Experimental Site Design

Vadose Zone Infiltration Plot and Pre-modeling

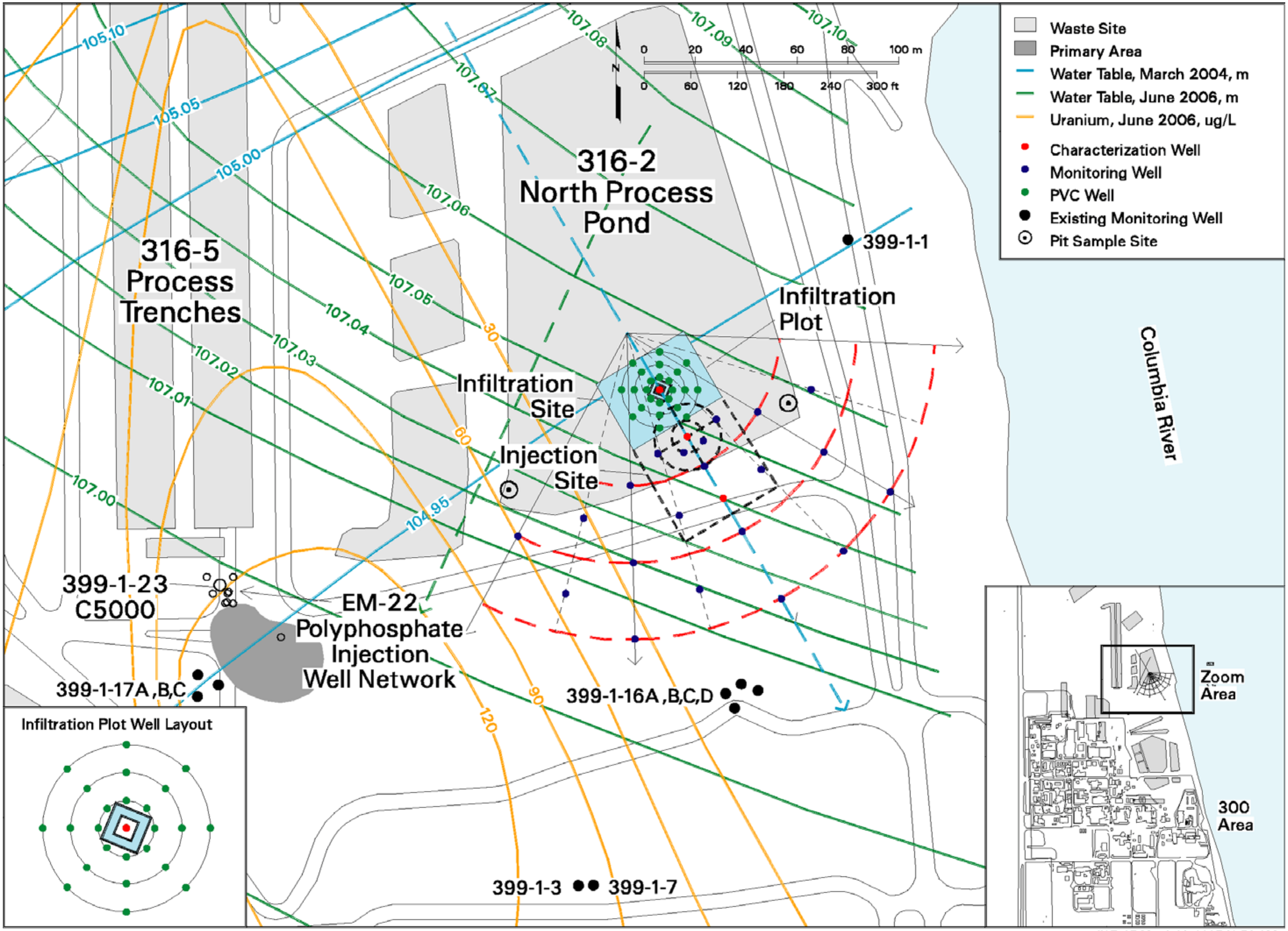
Mark Rockhold, Andy Ward (PNNL) and Roelof Versteeg (INL)

March 21-22, 2007

(PNNL-SA-54548)

Objectives

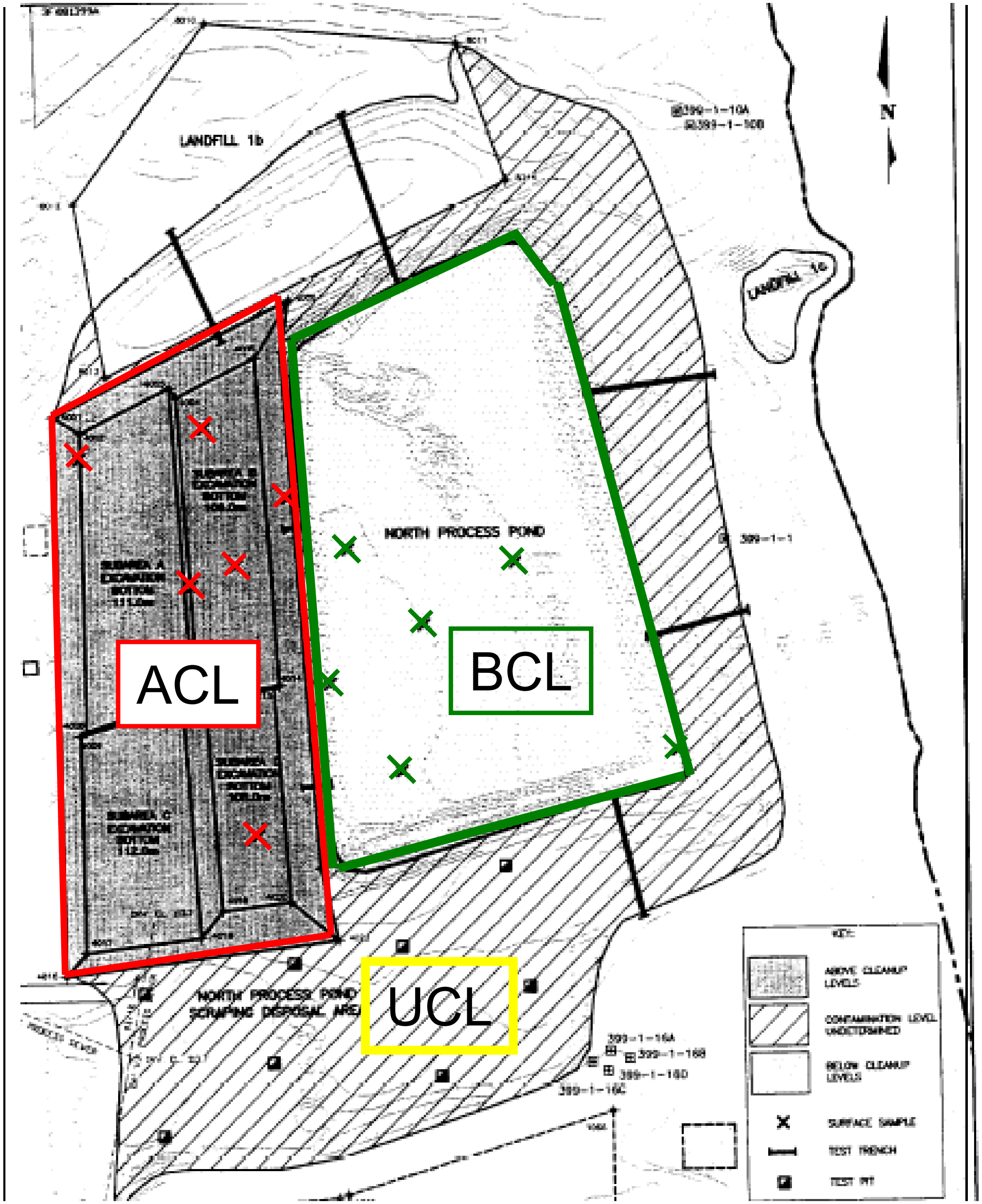
- Design a characterization and monitoring strategy for an infiltration plot (and its surroundings) that will serve as a vadose zone source area for controlled field experiments
  - Water infiltration with reactive chemical species (eg. bicarbonate, phosphate, etc.)
- Track spatial and temporal evolution of water and reactive chemicals
  - Transport and fate of reactive species
  - Influence of multi-scale heterogeneity on mass transfer



