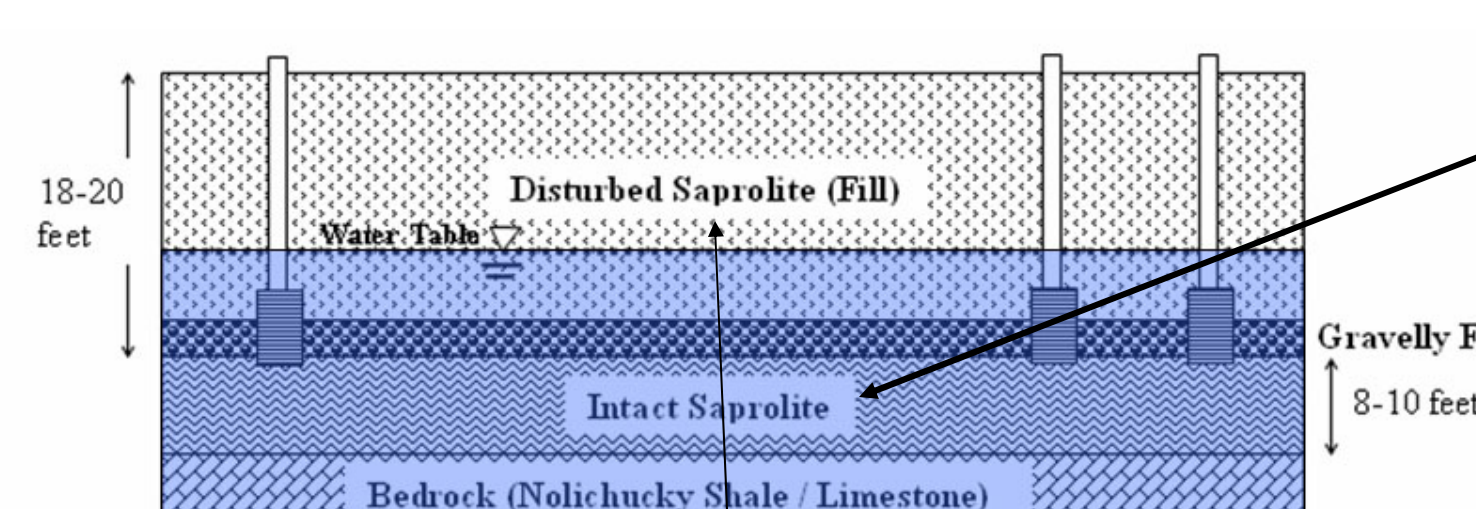


# In Situ Immobilization of Uranium in Structured Porous Media via Biomineralization at the Fracture/Matrix Interface (FRC Area 2 Field Project)

## Concept/Hypotheses

**ORIGINAL HYPOTHESIS:** "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." (Roden and Scheibe, 2005)

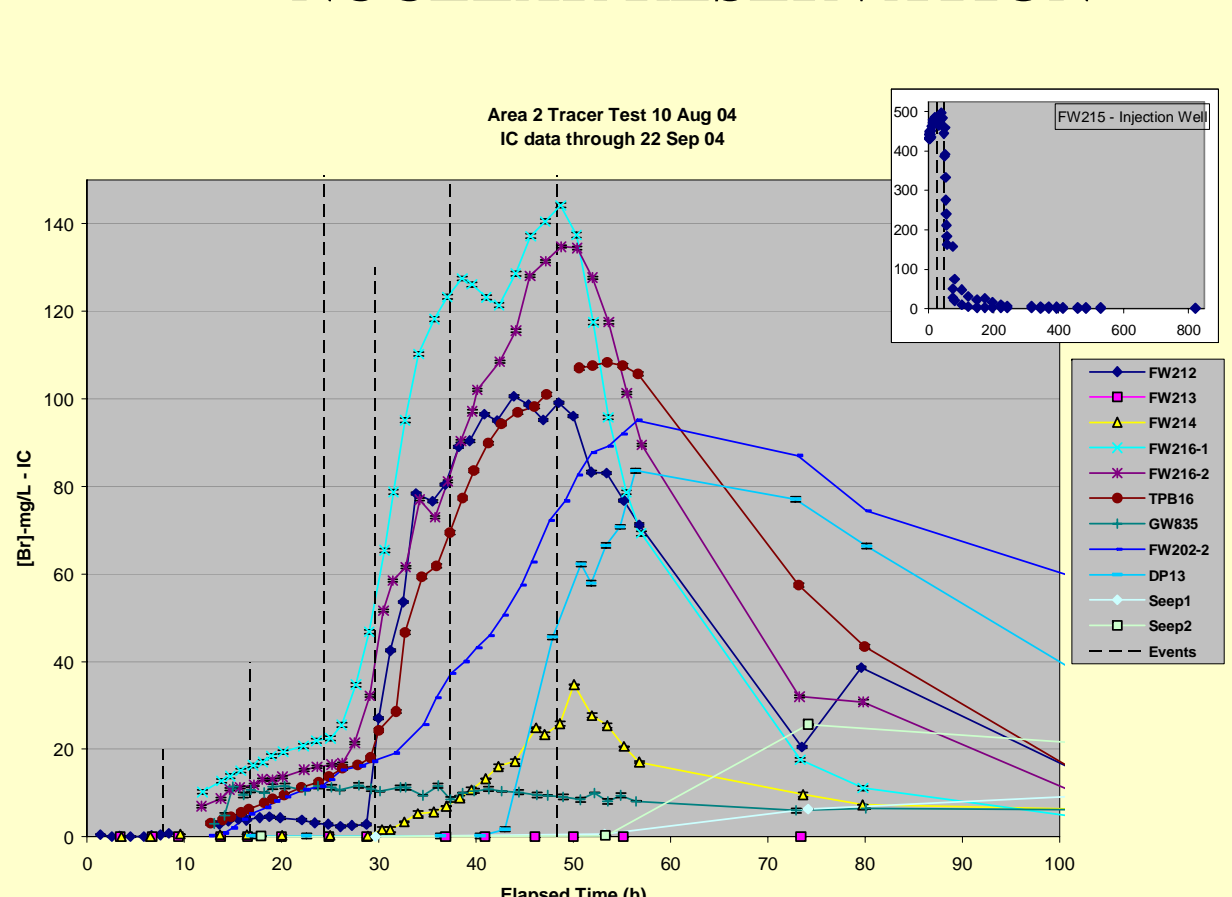


The original hypothesis focused on the intact fractured saprolite zone

**INTACT SAPROLITE HAS ISSUES:**

- Low U(VI) concentrations
- High nitrate concentrations
- Low permeability

### BROMIDE MISSING AT GOVERNMENT NUCLEAR RESERVATION

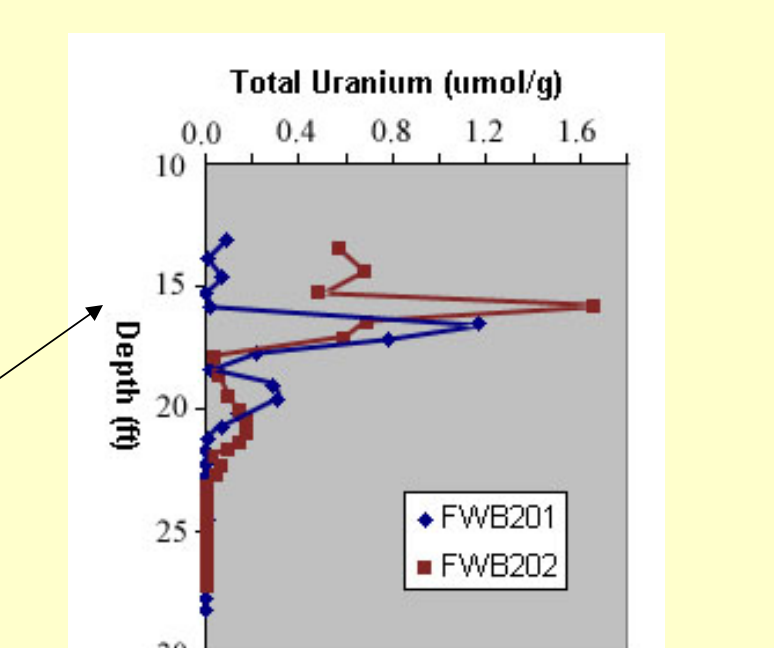


Bromide breakthrough curves from the Area 2 tracer test conducted August 2004.



