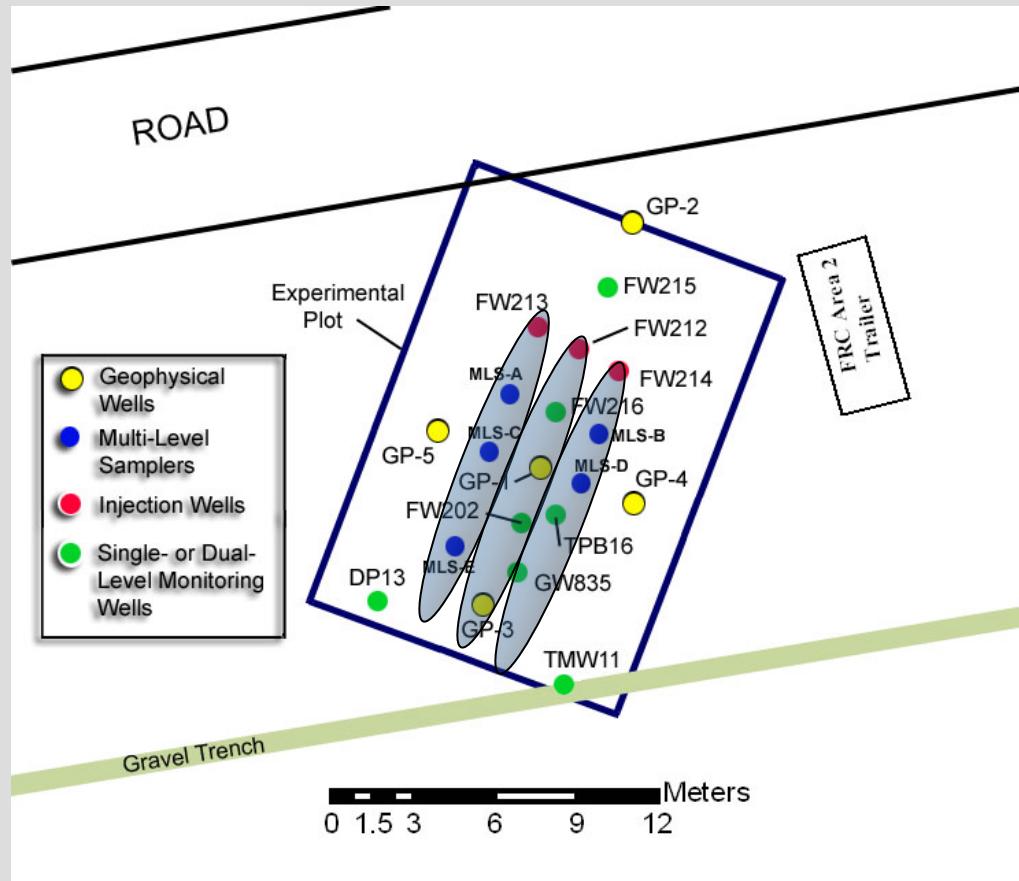


# Outline

- ▶ Background
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- ▶ **Recent progress**
  - Completed flow cell installation (MLS / Geophysical wells)
  - **Initiated biostimulation in late September**
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# Biostimulation Experiment