can_wil07_05 March 16, 2007 10:59 AM

N. Process Pond Remedial Action

- scraping and sediment removal



ACL = Above Cleanup Levels

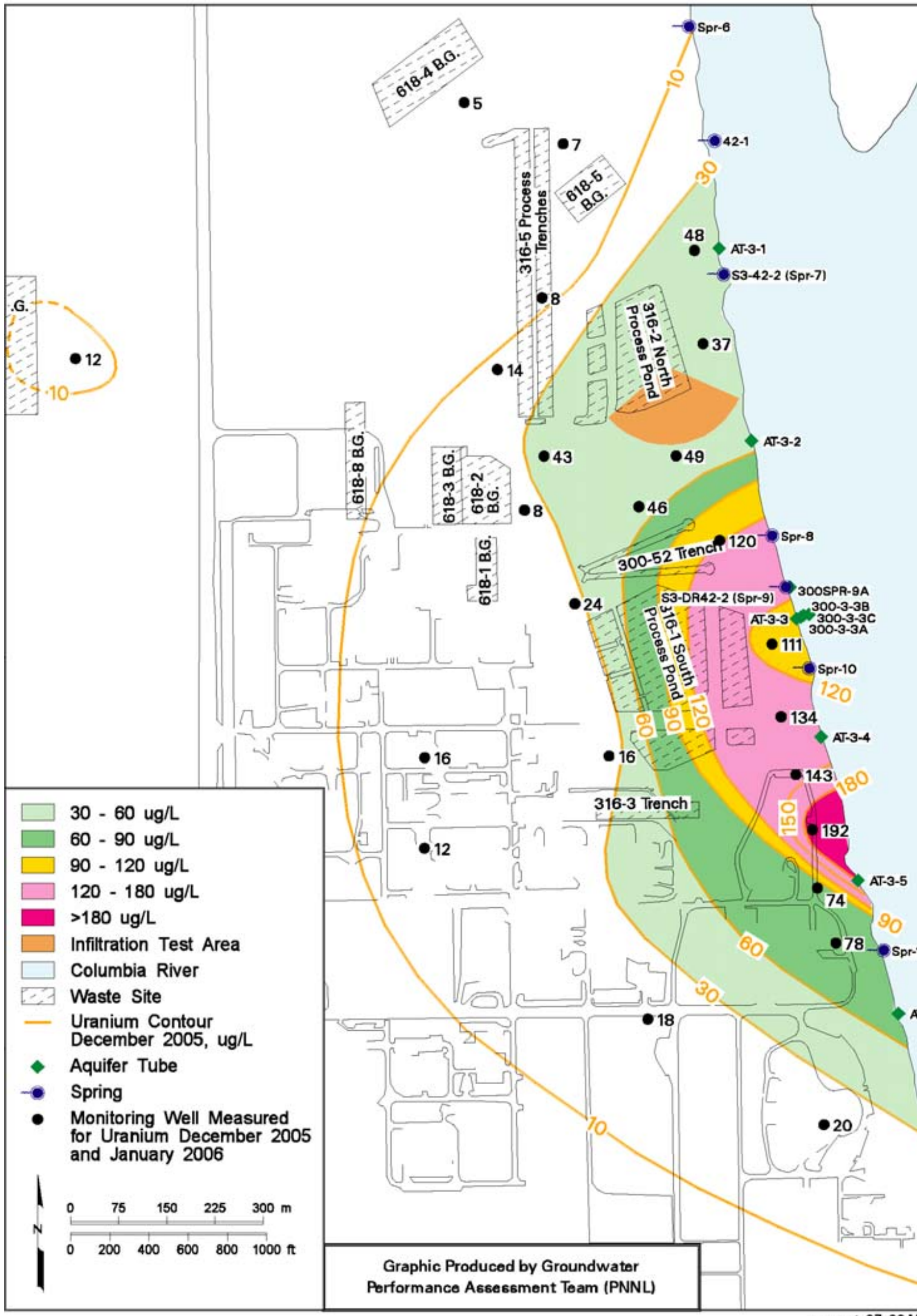
BCL = Below Cleanup Levels

UCL = Undetermined Contamination Level

× = Surface samples

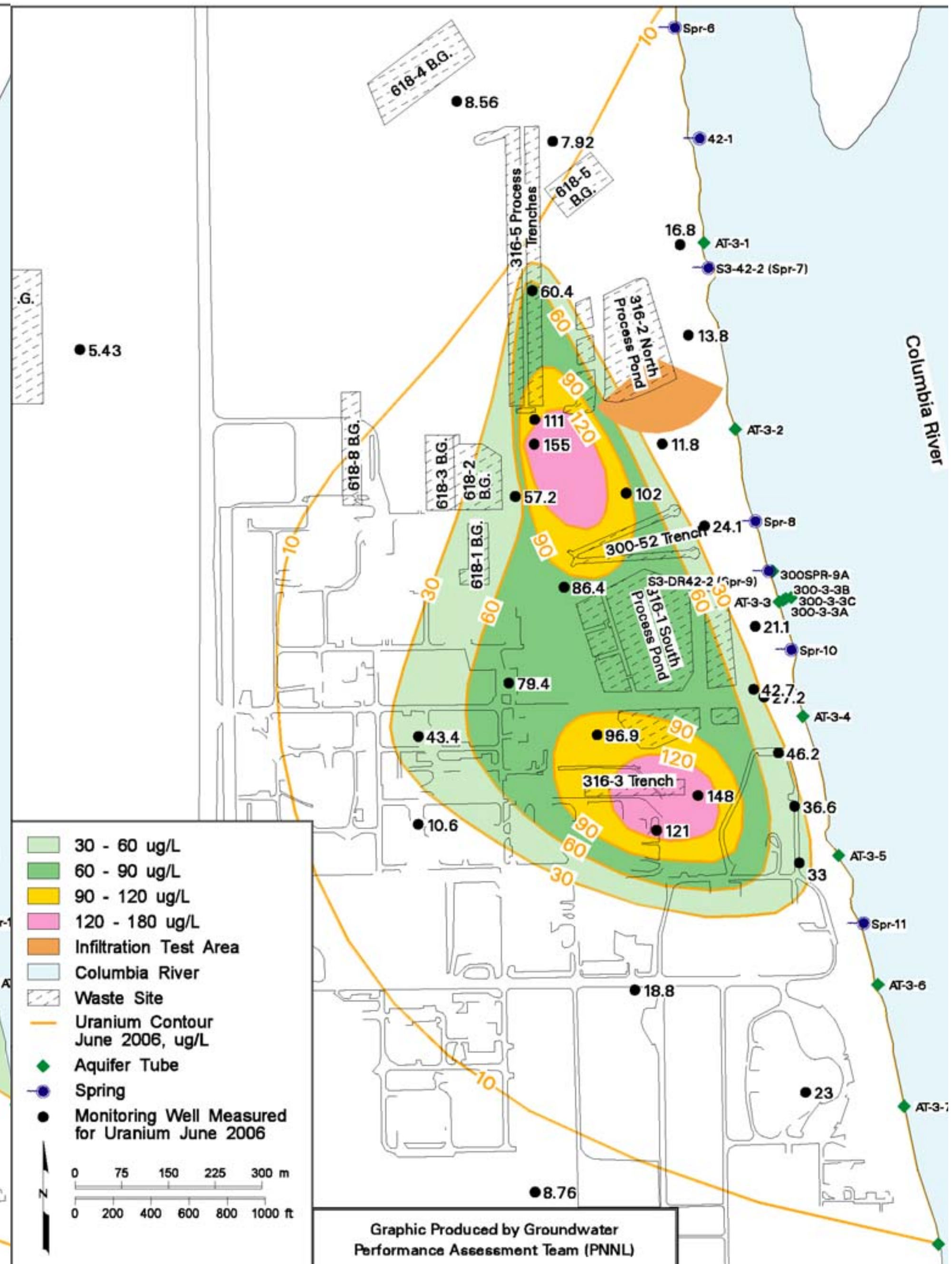
<u>Reference:</u> Lerch JA, 1999, 300-FF-1 Operable Unit, North Process Pond/ Scraping Disposal Area Verification Package. BHI-01298.