Intact Saprolite Material

### GRAVEL CAPTURES RESEARCHERS' ATTENTION



Vertical profiles of total sediment-associated uranium at two boreholes in Area 2. Gravel layer is at approximately 18 feet below ground surface.



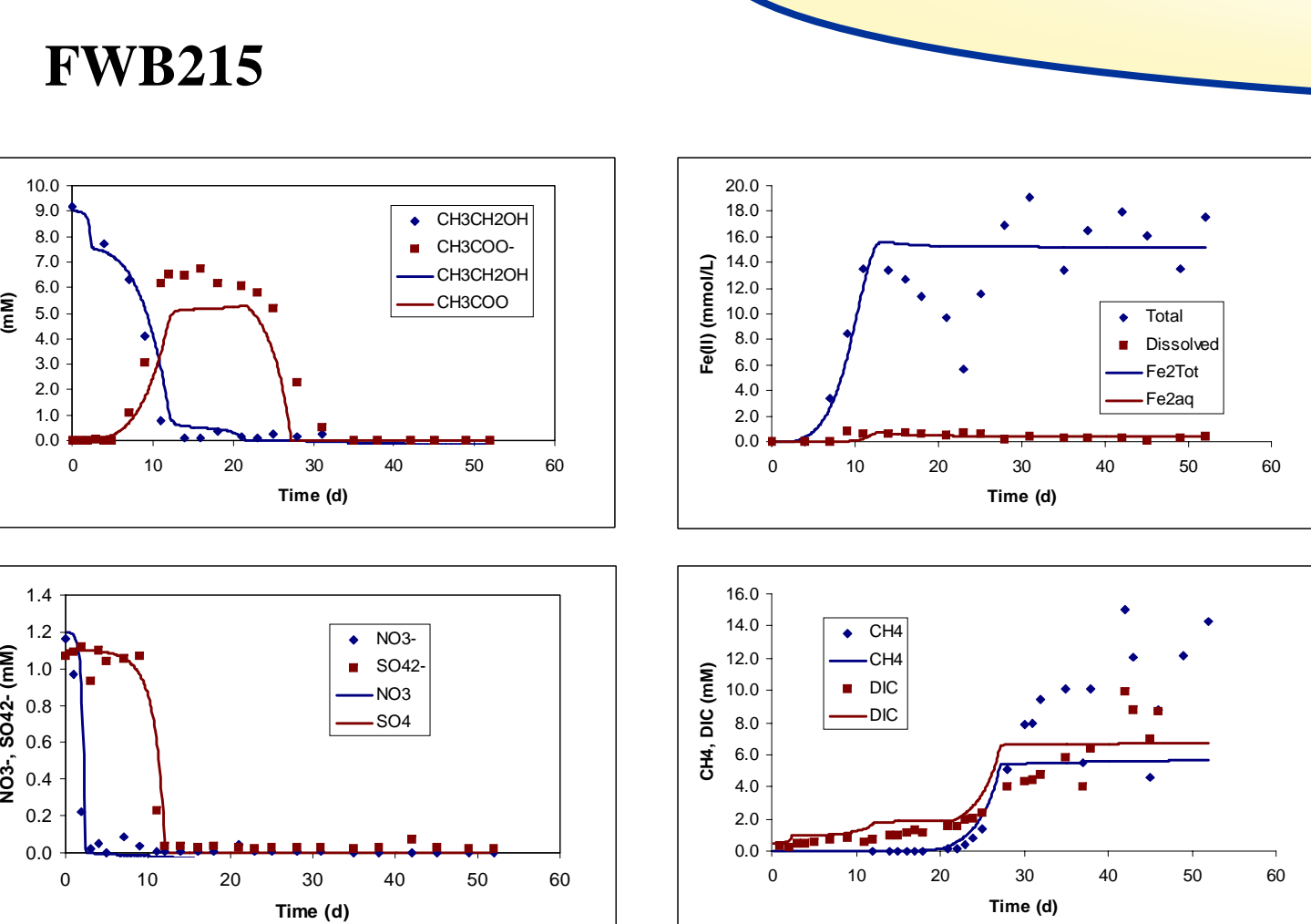
Saprolitic Fill Material



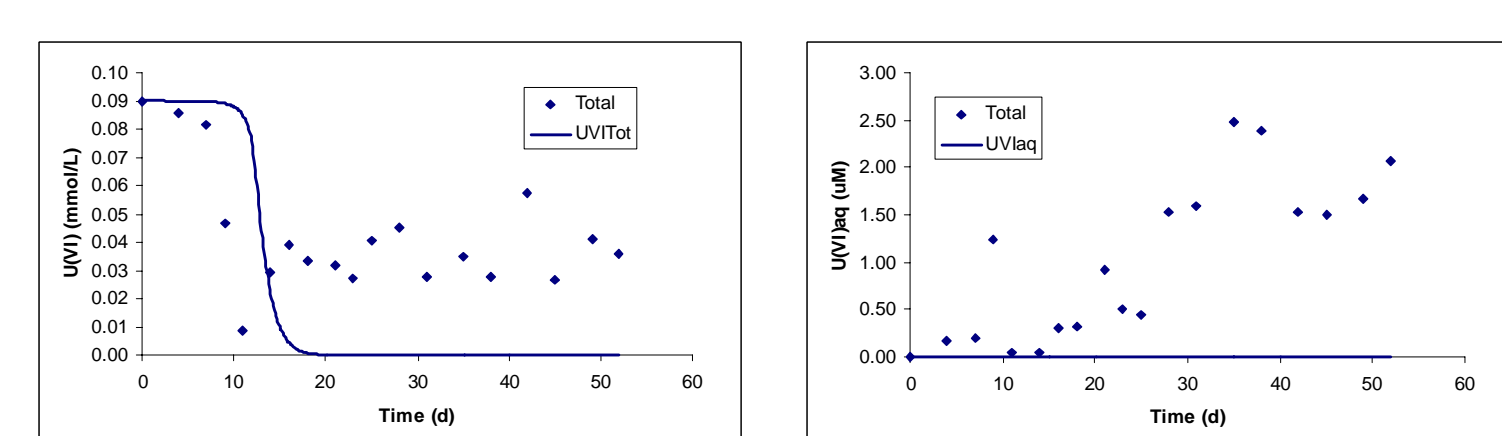
Gravel Zone