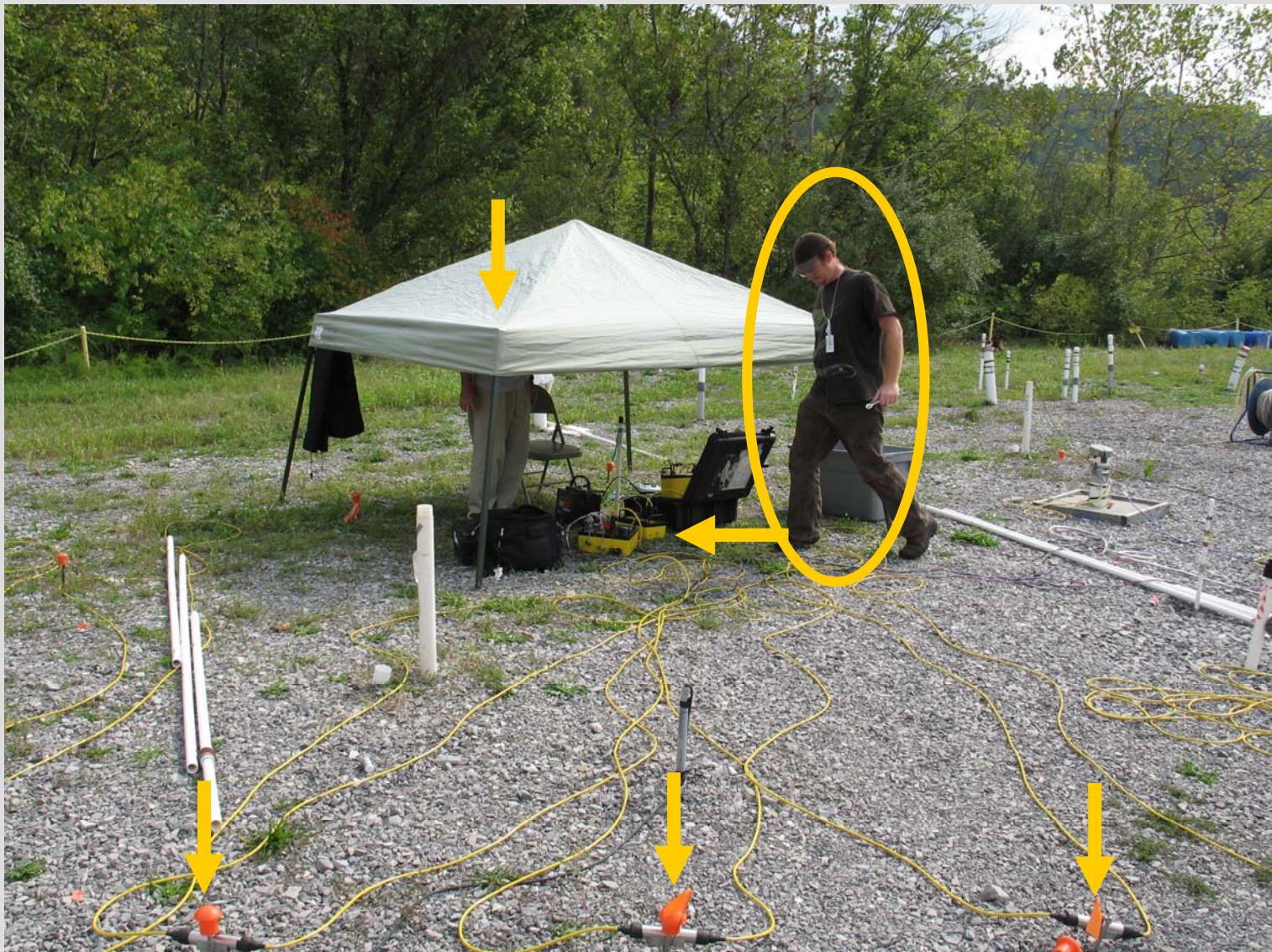
- ▶ 10 mM ethanol,  
5 mM bromide  
solution
- ▶ Three injection  
wells, 3 L/min each  
well
- ▶ 24-hour initial  
injection pulse  
followed by daily  
one-hour pulses
- ▶ Started Sept. 28