300 Area Uranium, December 2005



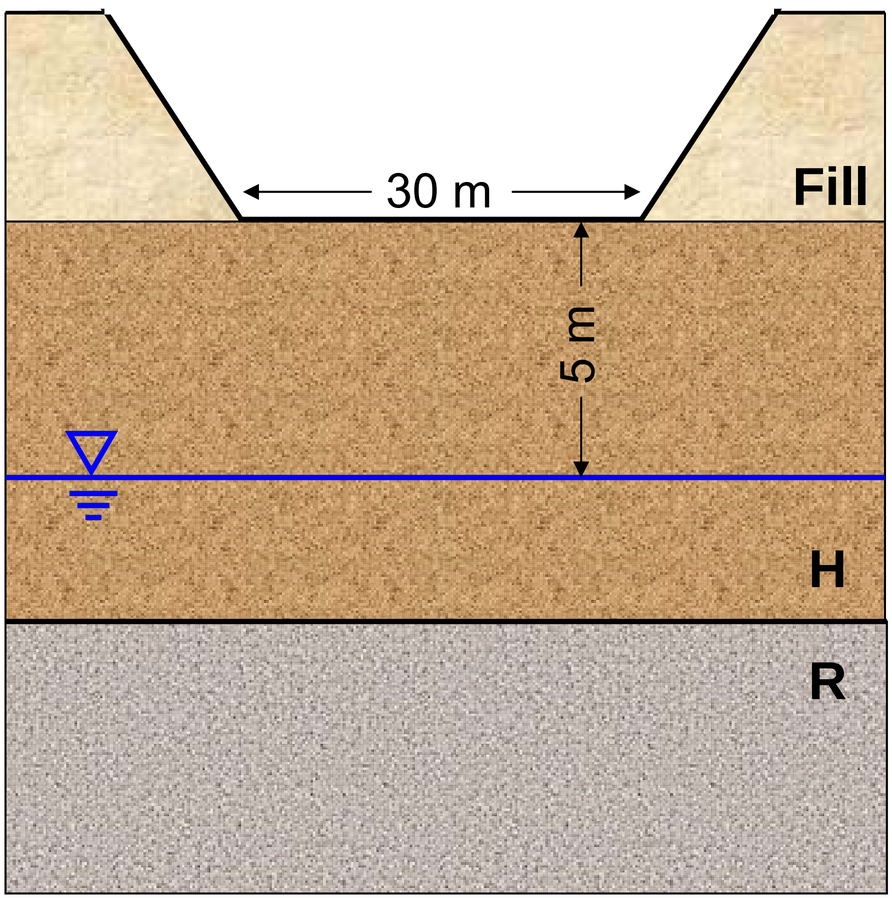
can pete07 09 M

300 Area Uranium, June 2006



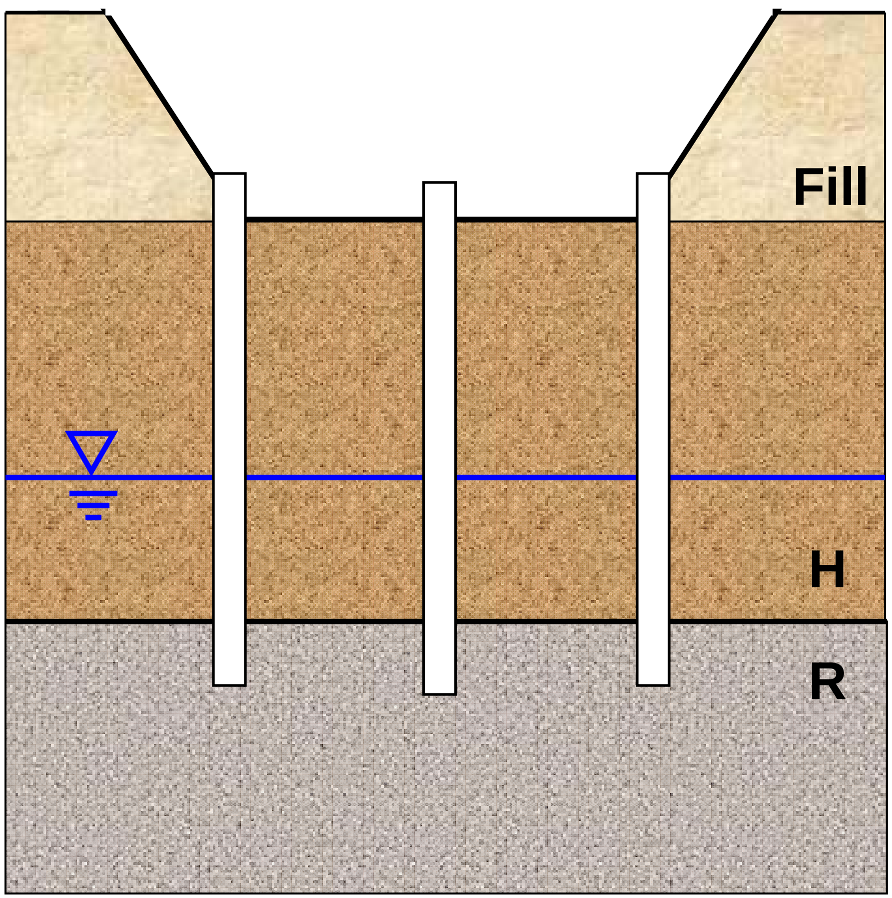
can pete07 10 March 16,

Cross-section depicting development of the infiltration plot



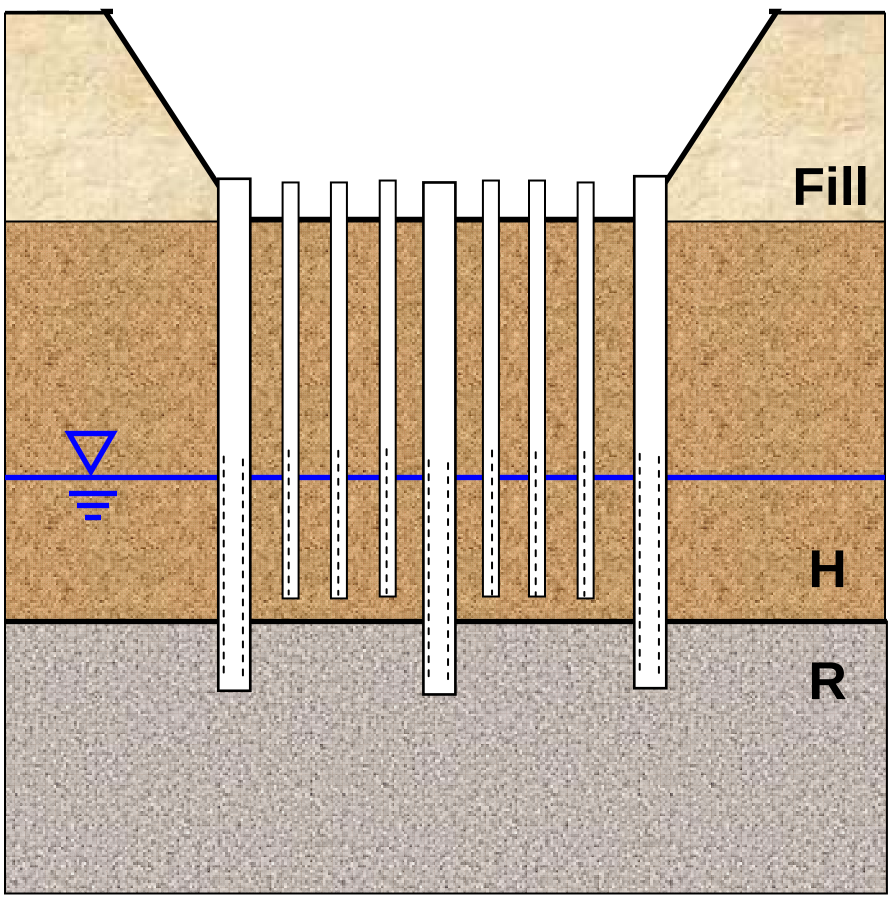
- Excavate fill material to base of former N. process pond

Cross-section depicting development of the infiltration plot



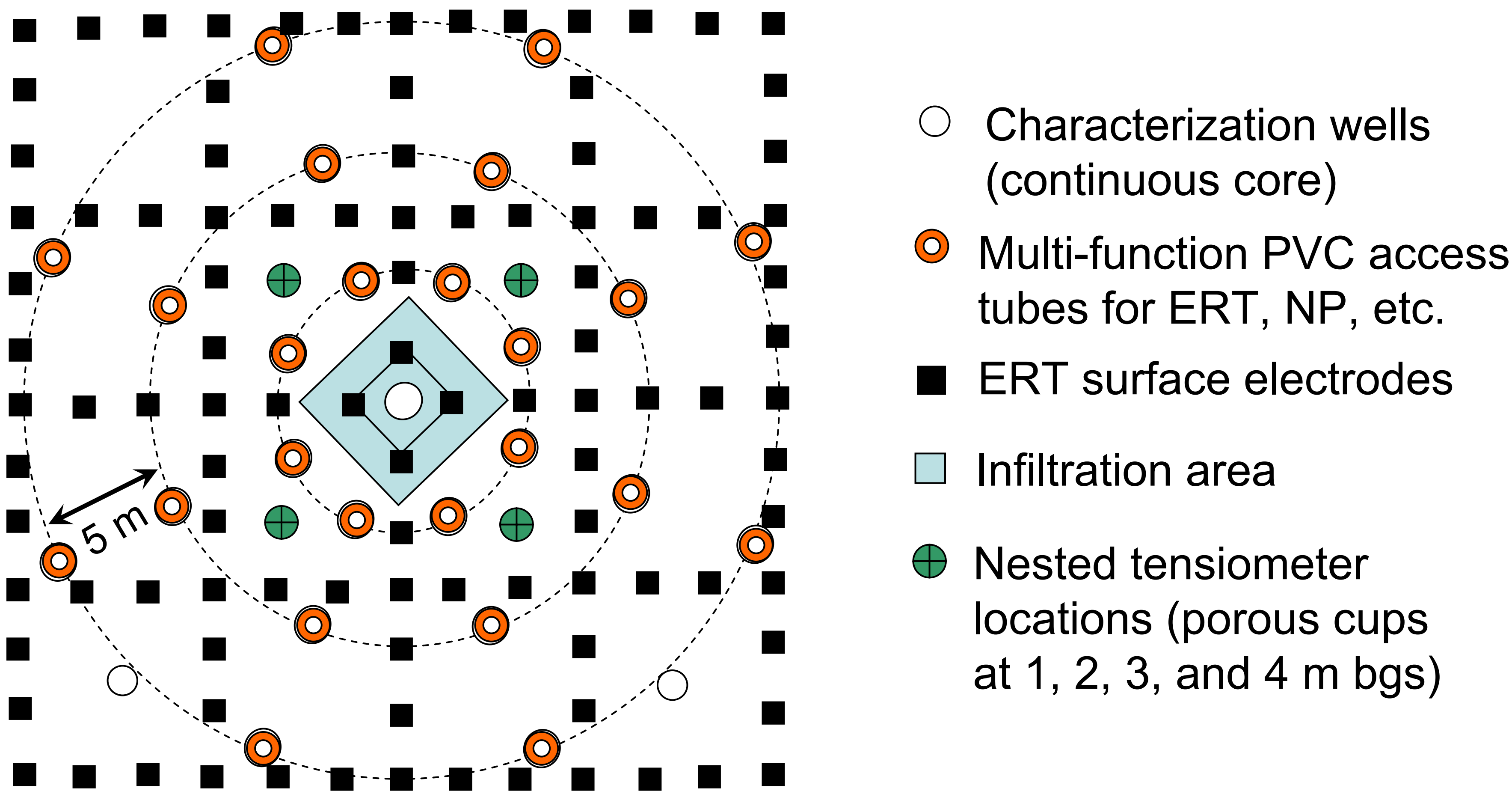
- Excavate fill material to base of former N. process pond
- Install 3 large-diam. (6-8 in) characterization boreholes to top of Ringold fm
  - Moisture content
  - Density and porosity
  - Grain size distribution
  - Hydraulic properties
  - Bulk mineralogy
  - Uranium

Cross-section depicting development of the infiltration plot



- Excavate fill material to base of former N. process pond
- Install 3 large-diam. (6-8 in) characterization borehole to top of Ringold fm
- Install 24 small-diam. (2 in) PVC wells to low-stage water table elev. (~104.5 m)
  - Grab samples for uranium, etc.

