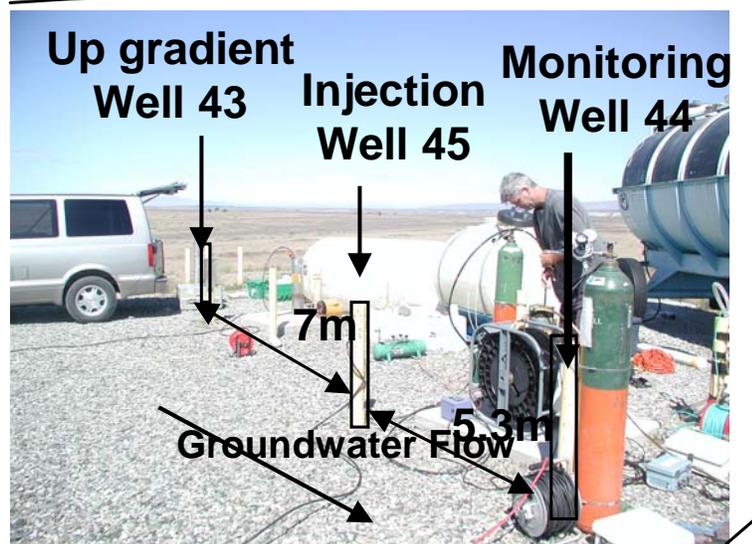
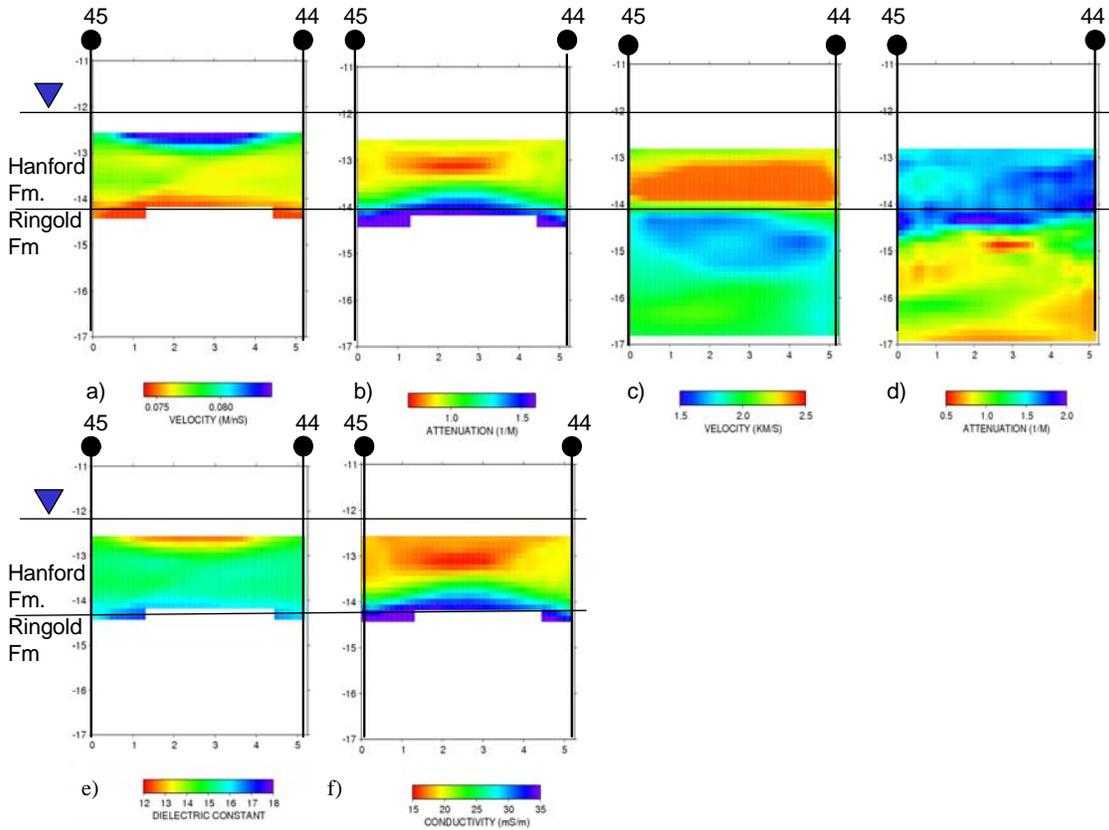




Experimental timetable, indicating dates of HRC injection, tracer tests, geophysical acquisition campaigns, and pumping activity. Radar (R) and seismic (S) tomographic datasets were collected together for all campaigns, except where noted.