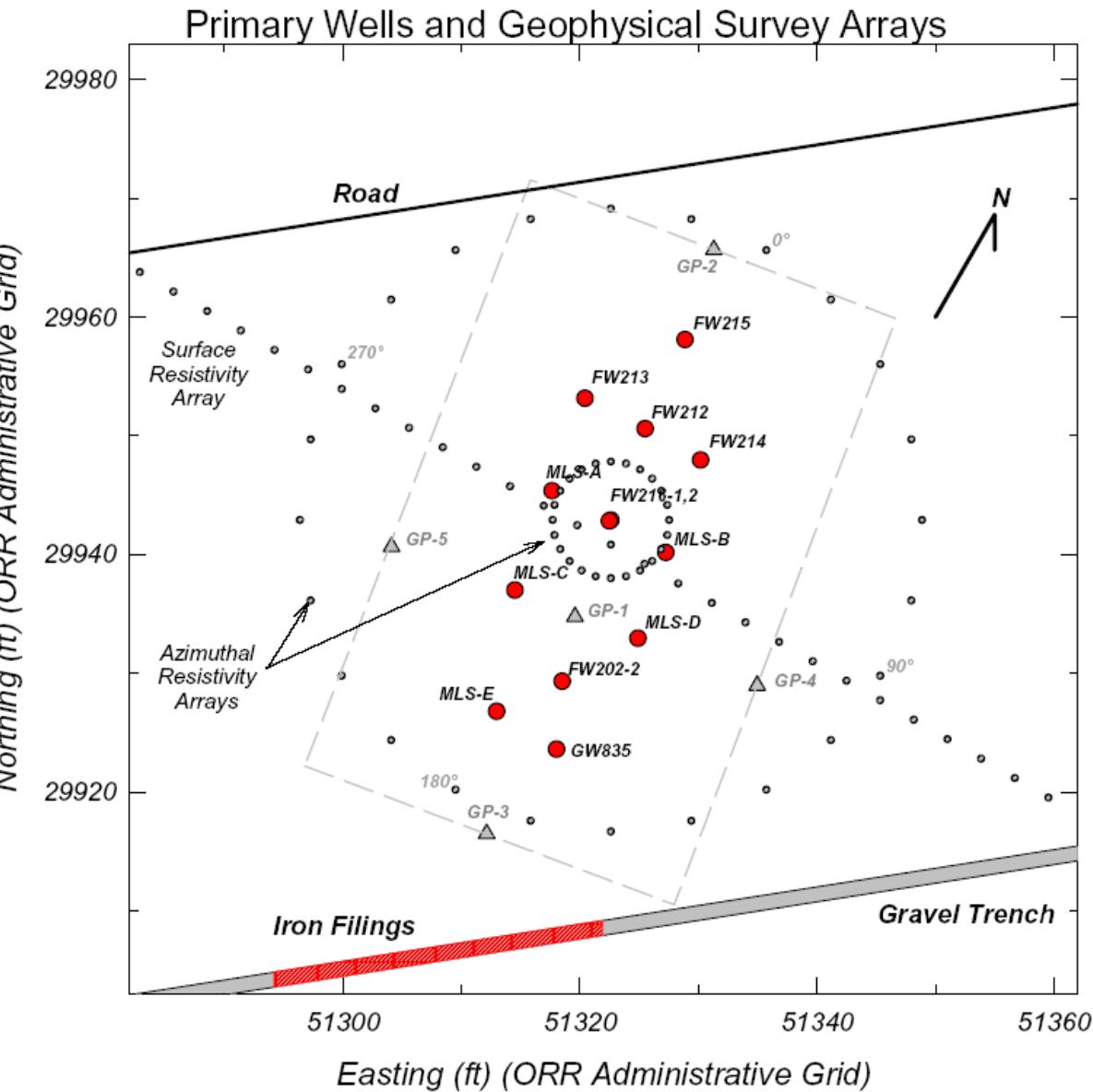


# Biostimulation Field Site



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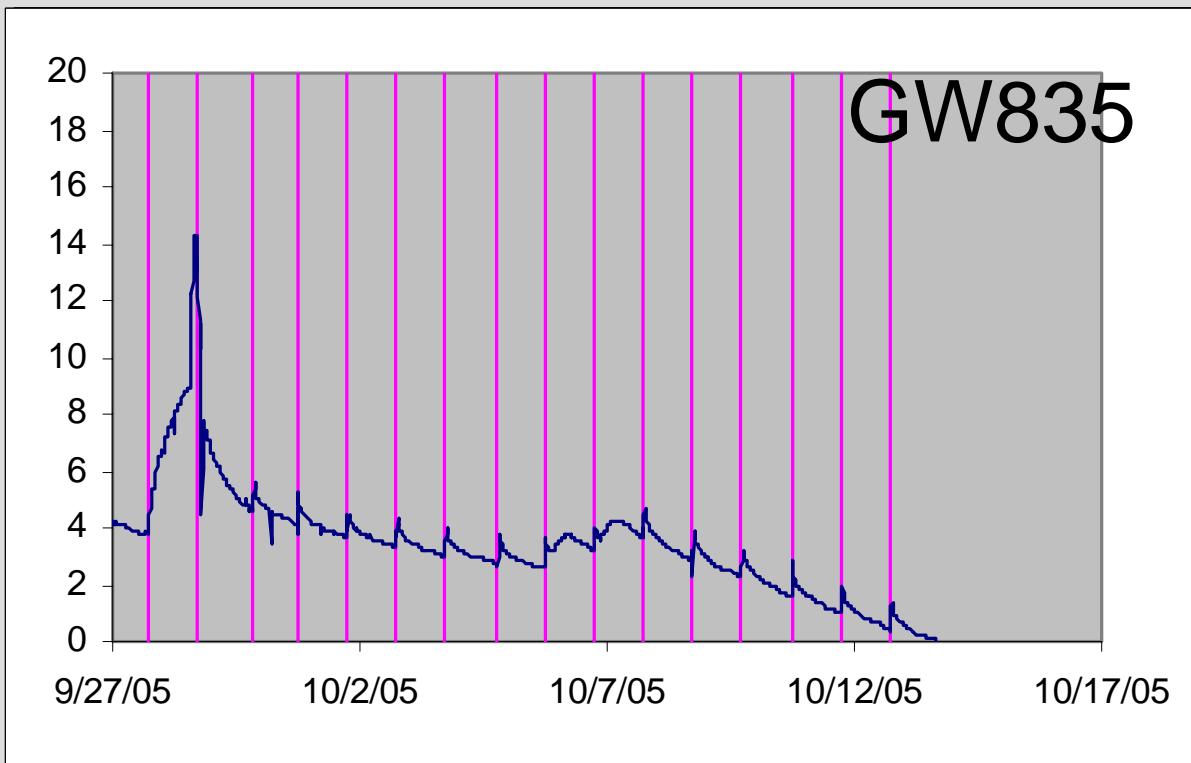