**REVISED 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."

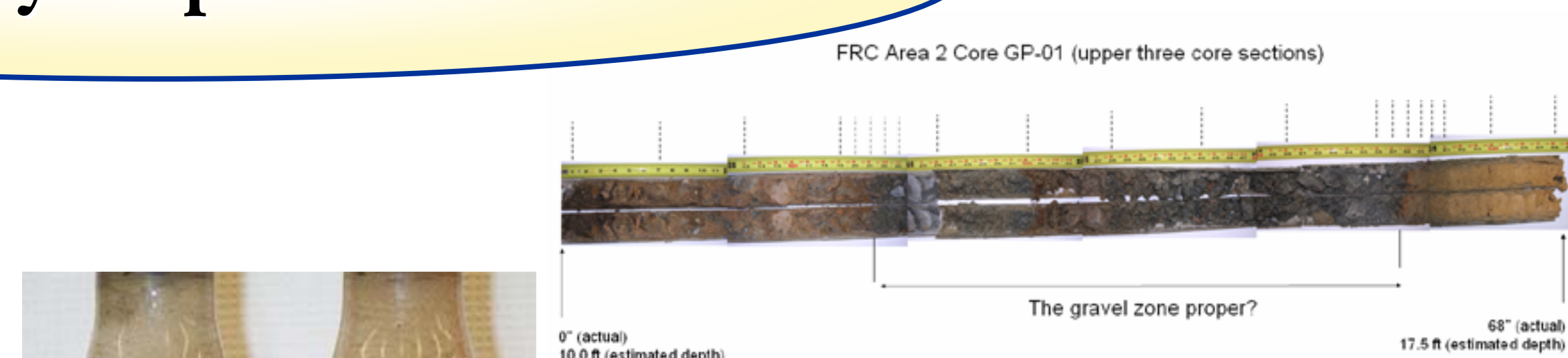
## Slurry Experiments



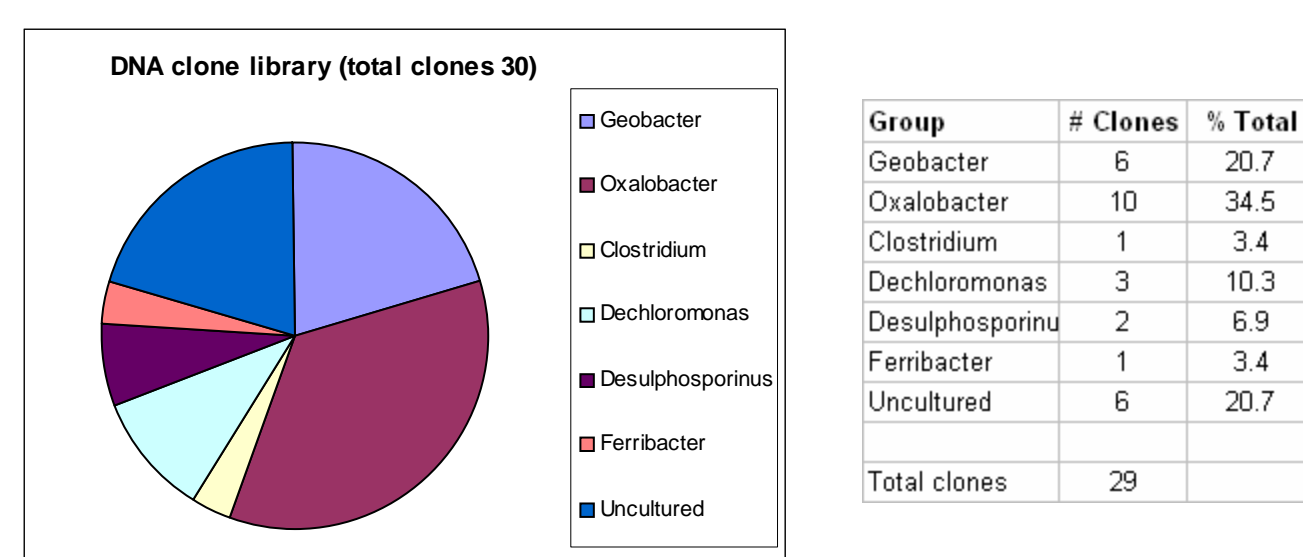
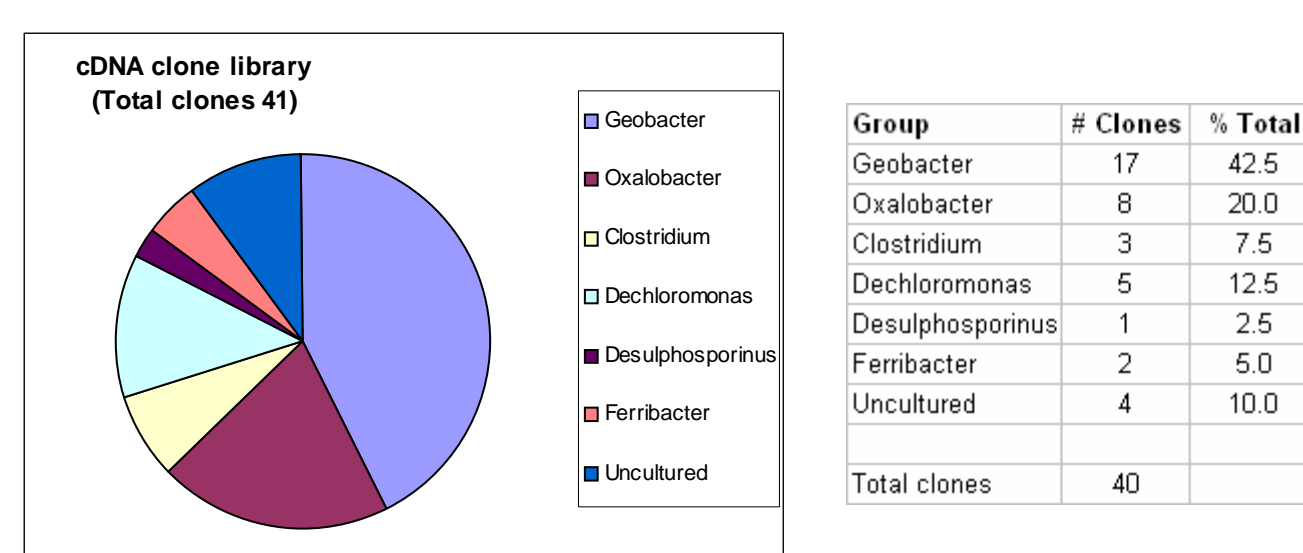
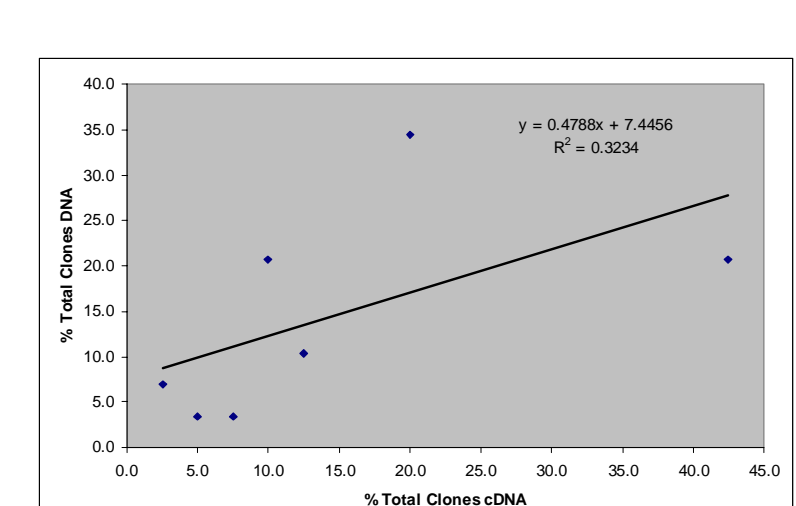
Terminal Electron Accepting Processes (TEAPs) – Experimental and Model Results