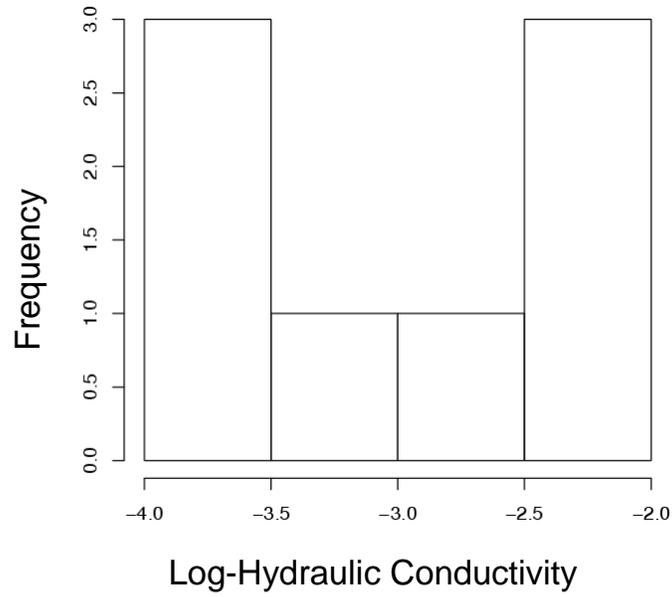
<u>Activity</u>	<u>Date</u>	<u>Days relative to HRC Injection</u>
KBr Injection	Aug. 1, 2004	-2
Baseline Geophysical Campaign	Aug. 3, 2004	0
HRC Injection	Aug. 3, 2004	0
Geophysical Monitoring (S)	Aug. 4, 2004	1
Pump turned on	Aug. 5, 2004	2
Geophysical Monitoring(R)	Aug. 5, 2004	2
Geophysical Monitoring (S)	Aug. 5, 2004	2
Geophysical Monitoring (R)	Aug. 6, 2004	3
Geophysical Monitoring	Aug.16, 2004	13
Pump turned off	Aug.30, 2004	27
Geophysical Monitoring	Sept. 2, 2004	30
Geophysical Monitoring	Oct 28, 2004	86
Geophysical Monitoring	June 1, 2005	302
Geophysical Monitoring	June 7, 2005	308
Pump turned on, KBr injection	June 7, 2005	308
Geophysical Monitoring	June 9, 2005	310
Geophysical Monitoring	June 23, 2005	324
Pump turned off	July 11, 2005	342
Geophysical Monitoring ®	Aug. 8, 2005	370
Geophysical Monitoring	March 30, 2006	604
Pump turned on, KBr injection	Apr. 10, 2006	615
Pump turned off	May 2, 2006	637
Geophysical Monitoring	June 7, 2007	1008

## 'Baseline' Images between Wells 45 and 44



# Baseline Hydrogeological Heterogeneity

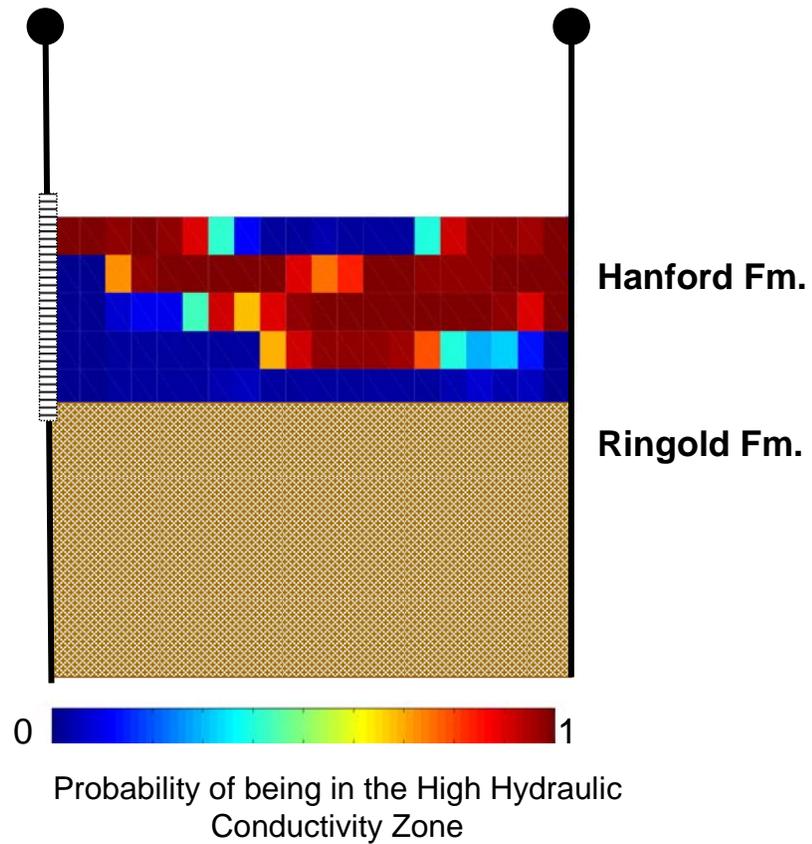
a)