# Contributors Not Pictured

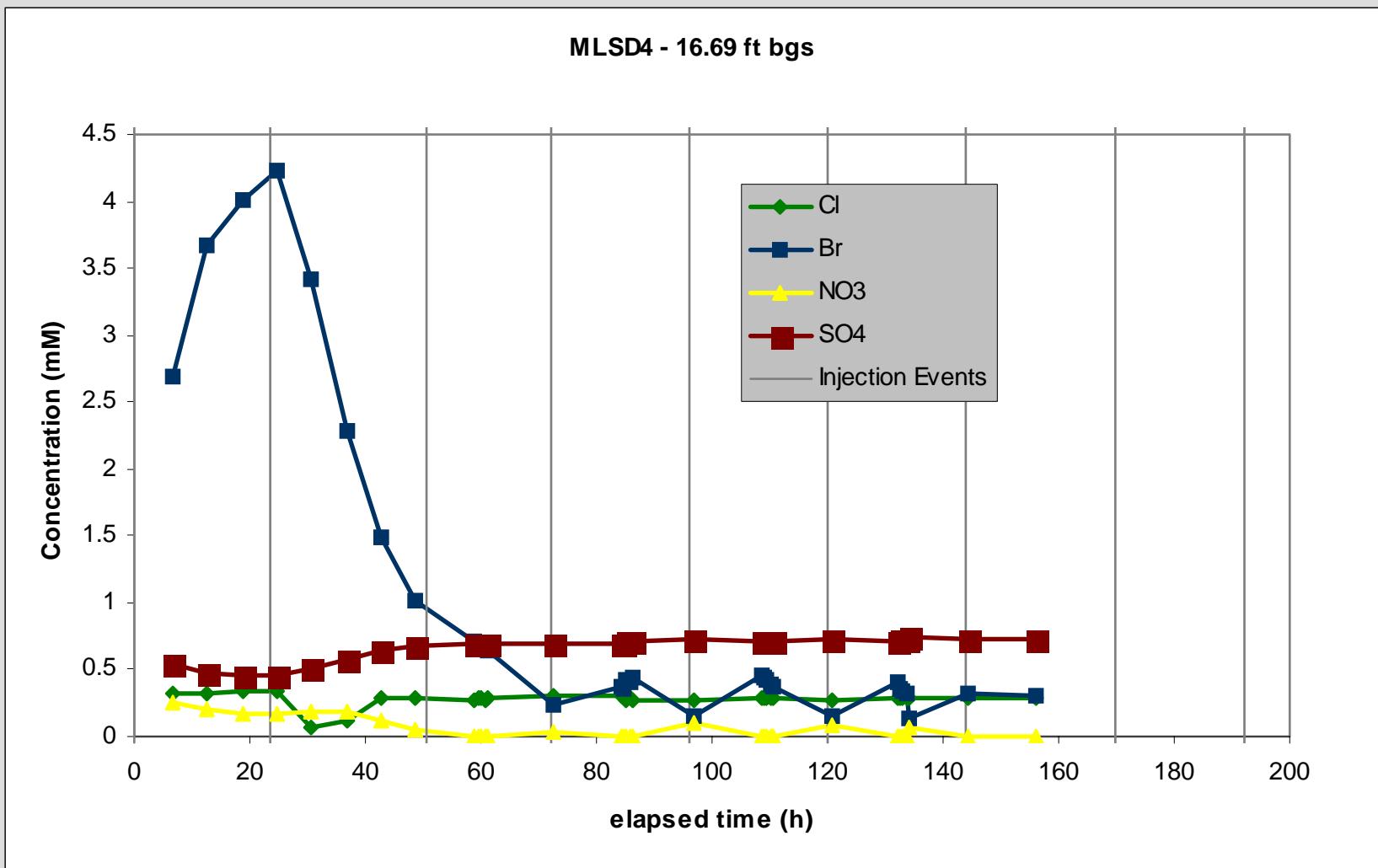
- ▶ Co-PI – Eric Roden
- ▶ Coring and well installation – Kirk Hyder and Ken Lowe
- ▶ Safety, logistics, sampling – Mary Anna Bogle
- ▶ Radiation protection – George Houser
- ▶ Field work support:
  - Melanie Mayes
  - Tonia Mehlhorn
  - Lisa Fagan
- ▶ Numerical modeling – Yilin Fang
- ▶ Borehole gamma logging – Brian Spalding
- ▶ FRC Manager – David Watson