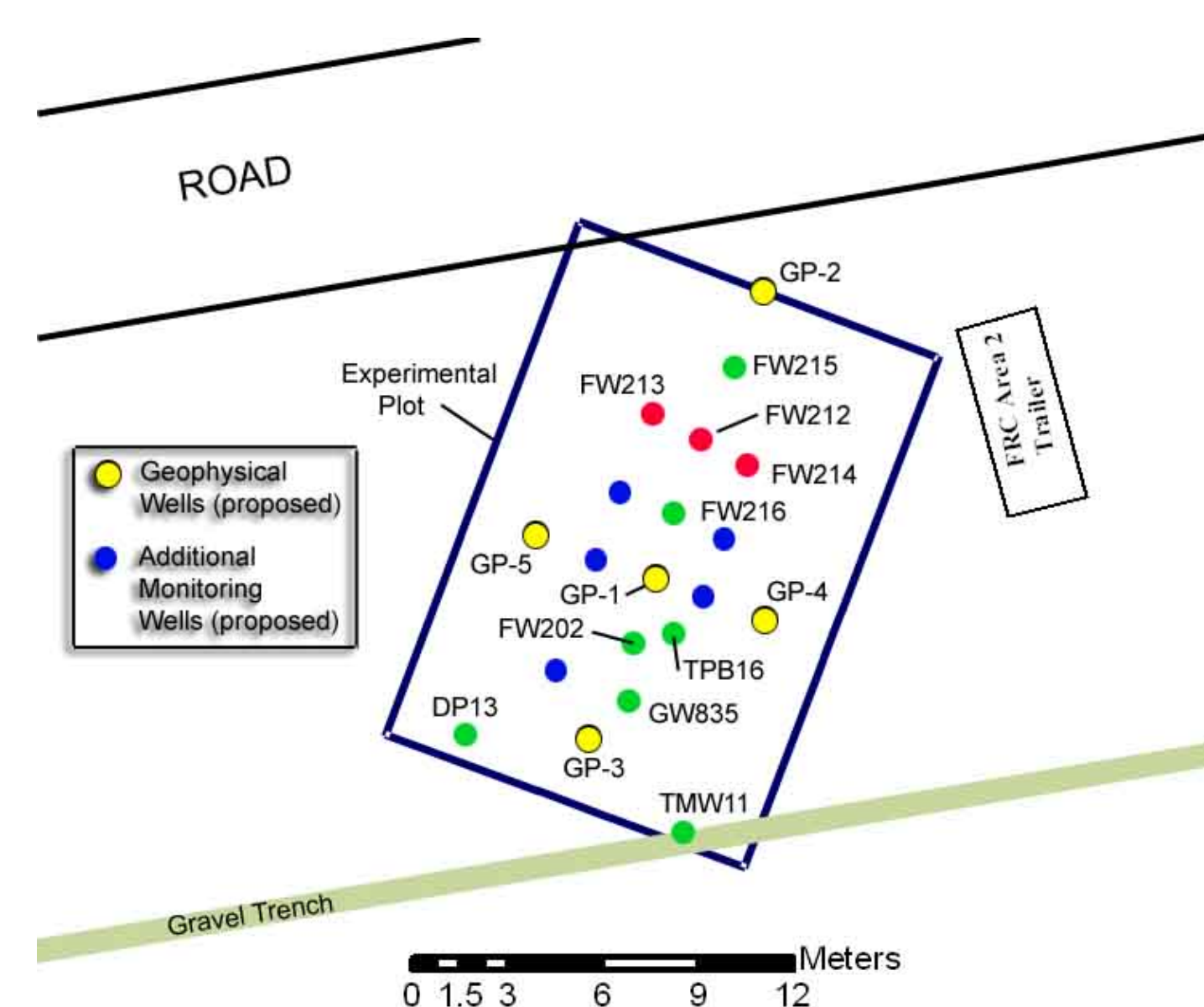
U(VI) Partitioning and Reduction – Experimental and Model Results



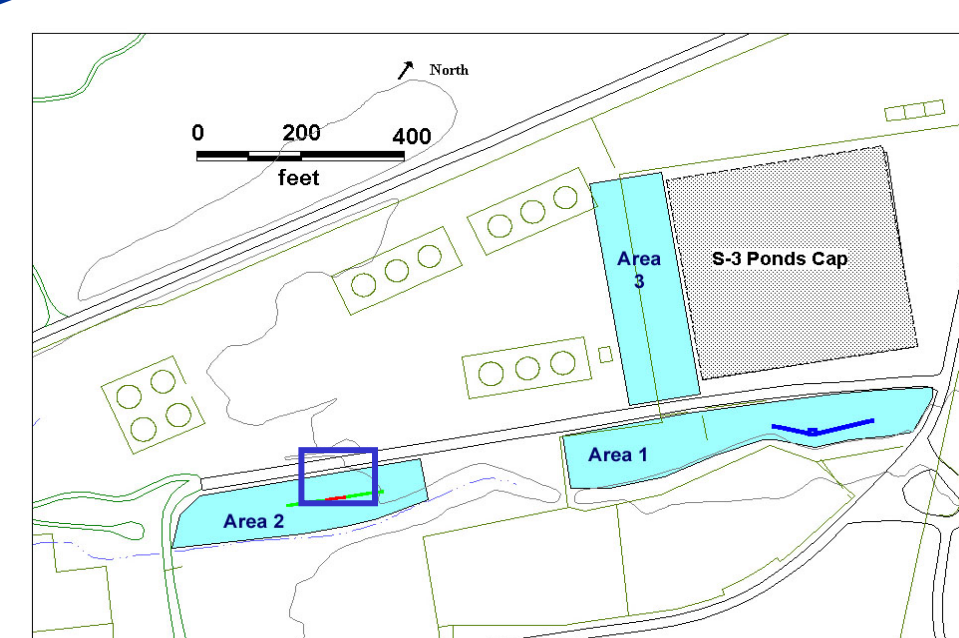
FRC Area 2 Core GP-01 (upper three core sections)



## Field Site Development

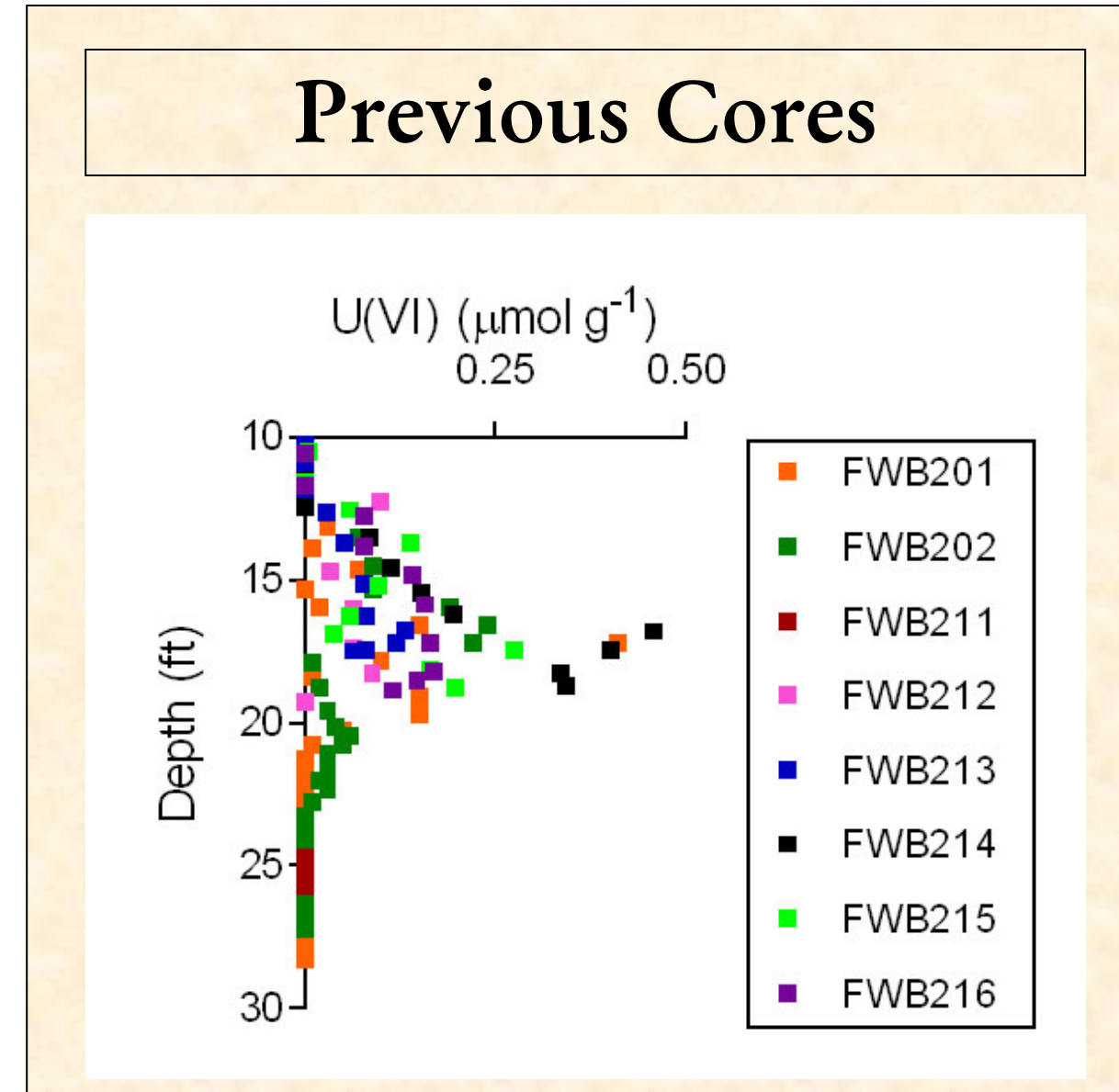


- Geophysical wells GP-1, GP-2, GP-3, GP-4 and GP-5 were recently completed.
- Additional monitoring wells (blue in figure to the left) will be multi-level sampling (MLS) wells. Materials have been delivered and construction will begin soon.
- Site infrastructure will then be complete. Wells FW212, FW213, and FW214 will serve as electron donor injection wells; flush experiment (tracer and water injection) will be conducted using FW215.