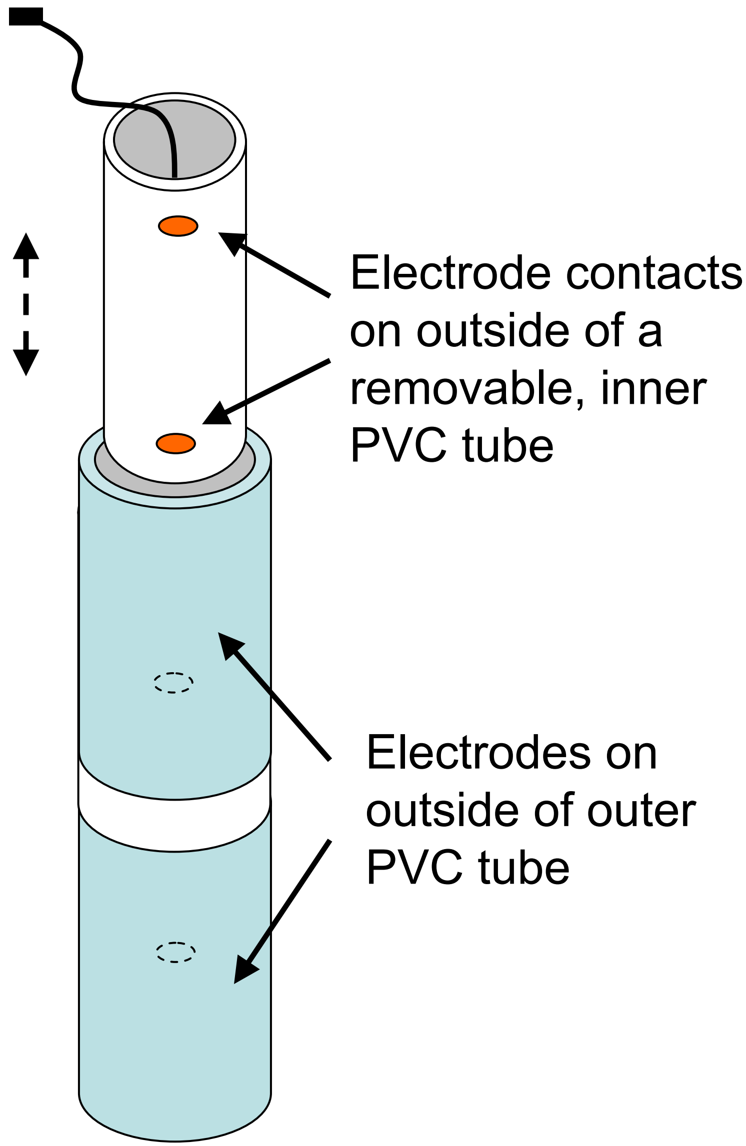
Plan view of infiltration plot



Monitoring data

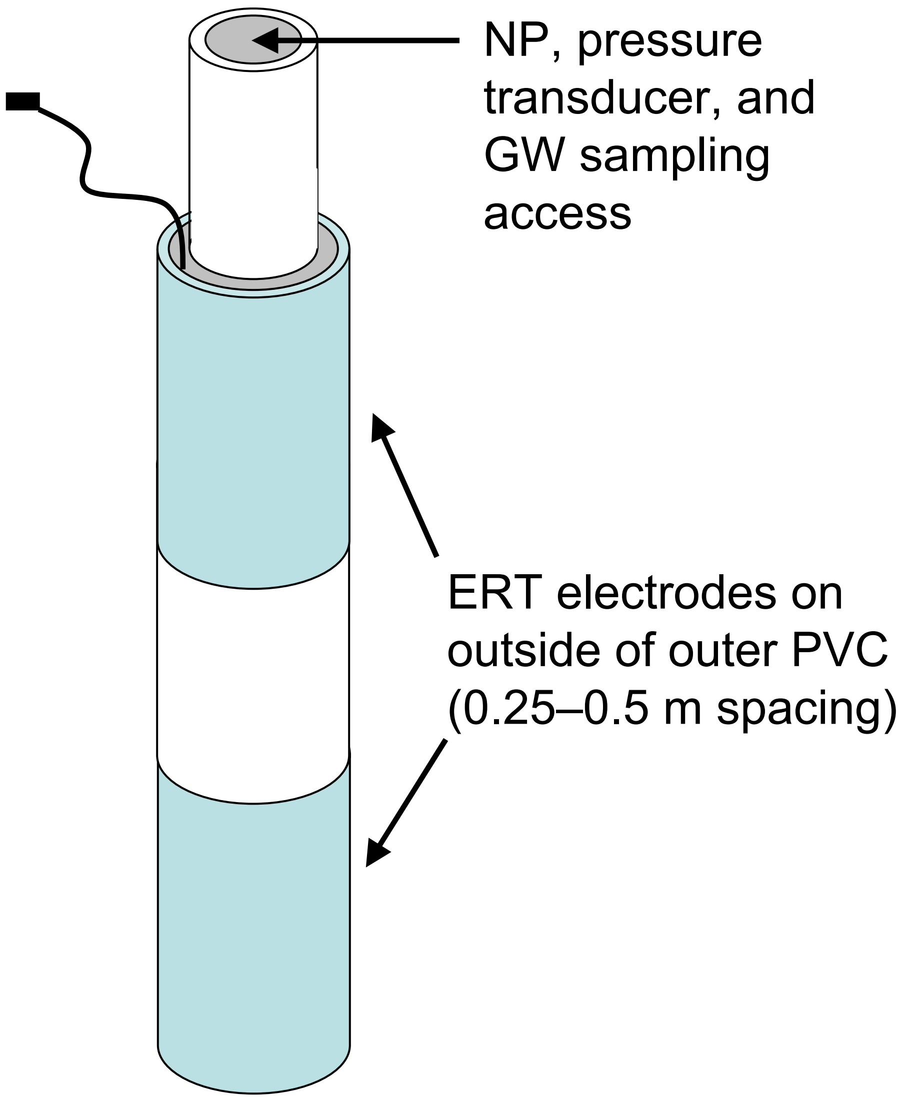
- Moisture content
  - Gravimetric sampling (initial conditions)
  - Surface and borehole geophysics
    - Neutron moisture logging (PVC wells)
    - Surface and cross-borehole radar data
    - ERT
- Hydraulic head
  - Tensiometers in vadose zone
  - Piezometers and pressure transducers in aquifer
- Solute concentration
  - Wick samplers in vadose zone
  - Groundwater sampling from PVC wells
  - Surface and cross-borehole geophysics
    - Indirect estimation of ionic solute concentrations is possible using time-lapse electrical methods under steady flow conditions
- Temperature(?)
  - Thermocouples