# Preliminary Results

## ► Water level response

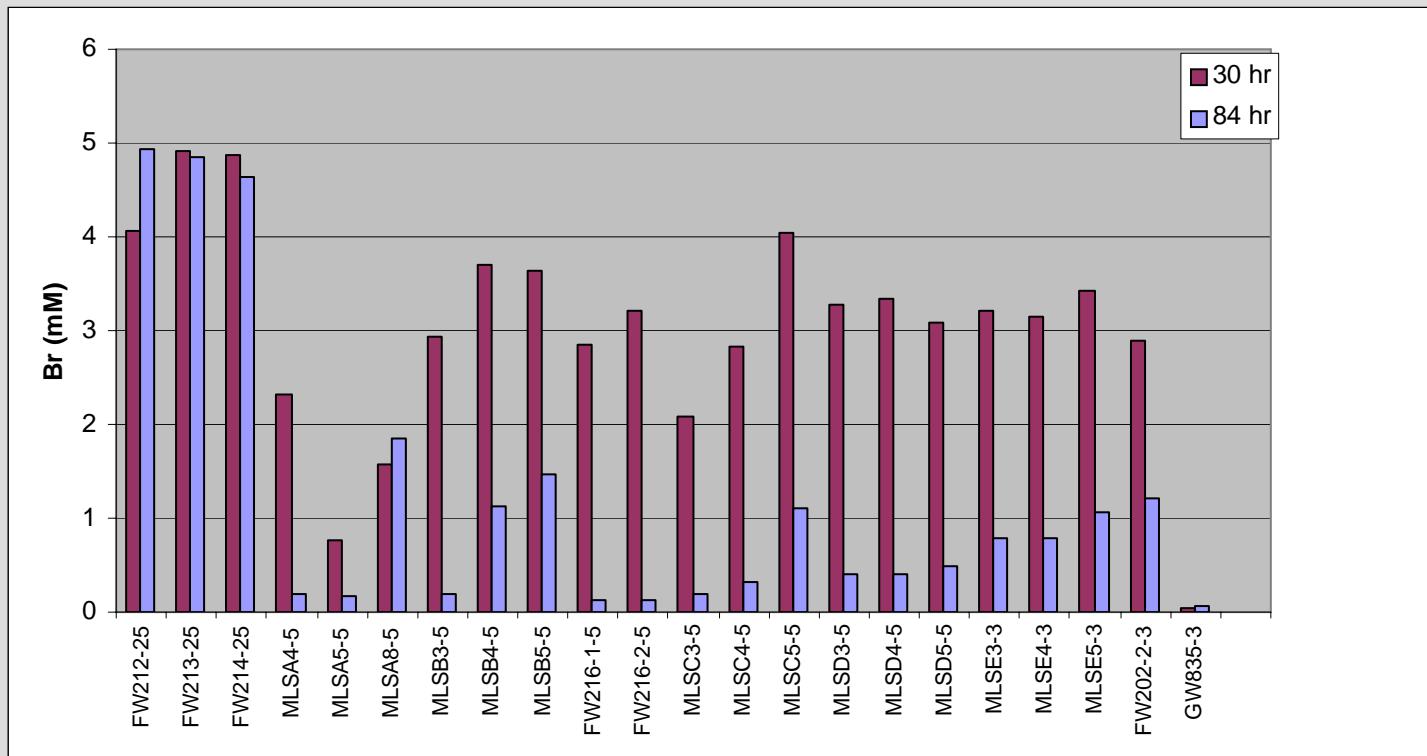


# Preliminary Results



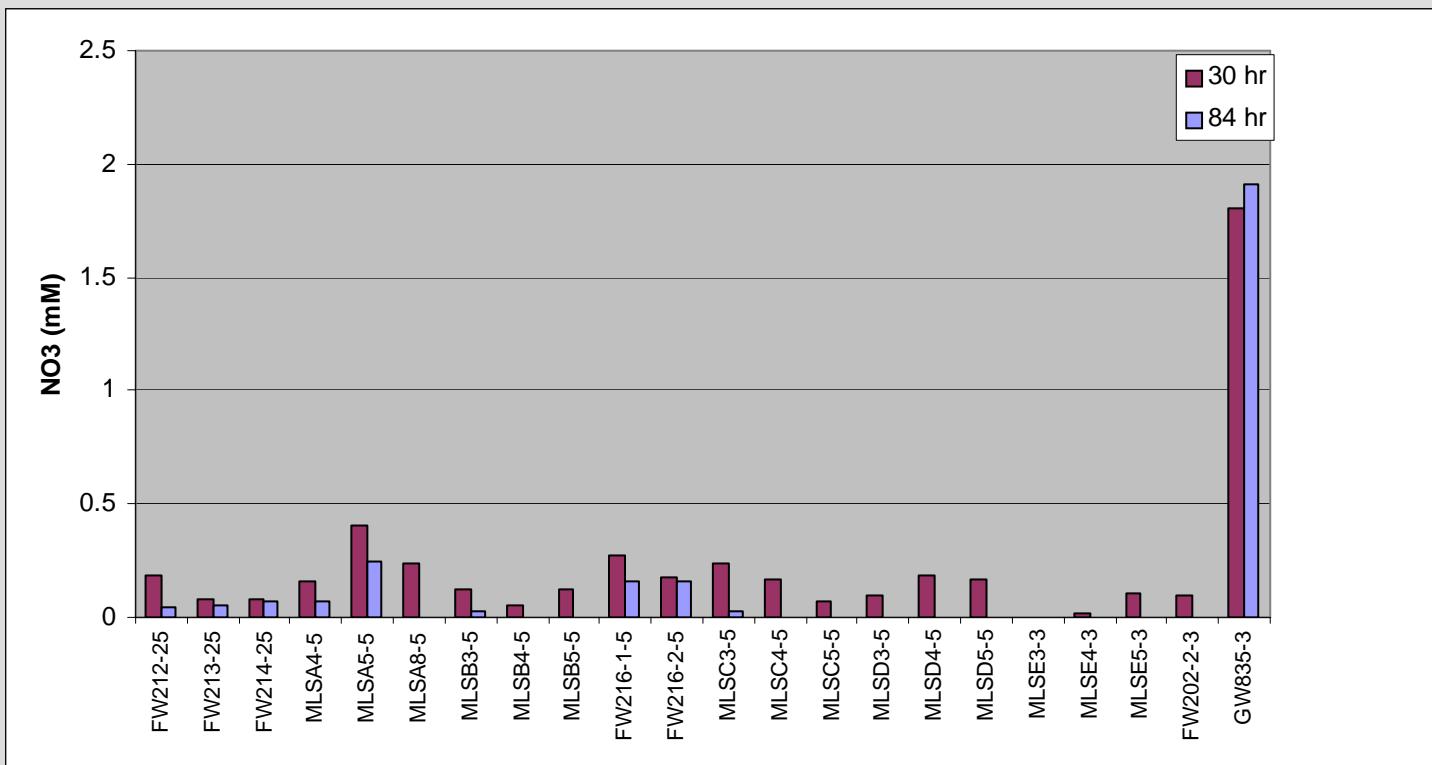