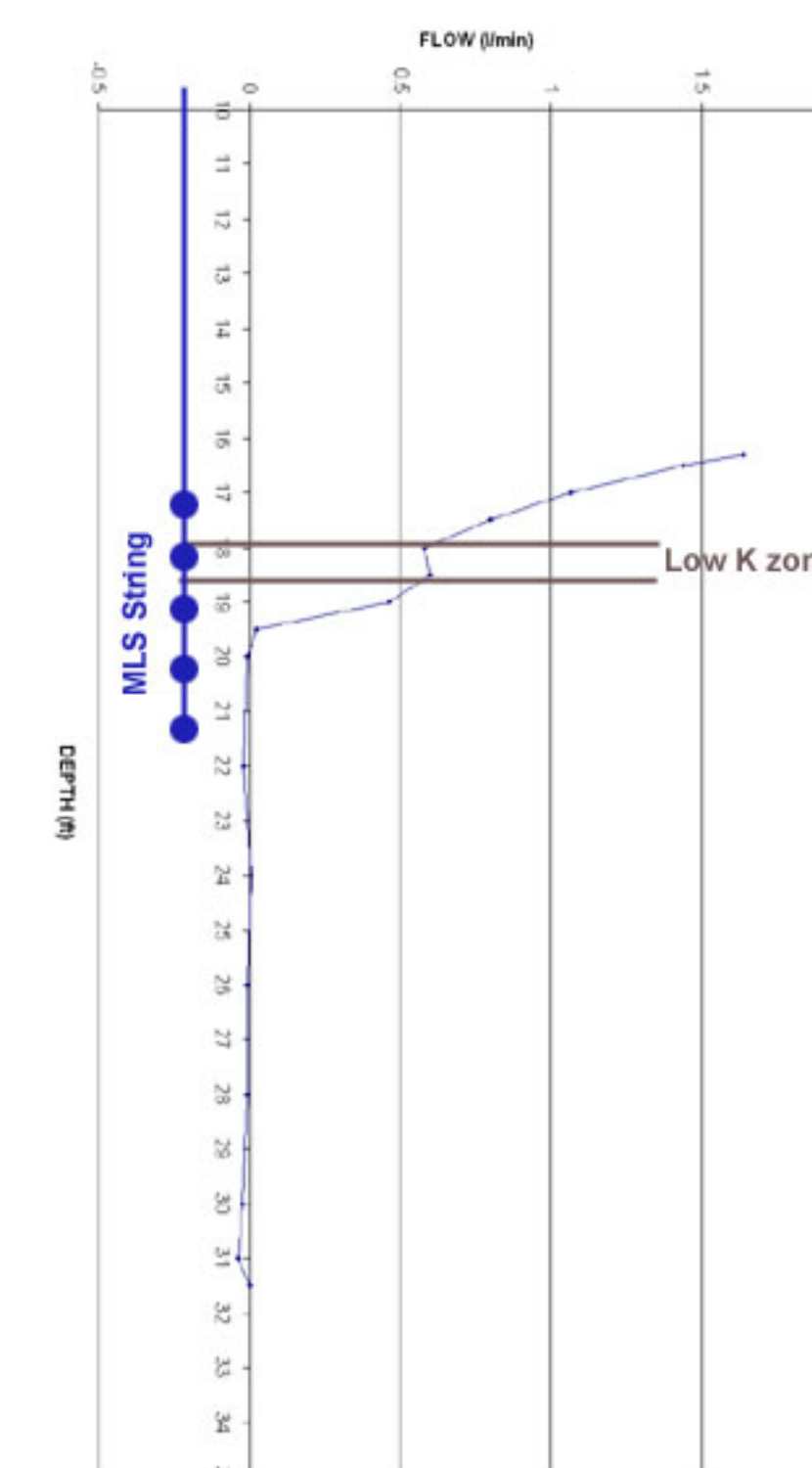
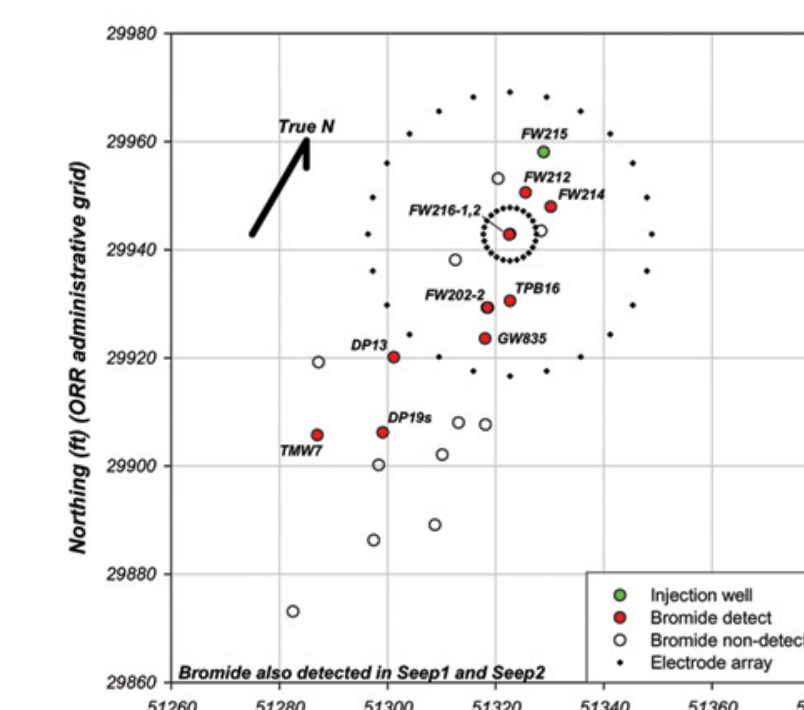