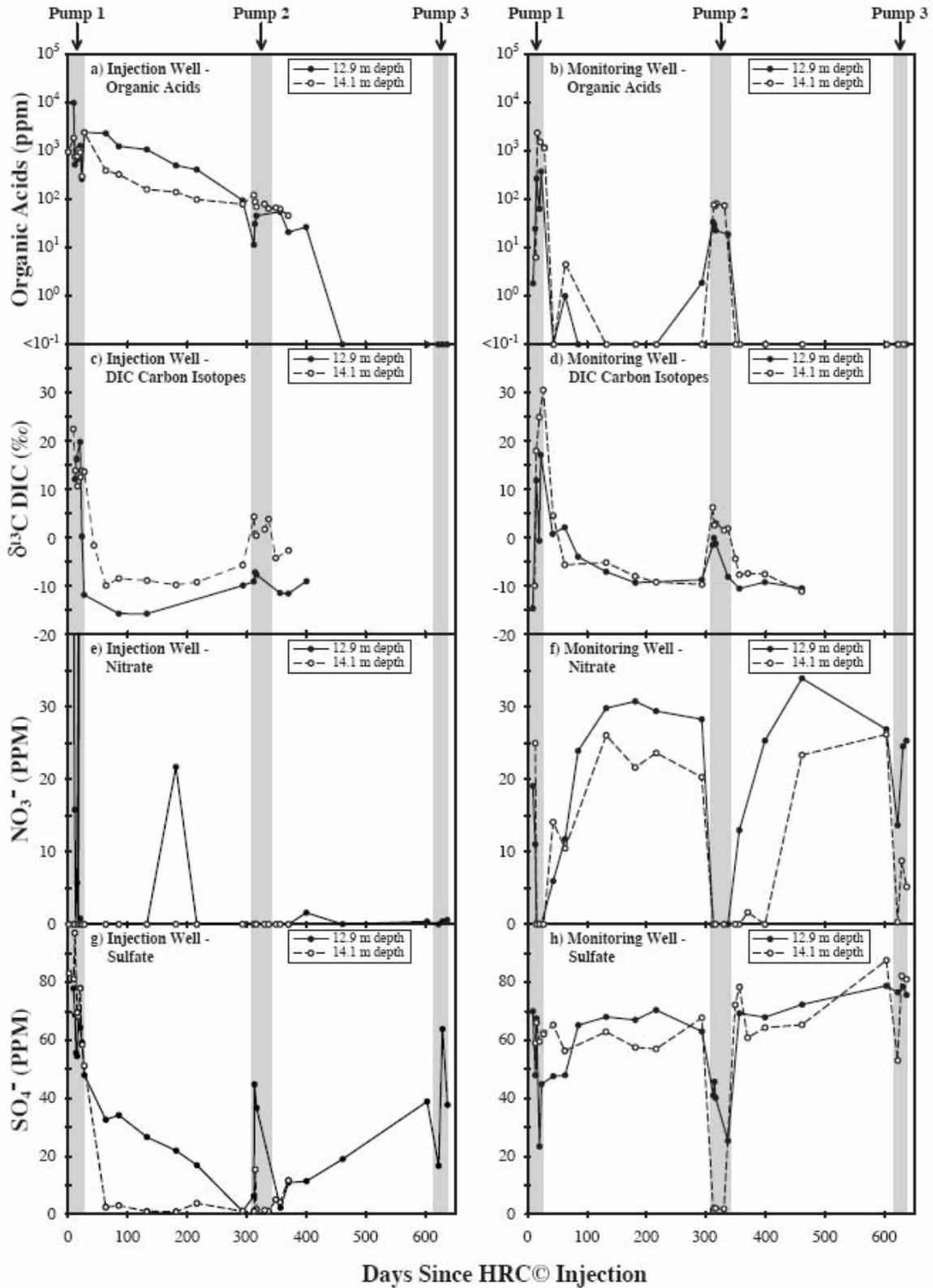
Injection Well 45

Monitoring Well 44

b)