Multi-function access tube design



- Outer PVC tube
  - ERT electrodes on outside
  - Electrode contacts on inside
- Removable inner PVC tube
  - Electrode contacts on outside
  - Wiring from contacts on inside of inner PVC tube to external signal generator
- Use outer PVC (only) during periodic NP data collection and GW sampling
- This design might allow for cross-hole radar measurements

Alternative access tube design



- Similar to previous tube-within-a-tube design but simpler
  - inner tube remains in place (minimizes risk of ERT probe contact interference)
  - ERT electrode wiring runs between inner and outer tubes
- Inner tube can be used at any time for
  - NP access
  - GW sampling
- Probably can't be used for cross-hole radar
  - ERT probe wiring interference

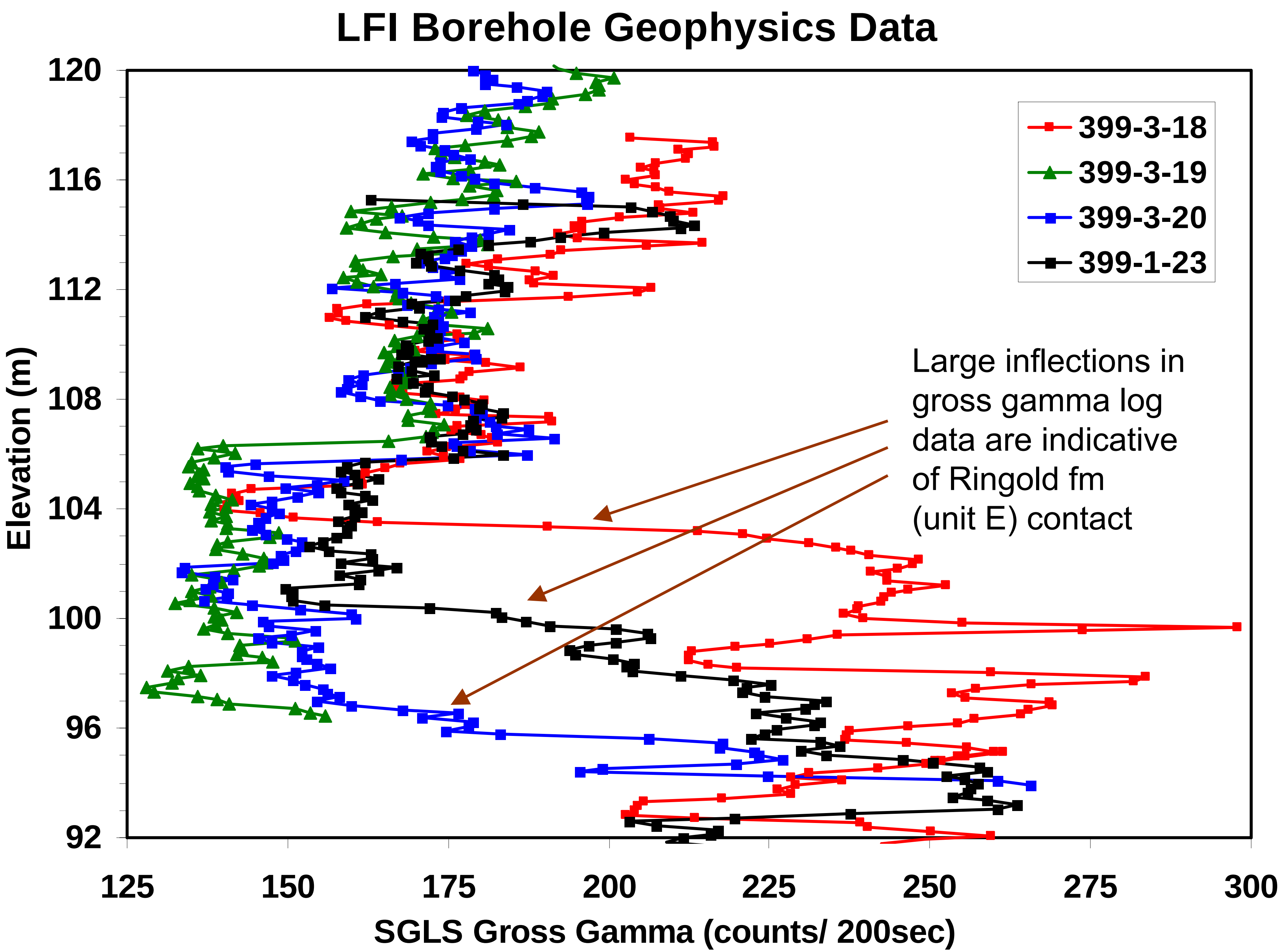
Example pre-modeling of an infiltration experiment at the IFC

- Borehole geophysical data have higher spatial resolution and data density than core data
- Correlate geophysics data (eg. gross and spectral gamma, neutron moisture ↔ moisture content inferred from ERT) with grain size data from cores
- Estimate spatially distributed grain-size distribution metrics directly from geophysics data
- Use grain size metrics with pedotransfer functions (PTFs) or scaling methods to estimate hydraulic properties at the resolution of the geophysics data

Photograph of open-framework gravels from base of Hanford fm.