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## Core/Well Data

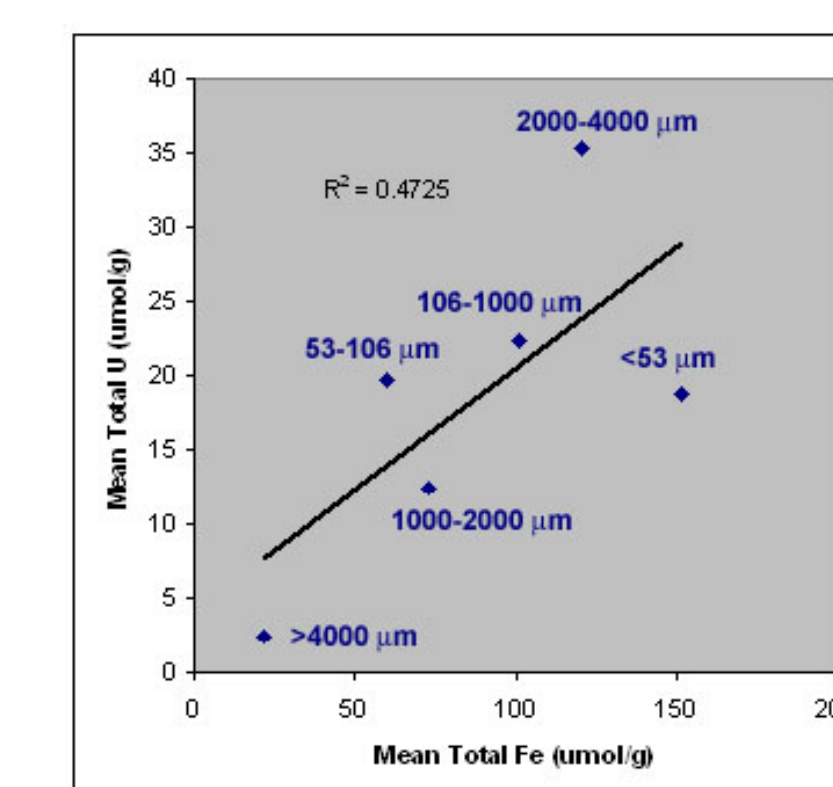
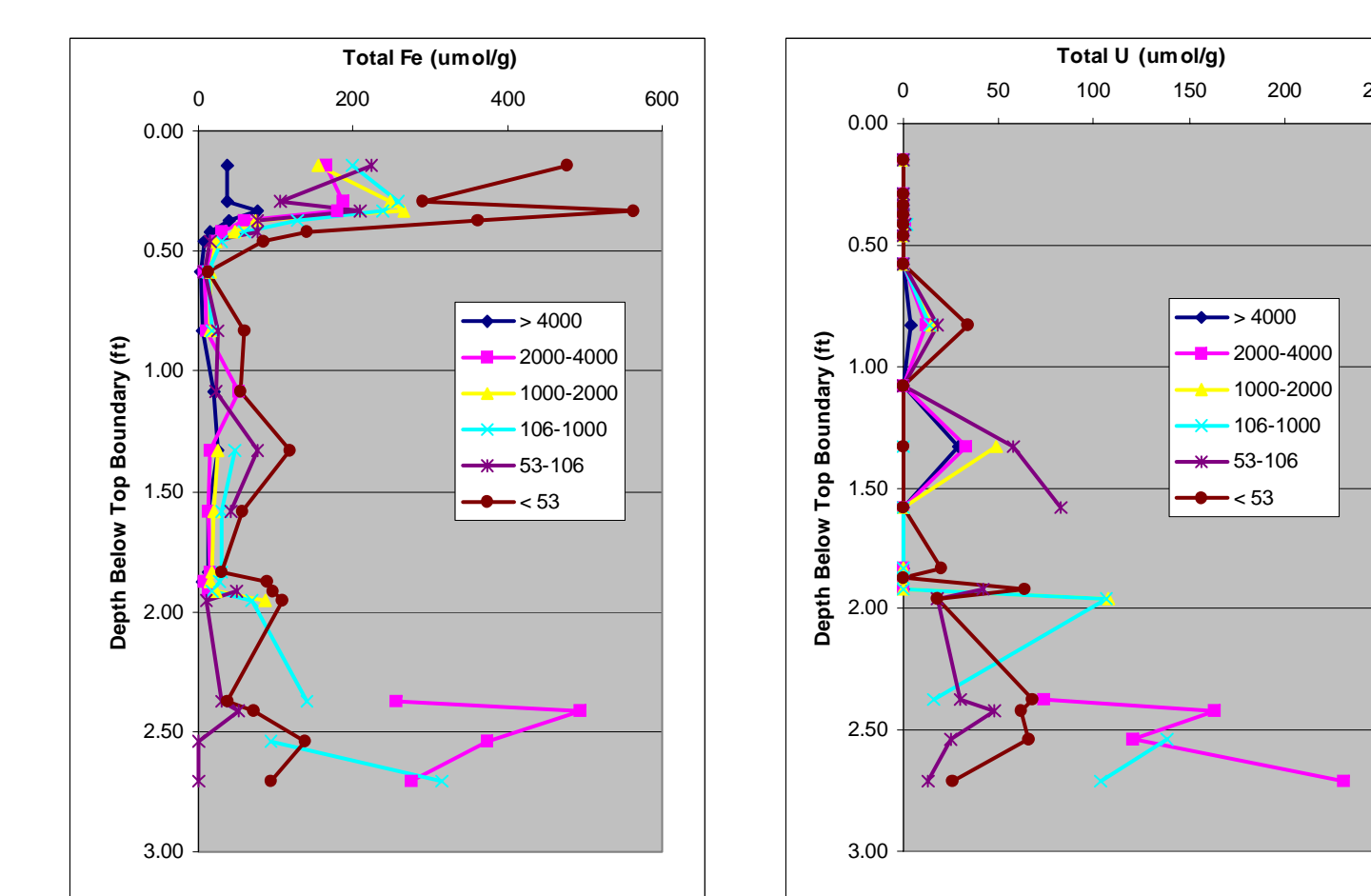


Right: Map of experimental cell showing those wells with bromide breakthrough



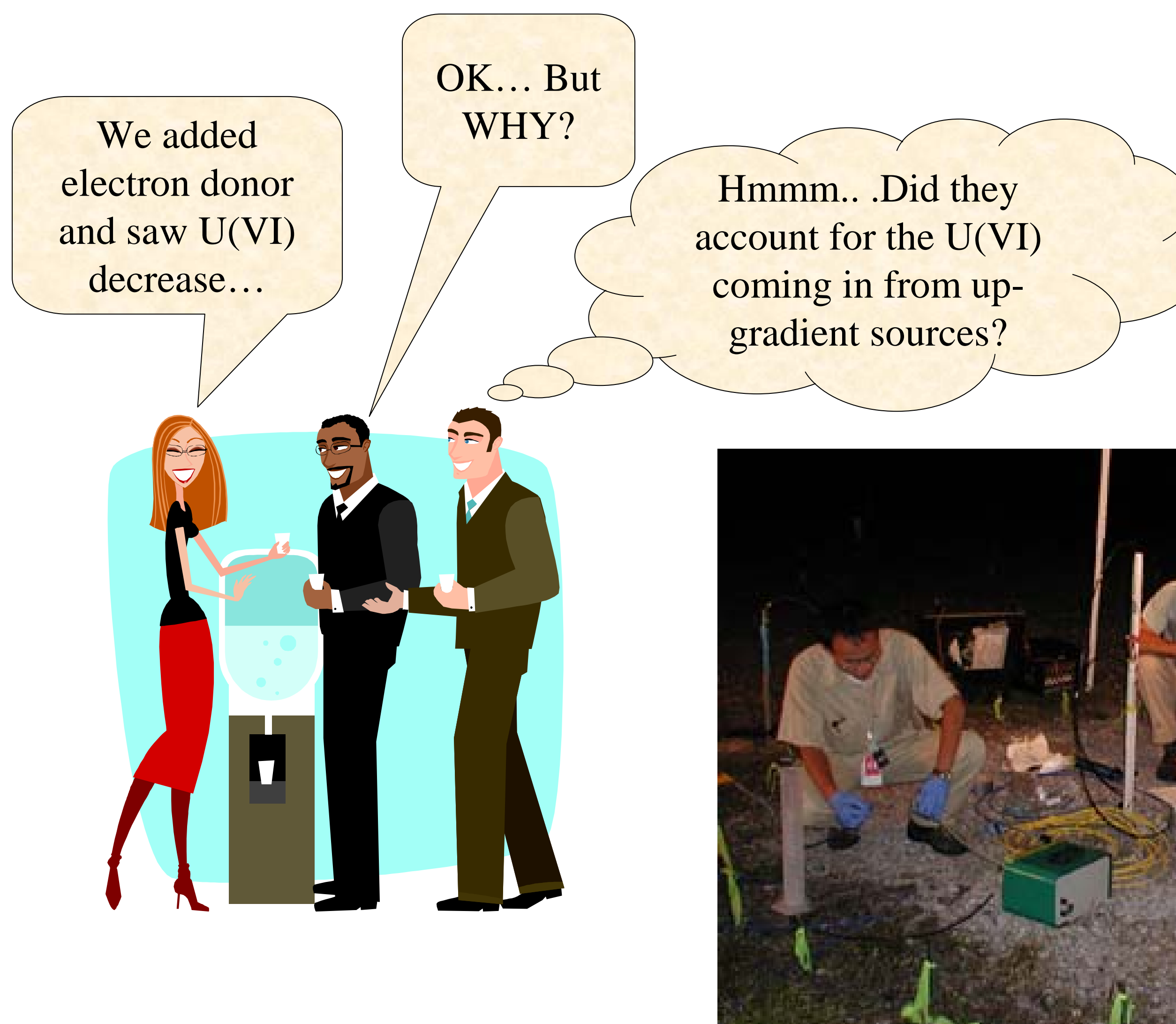
Above: Borehole flowmeter data from well GP-01. Total pumping rate = 2 L/min.