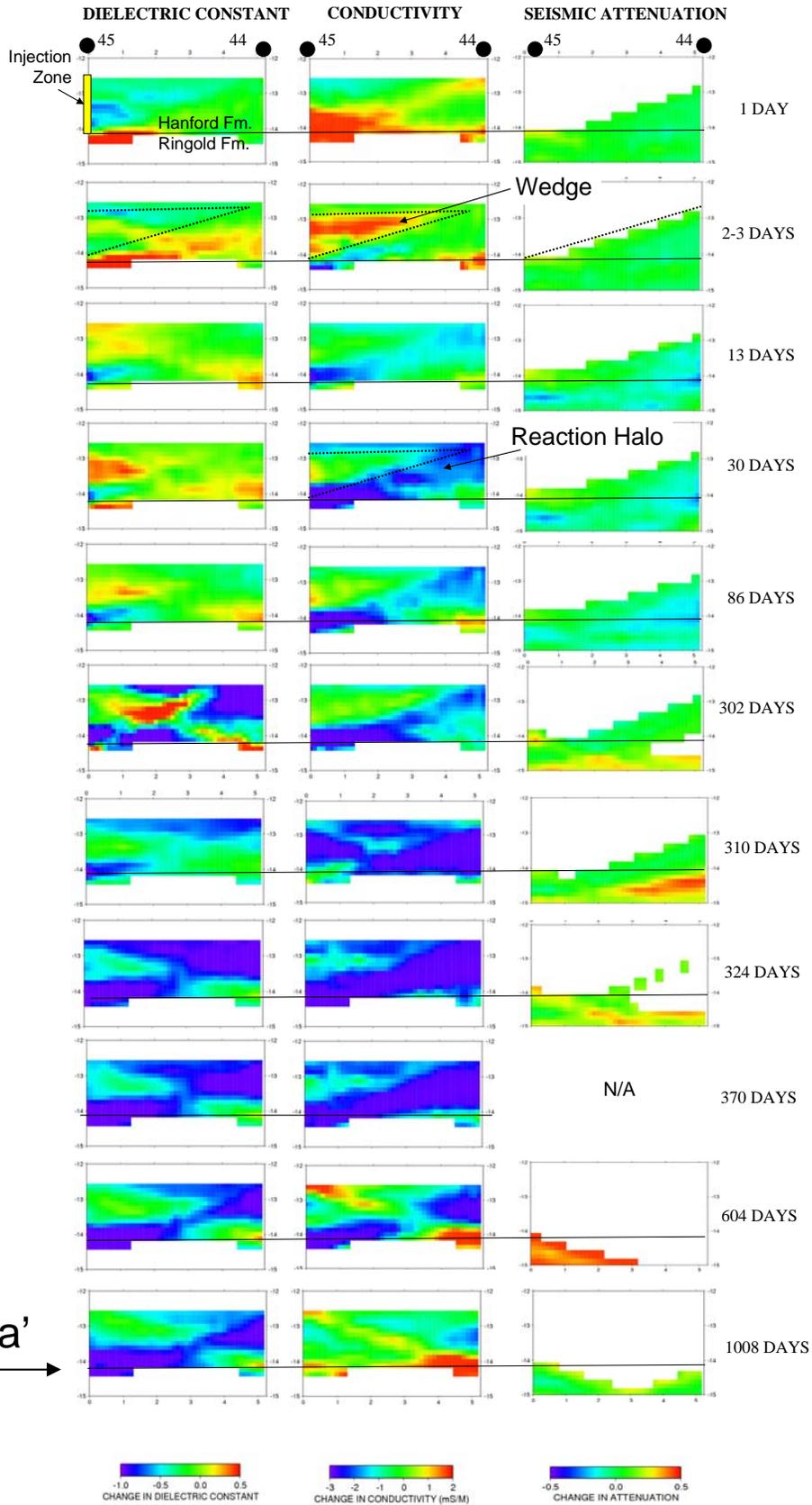


# Wellbore Monitoring Data: Aq Geochemistry (M. Conrad)



# Geophysical Monitoring Data

## WELL PAIR 45-44



'New data'



# Interpretation

based on lab experiments and time-lapse field geochemistry and geophysical datasets

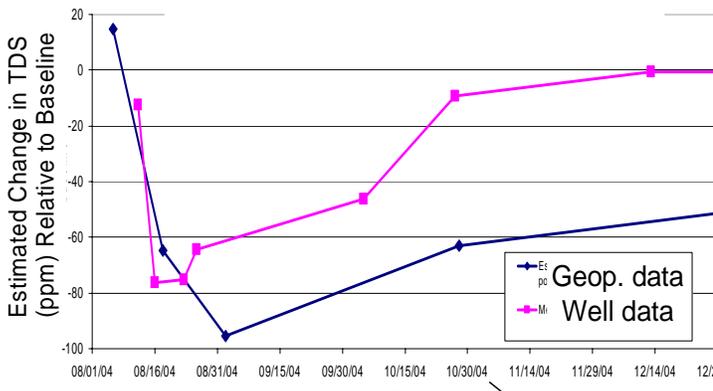
## Early Stage Transformations

(< or = 3 days).