# Preliminary Results

## ► Bromide transport



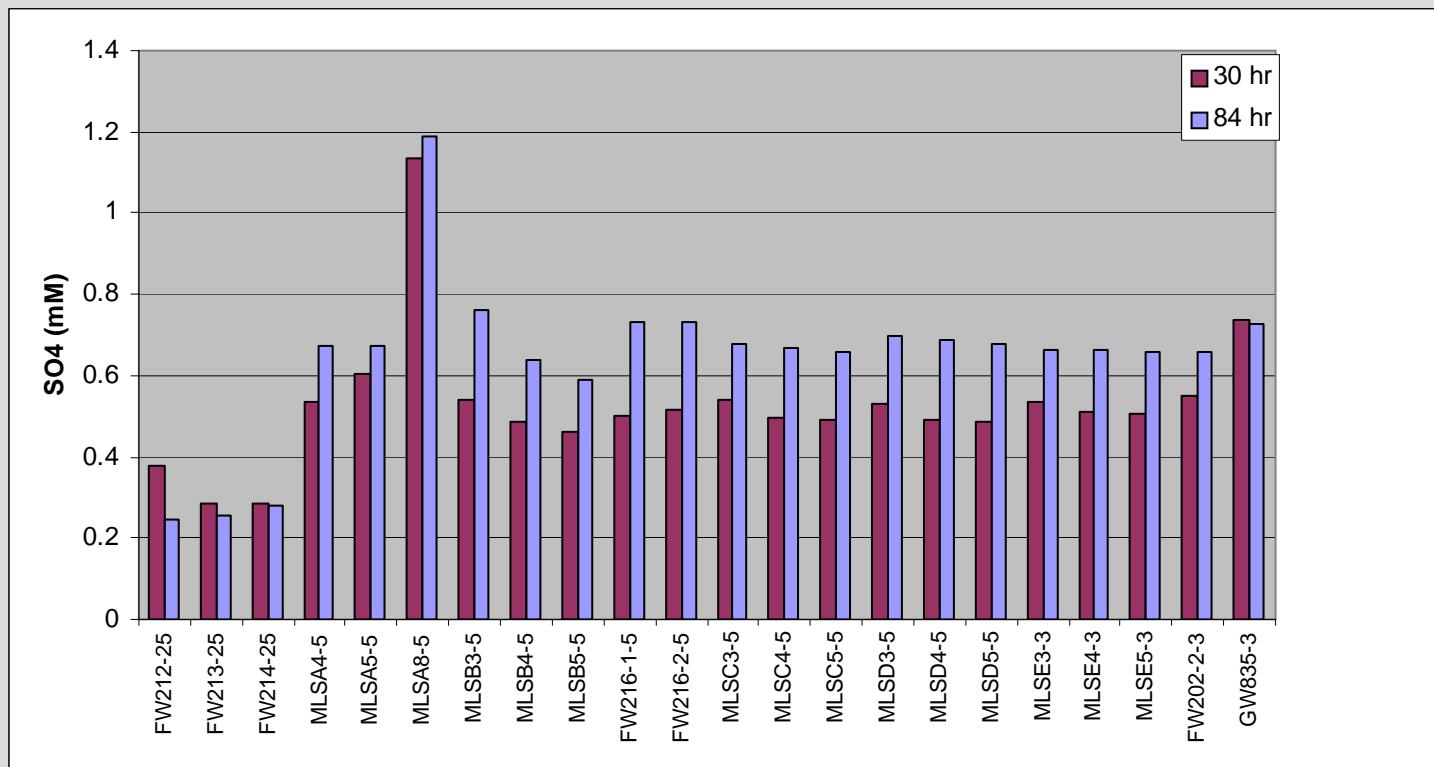
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## ► Nitrate