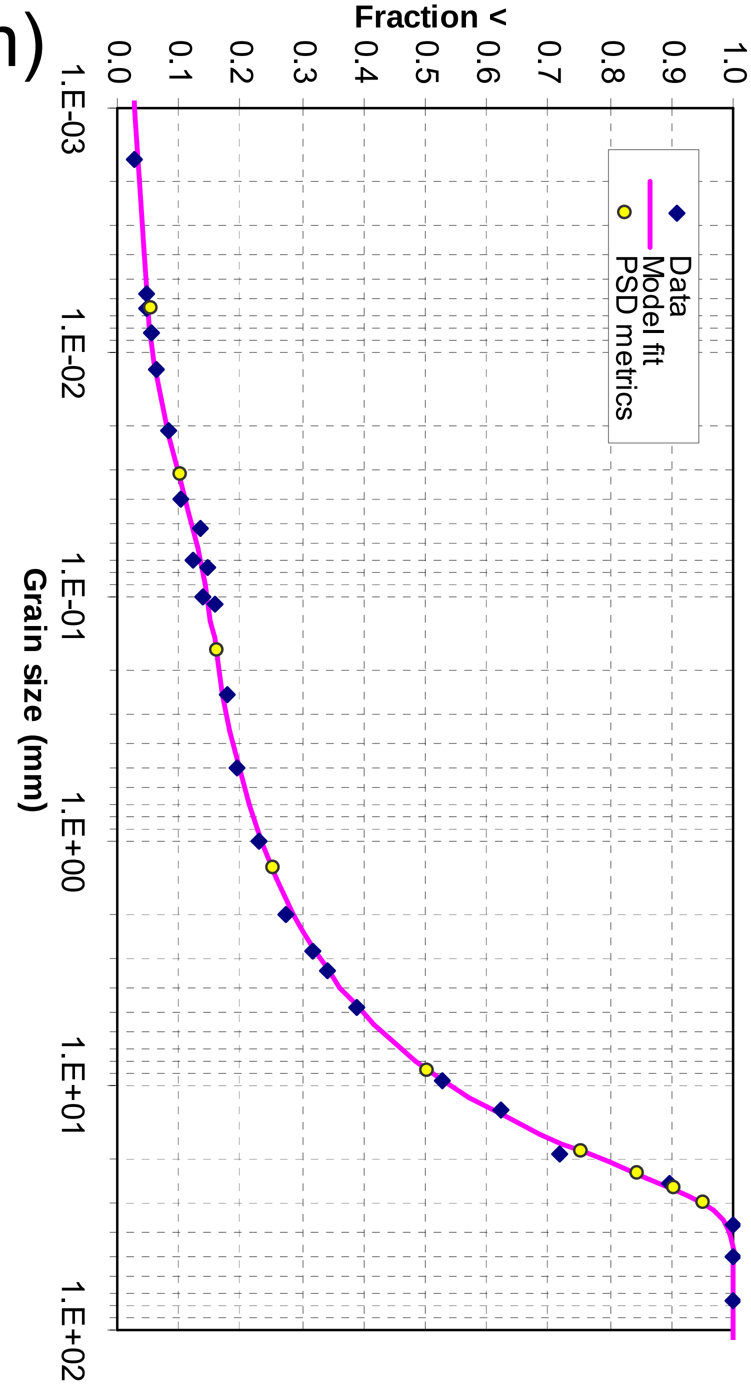
- Very coarse sediments
  - Difficult to obtain representative core samples
  - Difficult to collect solute samples under unsaturated conditions
  - Very high permeability necessitates near real-time monitoring strategy for vadose zone infiltration experiments

Additional 300 Area core samples

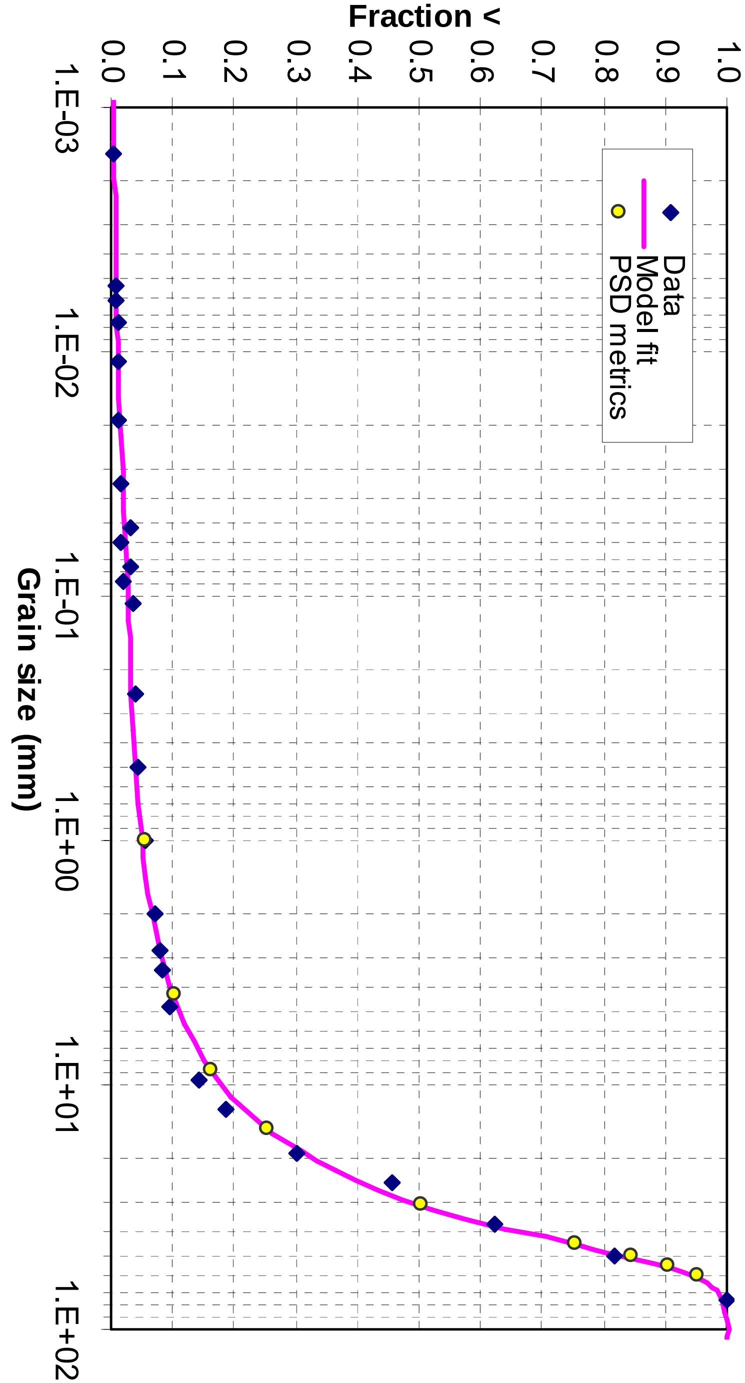


LFI Borehole Geophysics Data
Elevation (m)
120
116
112
108
104
100
96
92
125
150
175
200
225
250
275
300
SGLS Gross Gamma (counts/ 200sec)
399-3-18
399-3-19
399-3-20
399-1-23
Large inflections in gross gamma log data are indicative of Ringold fm (unit E) contact

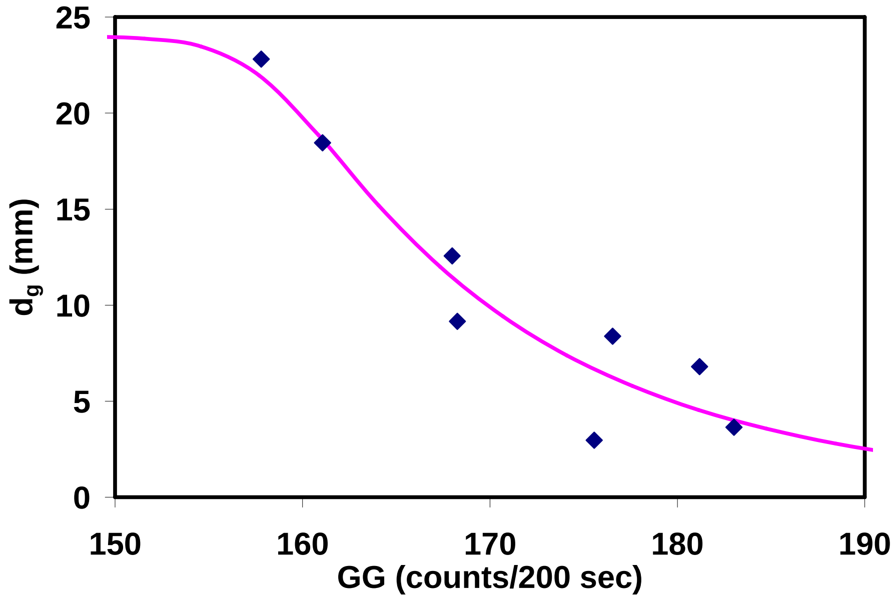
399-3-18 (sample elev. 106.6 m)