## GP01 – Geophysical Well Installed Feb. 2005

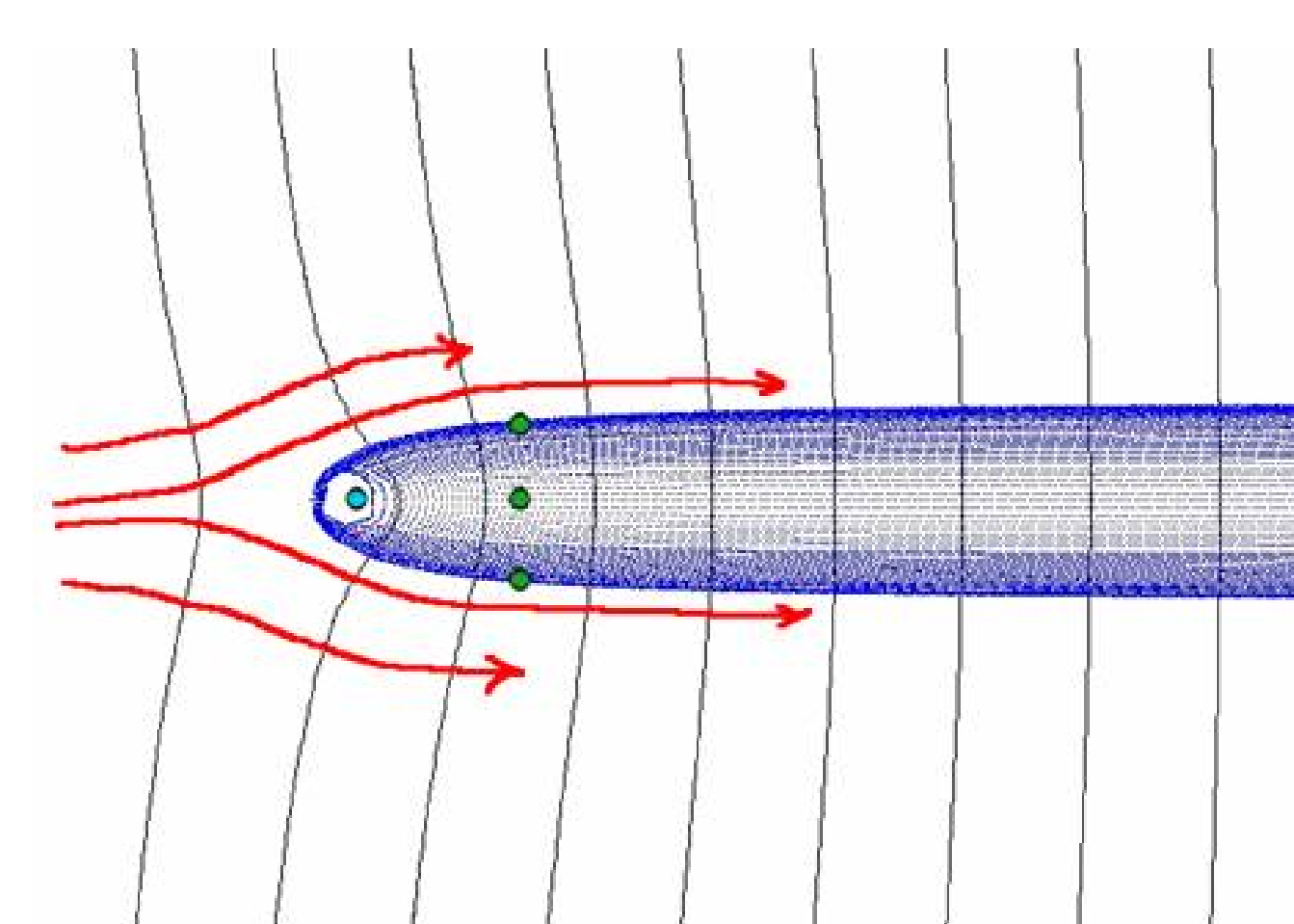


## Tracer Test / Flush Experiment

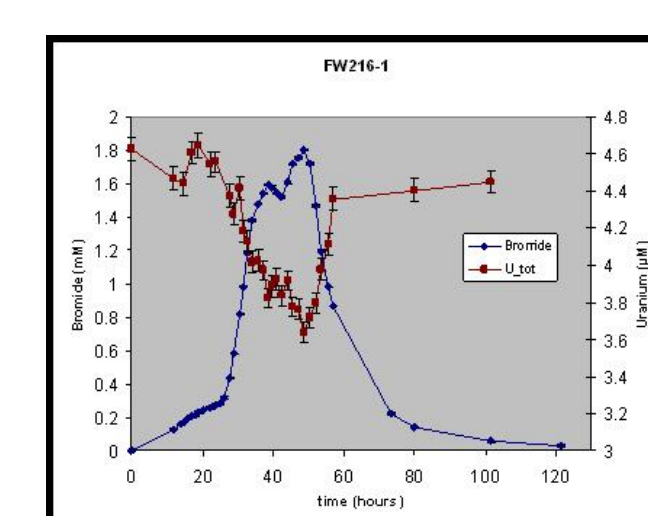
**CRITICAL ISSUE:** How to test hypothesis at the field scale?



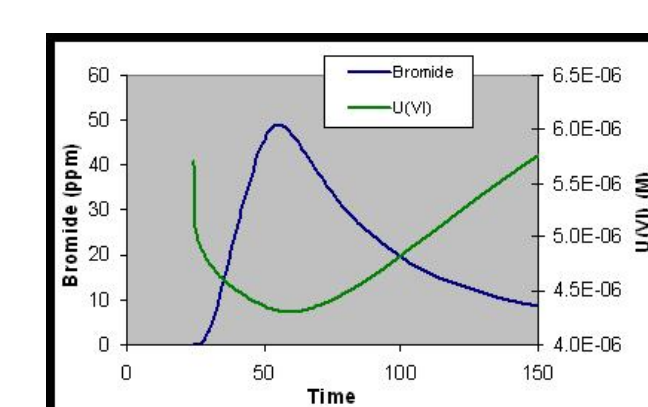
## EXPERIMENTAL CONCEPT: Flush Experiment for Mass Transfer Rate Determination