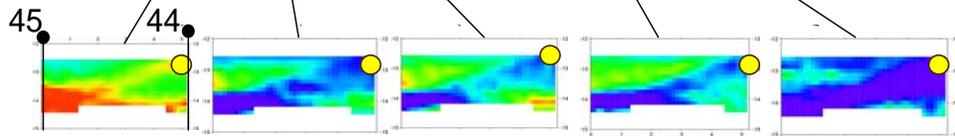
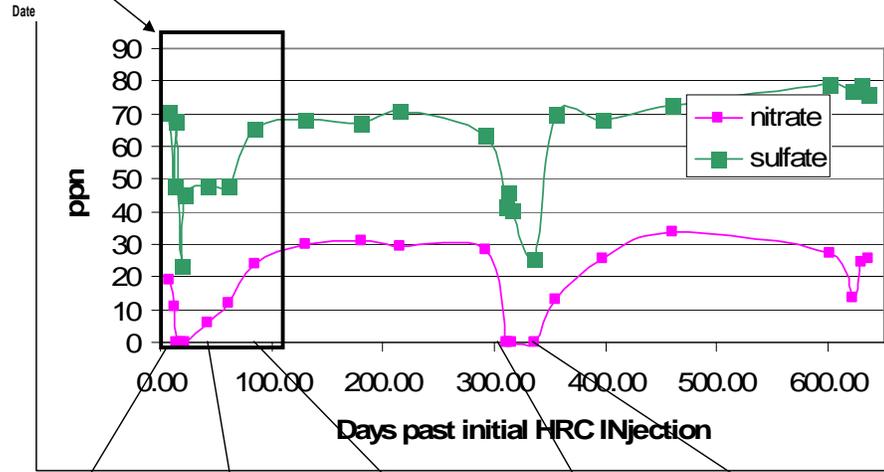
- Replacement of groundwater by the electron donor dominated the system response.
- Comparison of the interpretation of the HRC distribution with the hydraulic conductivity zonation estimates suggests that heterogeneity played a critical role in the distribution of the amendment within the higher hydraulic conductivity zone and along the Hanford-Ringold interface.

## Intermediate Stage Transformations (~13-86 days).

- **The reduction and oxidation of nitrates and sulfates**, which occurred as a function of pumping activity, dominated the system responses during the intermediate stage.
- Other key transformations that occurred during the intermediate stage included the dissolution of calcite and associated increase in porosity near the injection wellbore.



Well 44 (monitoring well)



## Late Stage Transformations

(> or = 302 days).

- **Dominated by solid-phase transformations**, including the development of calcite precipitation in the reaction halo region and associated decreases in porosity.
- In addition to calcite, other minerals (such as FeS) may have formed (it is not possible at this time to infer from the available datasets which of the multiple candidates of potential precipitates may have dominated this late-stage response)
- Additionally, localized regions of gas bubble accumulation were interpreted in the monitoring well vicinity.
- Although geochemical data are currently only available for up to ~2 years after the HRC injection, the last set of geophysical monitoring data suggested that the TDS in the reaction halo region had rebounded toward background conditions; the volume of evolved gas bubbles had decreased; and the porosity reduction was still prevalent at ~3 years post HRC injection.

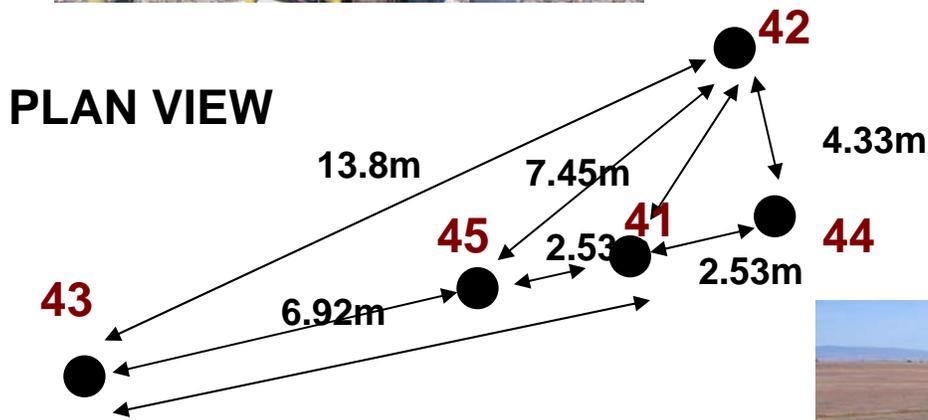
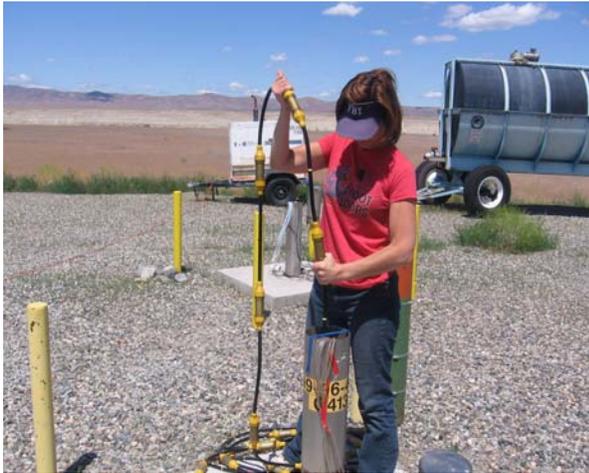
# Observations and Summary