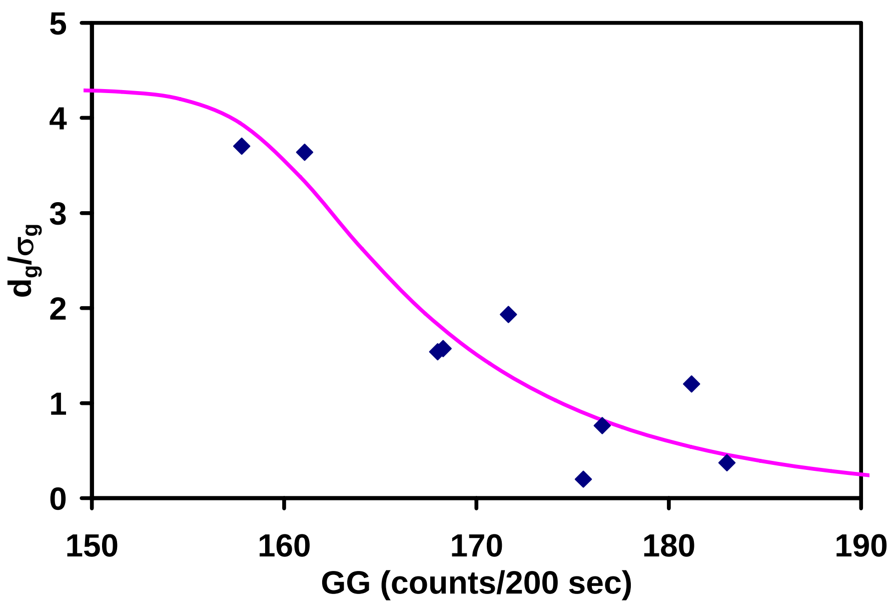


399-3-18 (sample elev. 105 m)



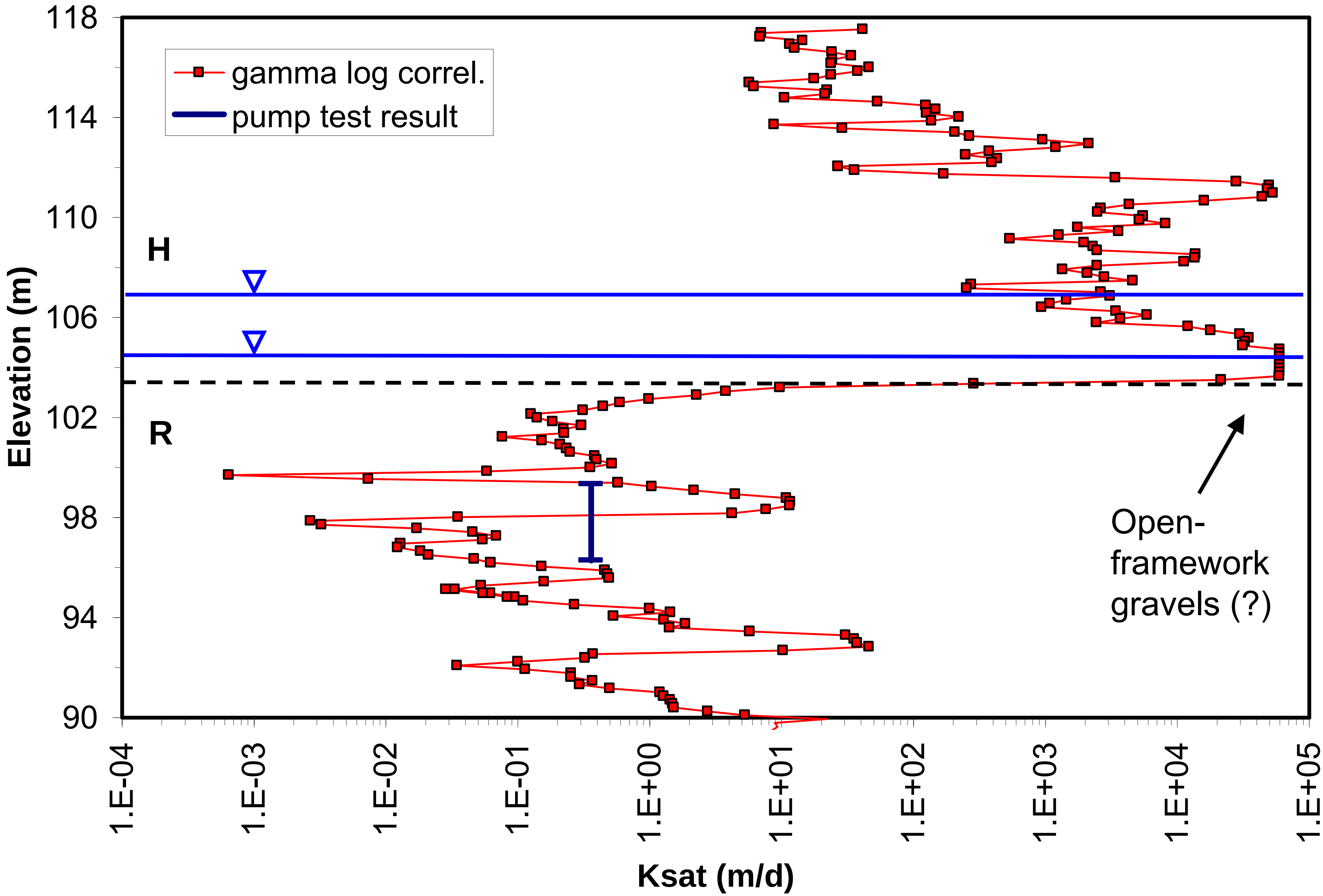
Trend plots for gamma log and grain size data





- Grain size metrics are correlated with borehole geophysical data
  - Neutron moisture
  - Gross and spectral gamma
- Correlations are well-specific and require
  - Cross-calibration
  - Standardization

Ksat from grain size and gamma log data, 399-3-18



Additional pre-modeling steps

- Variography of standardized gamma log data
- Conditional simulation using sequential Gaussian, indicator, or transition probability geostatistics
- Parameterization based on gamma log-grain size correlation and pedotransfer functions
- Simulation of flow and transport with STOMP

Feedback?

- Plot layout
- Instrumentation
- Integration of vadose zone and aquifer monitoring networks