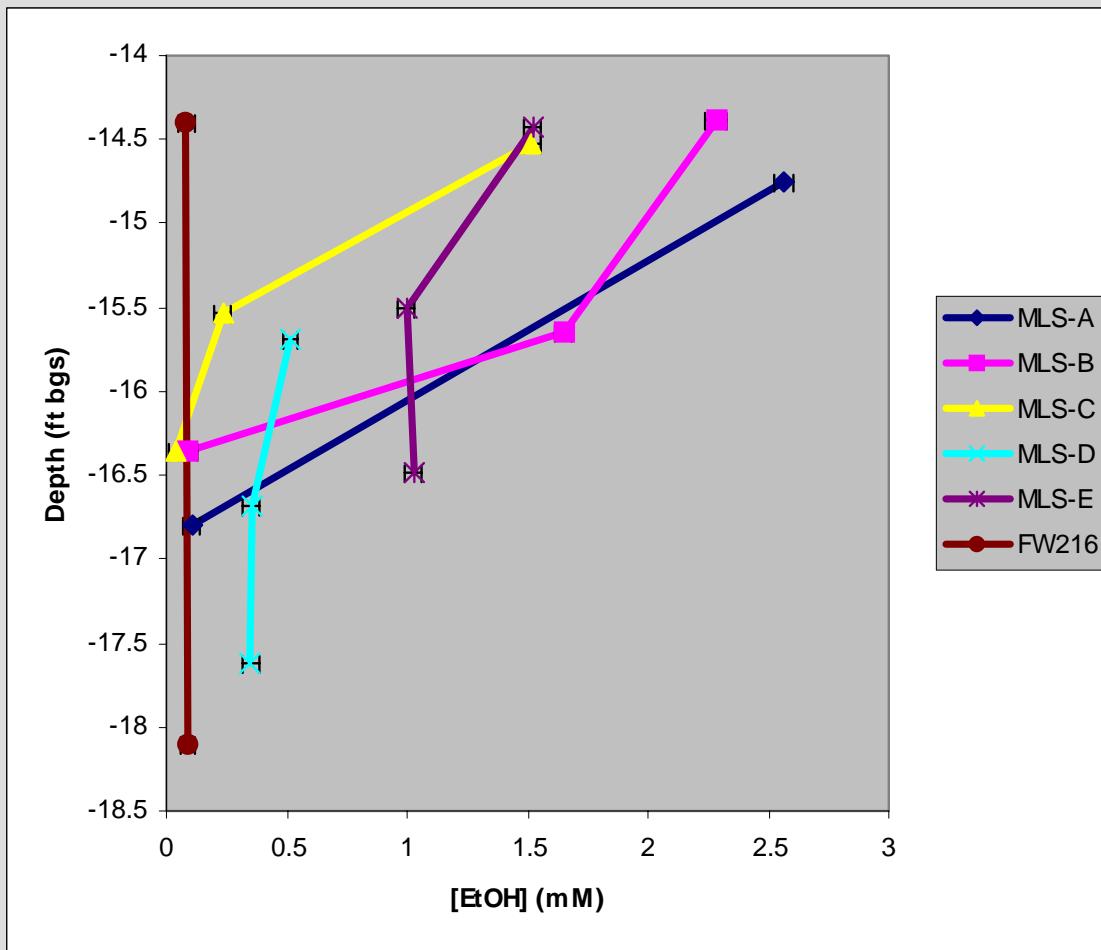
# Preliminary Results

## ► Sulfate



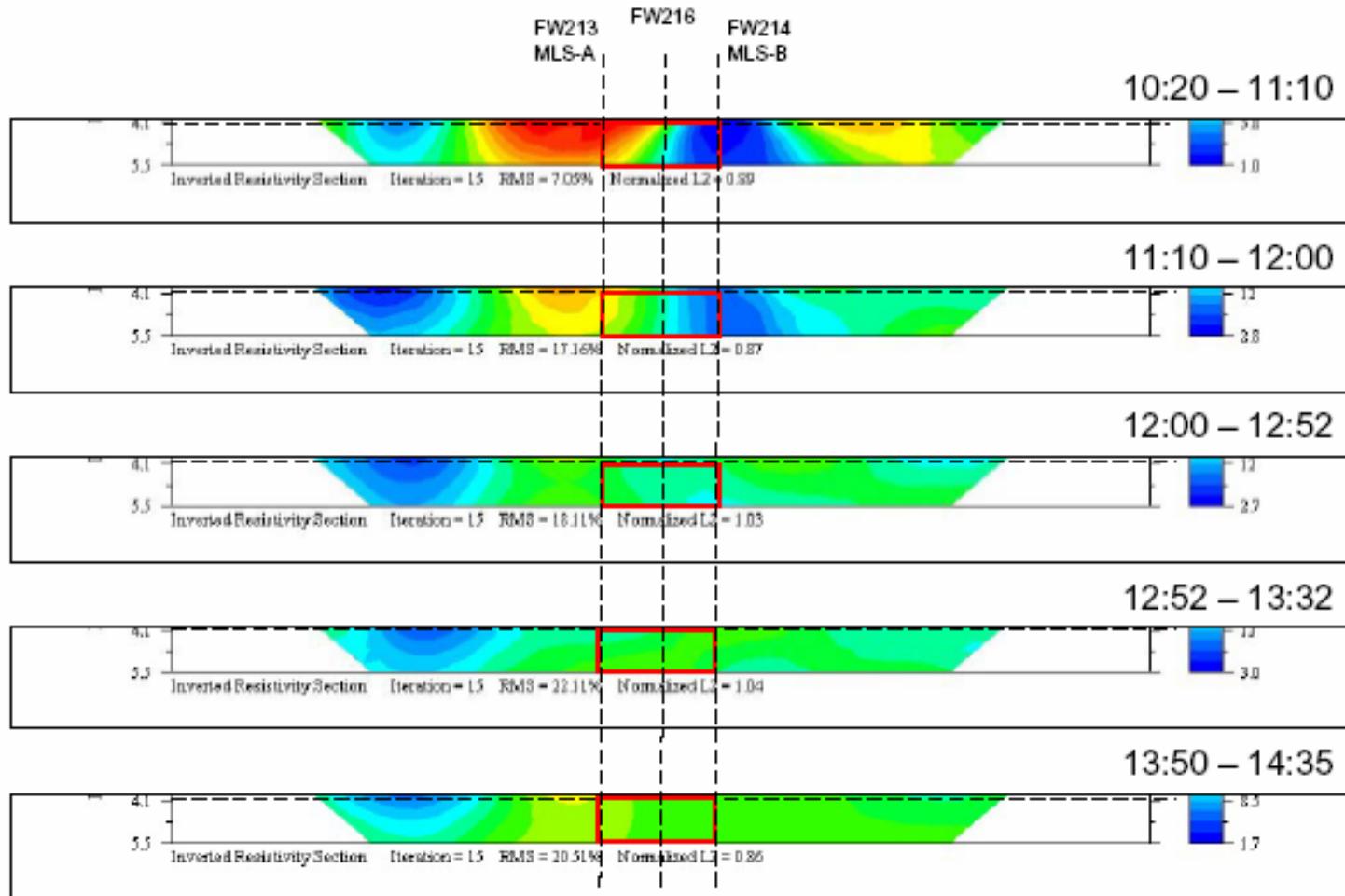
# Preliminary Results

► Ethanol  
(80-90  
hours)



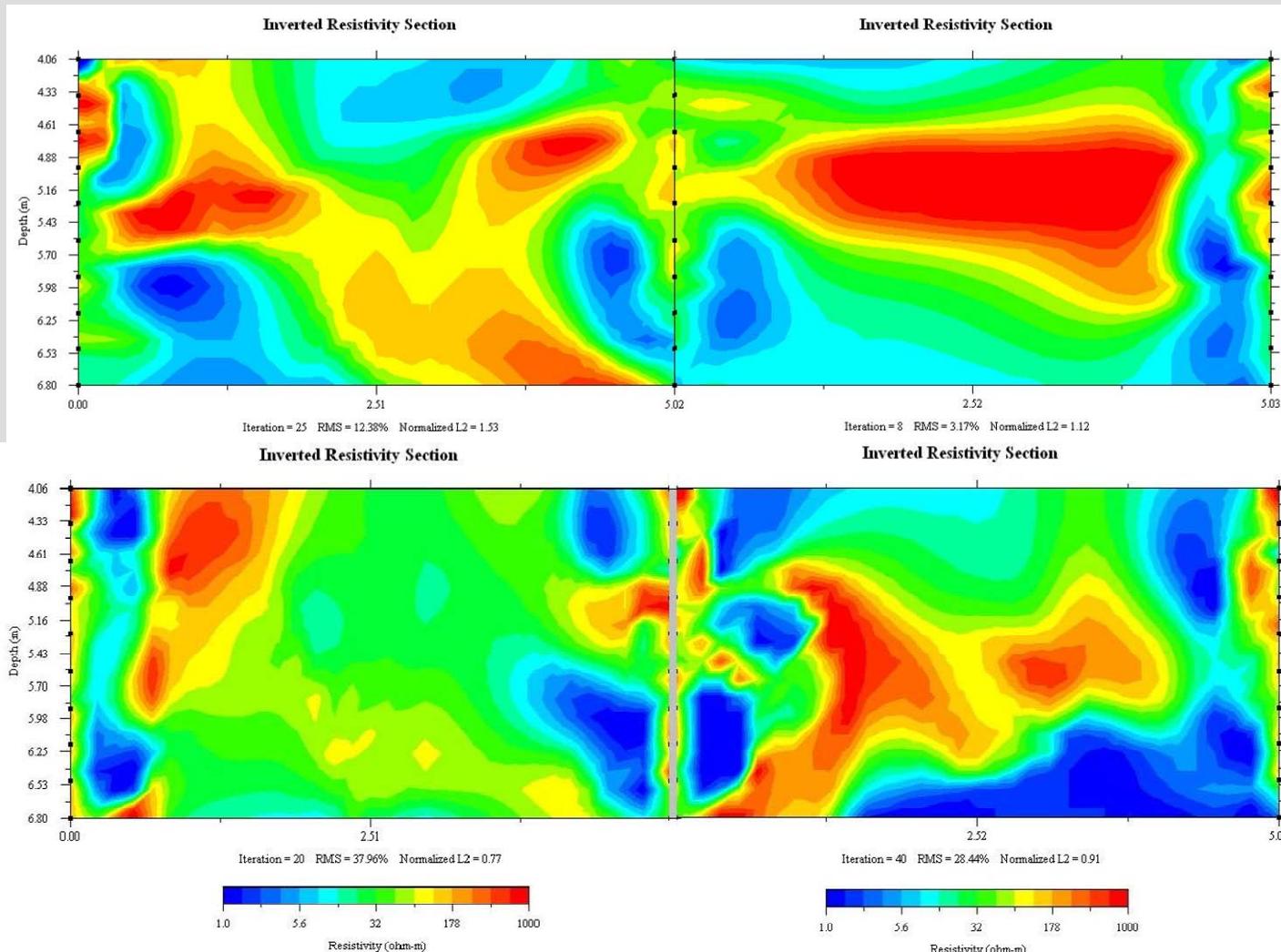
# Preliminary Results

## ► Surface electrical resistivity



# Preliminary Results

## ► Crosshole electrical resistivity



# Outline

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- ▶ Future plans
  - Continue biostimulation (2 months)
  - Tracer flush experiments (during and after)
  - Post-stimulation sediment collection and analysis