- Study highlighted the benefit of using time-lapse geophysical datasets to monitor biogeochemical transformations associated with a bioremediation treatment at high resolution, over field relevant scales, and in a minimally invasive manner.
- Multiple types of measurements, collected over long periods of time, [help to reduce the ambiguity](#) associated with interpretation of dynamic processes using geophysical datasets.
- Heterogeneity and pumping strategy played a critical role in spatiotemporal distribution of transformations.
- Once developed, such geophysical approaches could conceivably be used in a semi-autonomous and long-term monitoring mode

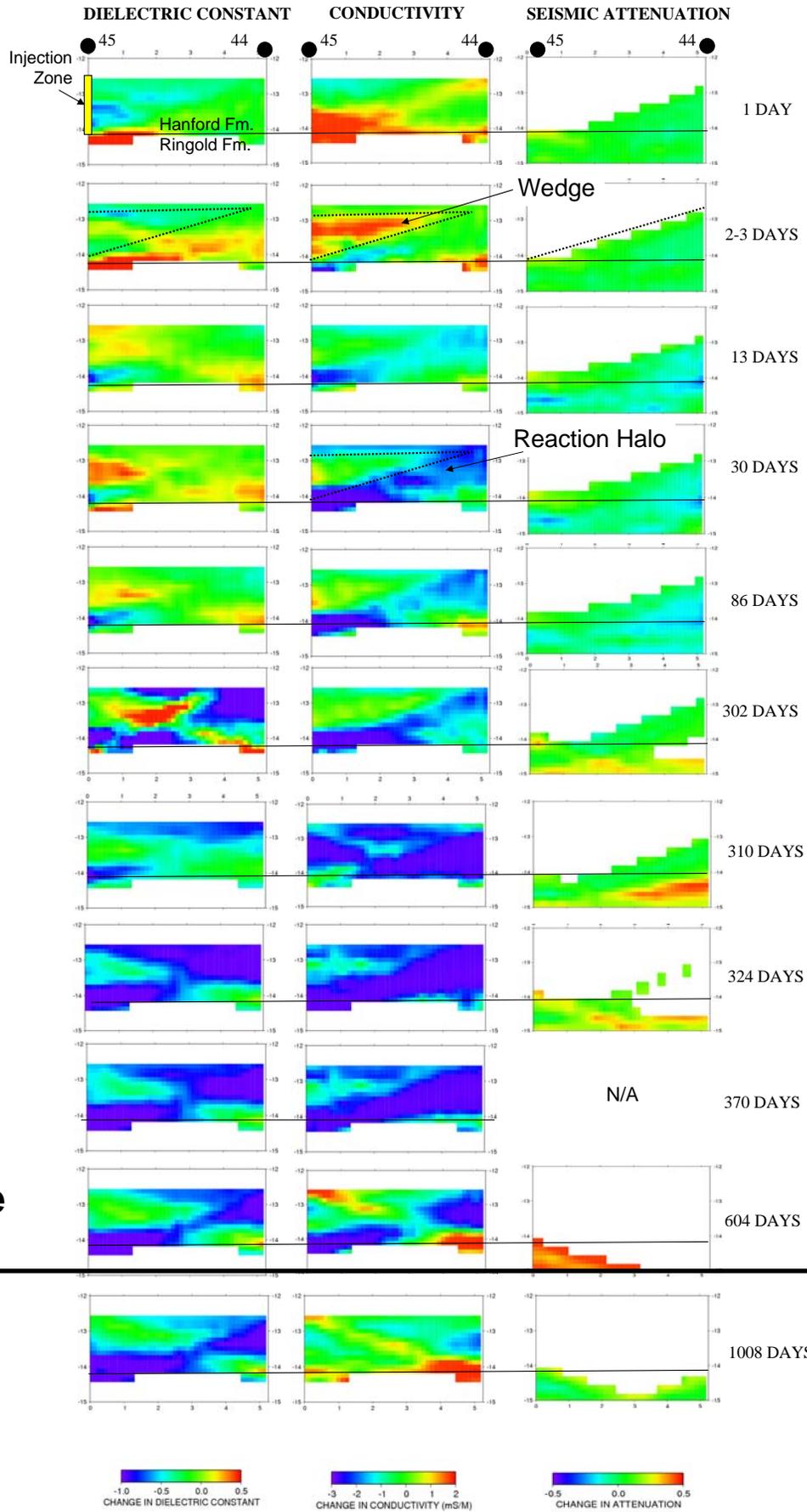
# June 2007 Field Campaign: New Wells



# Geophysical Acquisition: 6 radar tomograms and 10 seismic tomograms

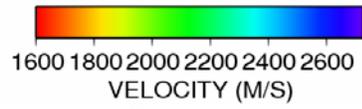
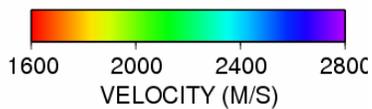
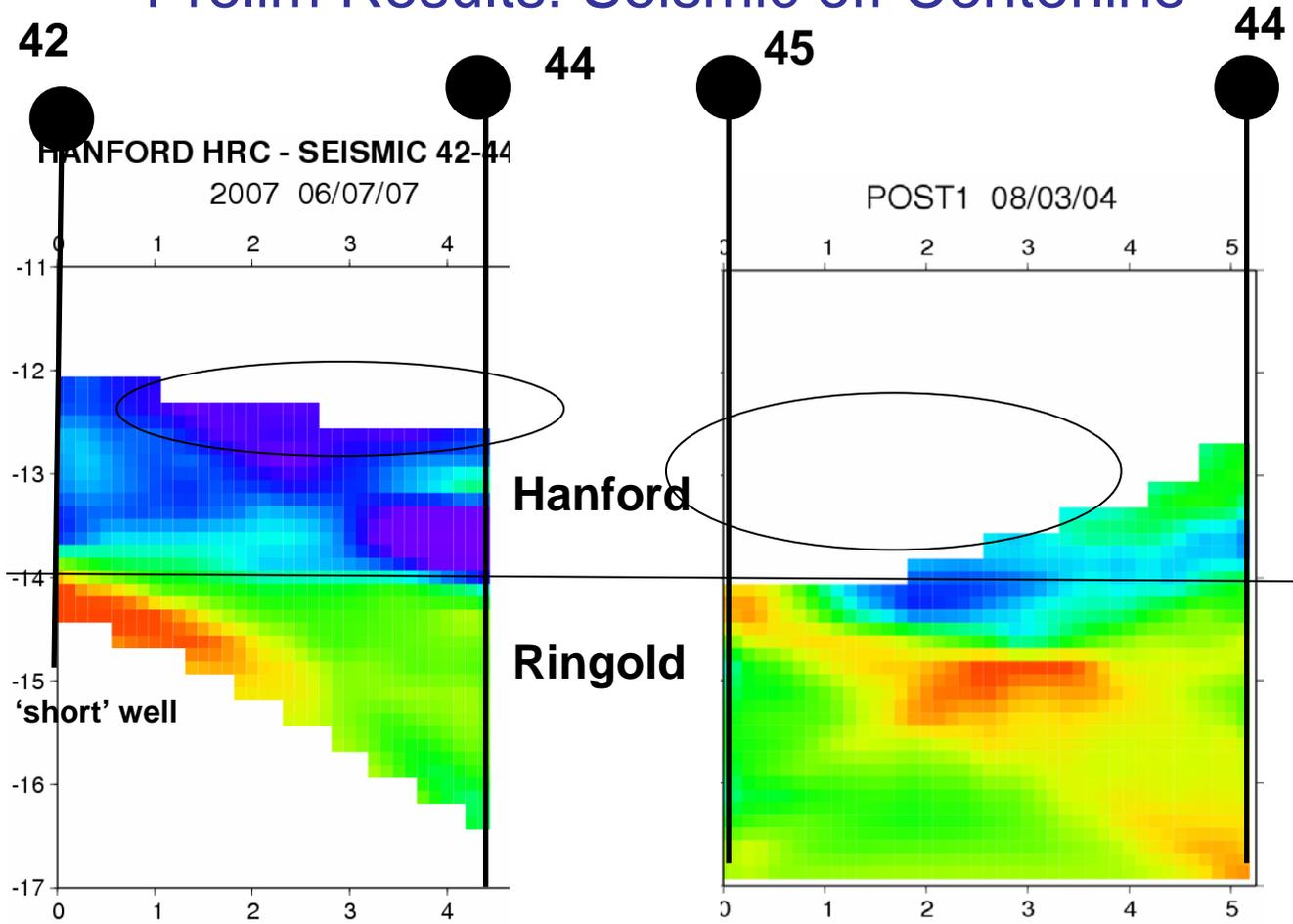