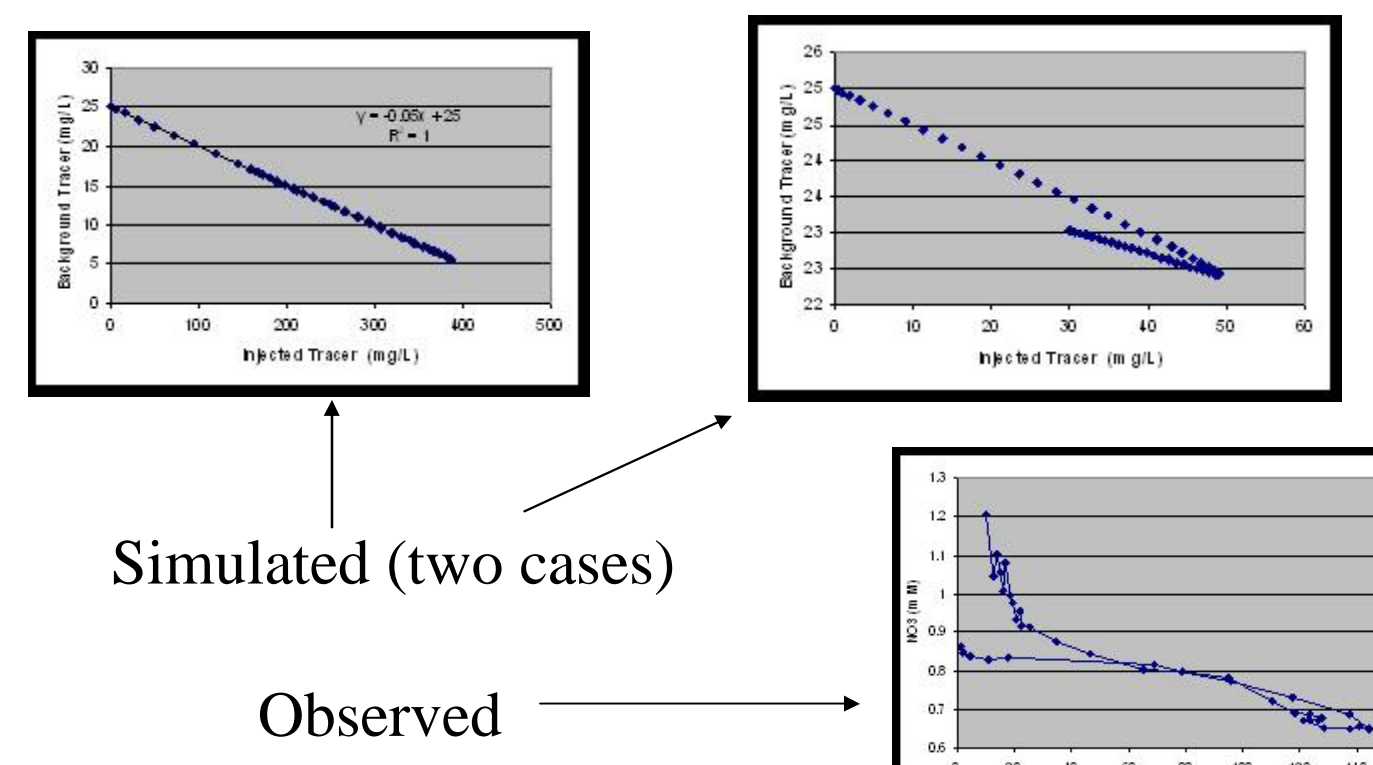
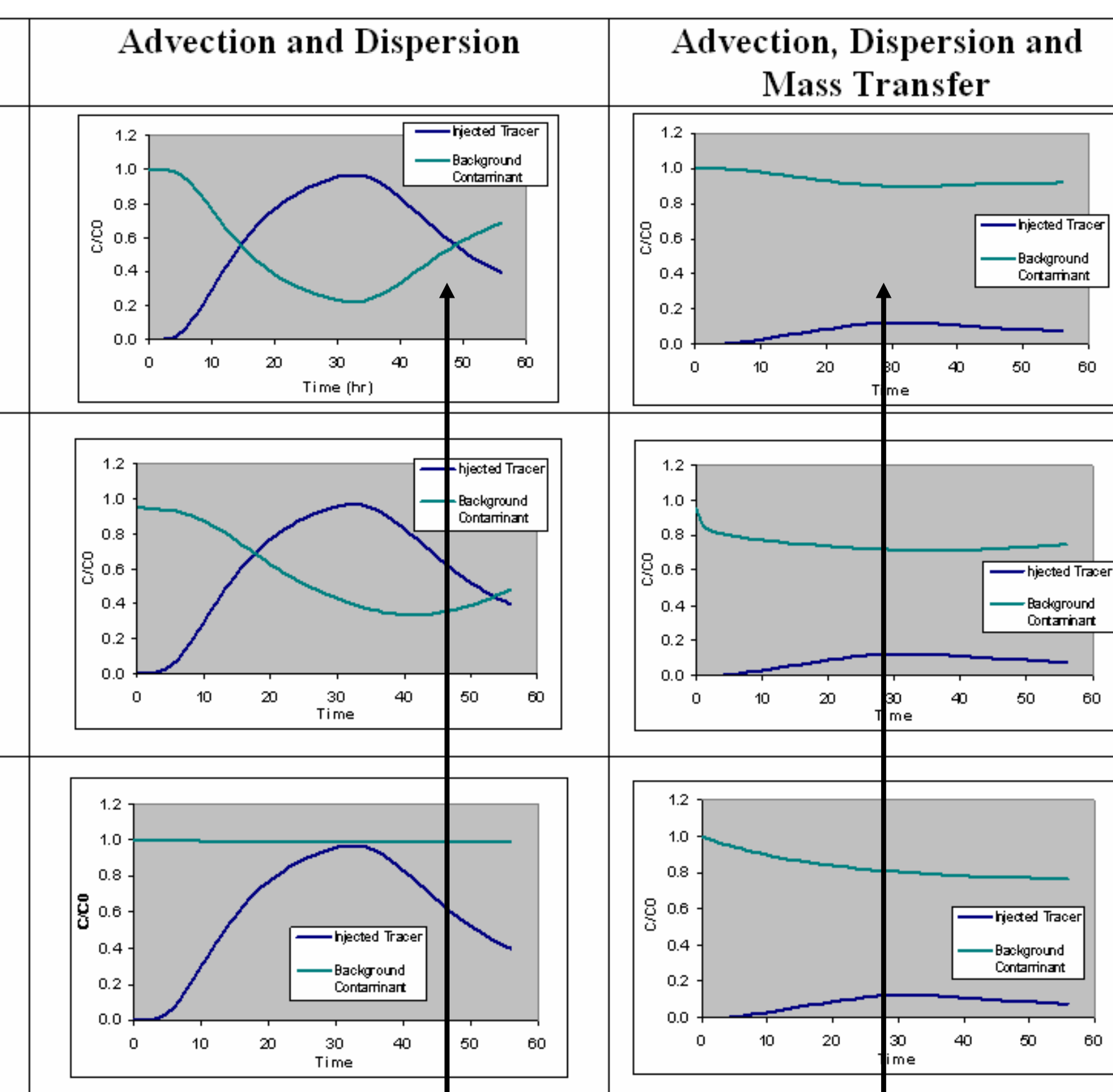
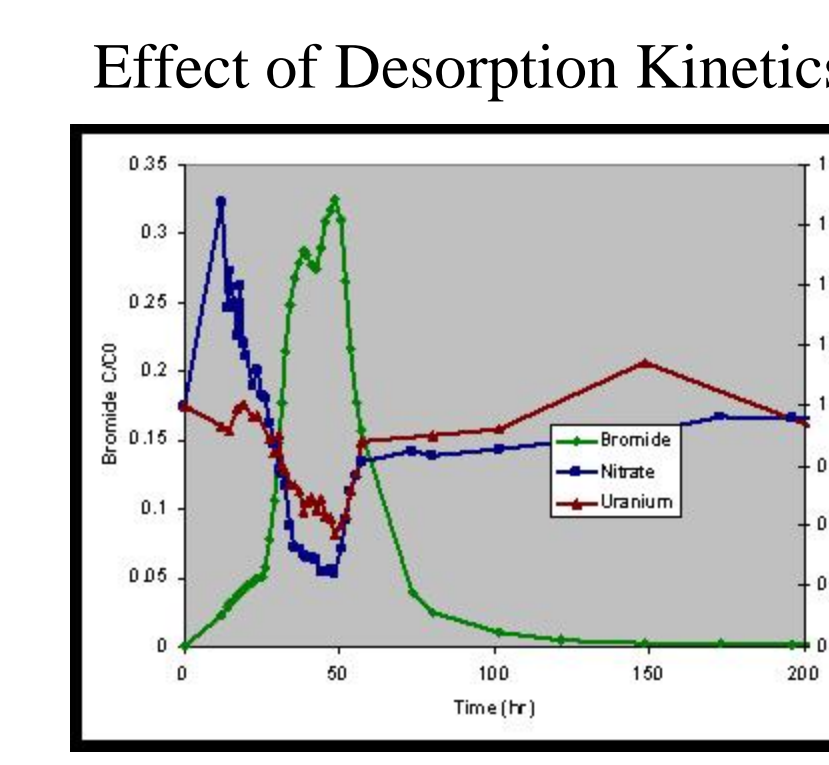
Schematic diagram showing streamlines of injected water (with tracer) in dark blue and diverted streamlines under injection conditions of contaminated water flowing into the study zone from upgradient (red lines with arrows). The light blue circle represents the injection well (i.e., FW215) and dark green circles represent nearby monitoring points (FW212, FW213, FW214). Contours of hydraulic head are indicated by the grey lines. Accessible porosity within the zone of the aquifer encompassed by the blue streamlines is "flushed" of ambient contamination during the injection event. Any remaining solutes must then be provided from a local source (e.g., desorption and/or mass transfer from secondary porosity or a non-advective zone)



Observed



Simulated



Simulated (two cases)

Observed