WELL PAIR 45-44

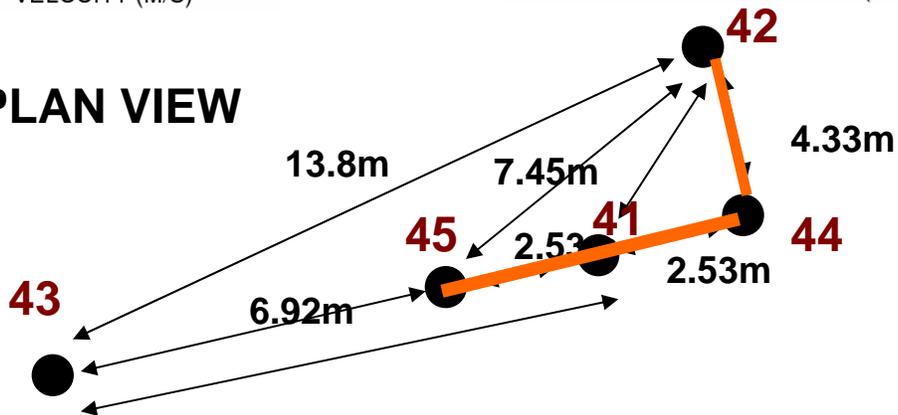


New  
Images  
along  
Centerline

# Prelim Results: Seismic off Centerline

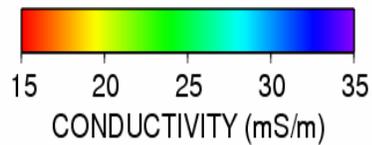
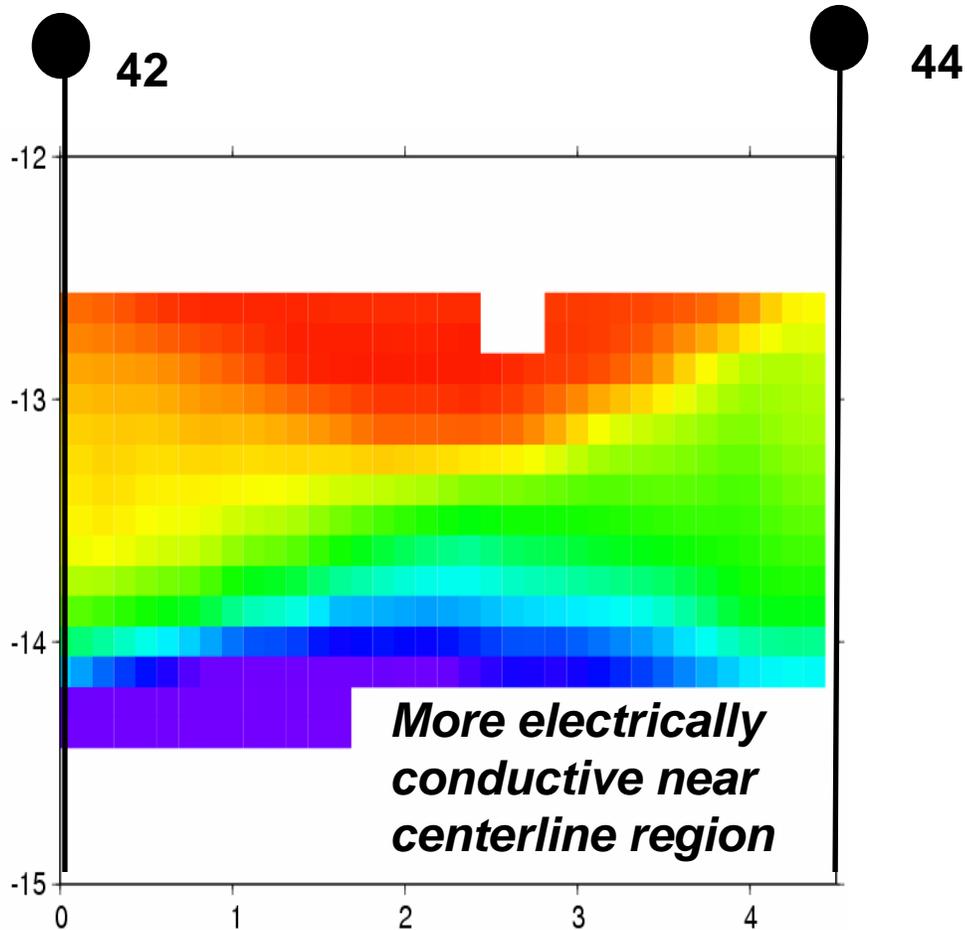


## PLAN VIEW



**Loss of seismic signal consistent parallel and perpendicular to flow**

# Prelim Results: Radar off Centerline



*Processing  
and  
Interpretation  
in Progress!*

## PLAN VIEW

