Hanford 300 Area IFC

Geophysical Characterization: Discussion Points

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Characterization Workflow

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┌─────────────────────────────┐
│  Surface Geophysics         │
│  Borehole Geophysics        │
│  Particle Size Distributions│
│  Correlation Structures     │
│  Transitional Probabilities │
└─────────────────────────────┘
              │
              ▼
      ┌──────────────┐        ┌──────────────────┐
      │ 3-D Inversion│        │  Site-specific    │
      └──────────────┘        │  Property Transfer│
              │               │  Models           │
              ▼               └──────────────────┘
┌─────────────────────────┐
│  Update PSD             │
│  Conditional            │
│  Means & Covariance     │
└─────────────────────────┘
              │
              ▼
┌─────────────────────────┐      ◇              ┌──────────────────┐
│  Flow/Transport Exps.   │──▶ Criteria  Yes──▶ │ Best Estimates of │
│  Inversion              │    met?             │ Facies            │
│  (PSD moments)          │      │              │ Distribution and  │
└─────────────────────────┘      │ No           │ Uncertainty       │
                                 ▼              └──────────────────┘
                          ┌──────────────────┐
                          │  Improved         │
                          │  Facies Model     │
                          │  (PSD moments)    │
                          └──────────────────┘
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IFC Well Field

Revised (01.21.08) Layout of Hanford 300 Area IFC Well Array
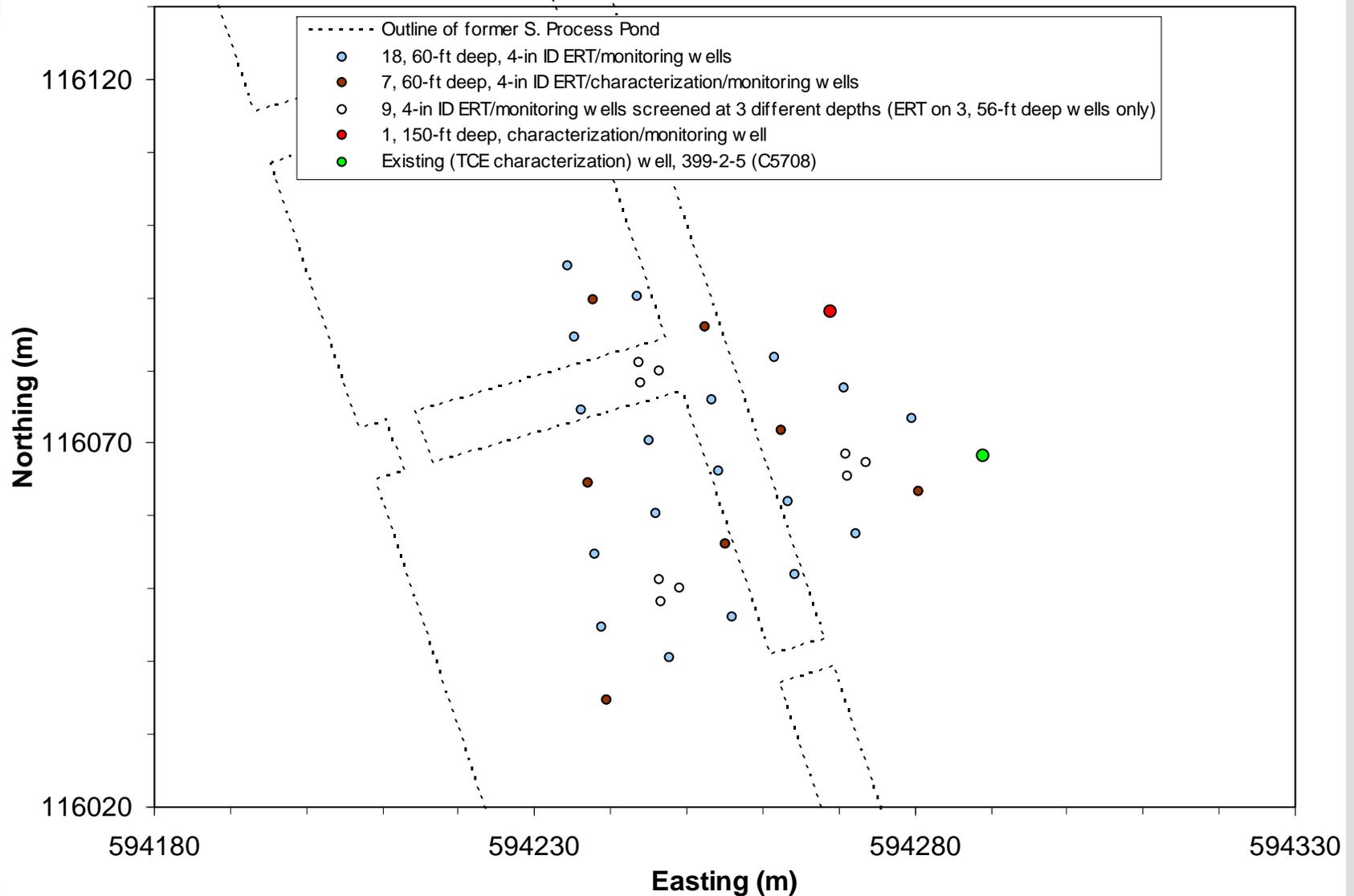
Borehole Measurements

Standard configuration for (27) IFC wells
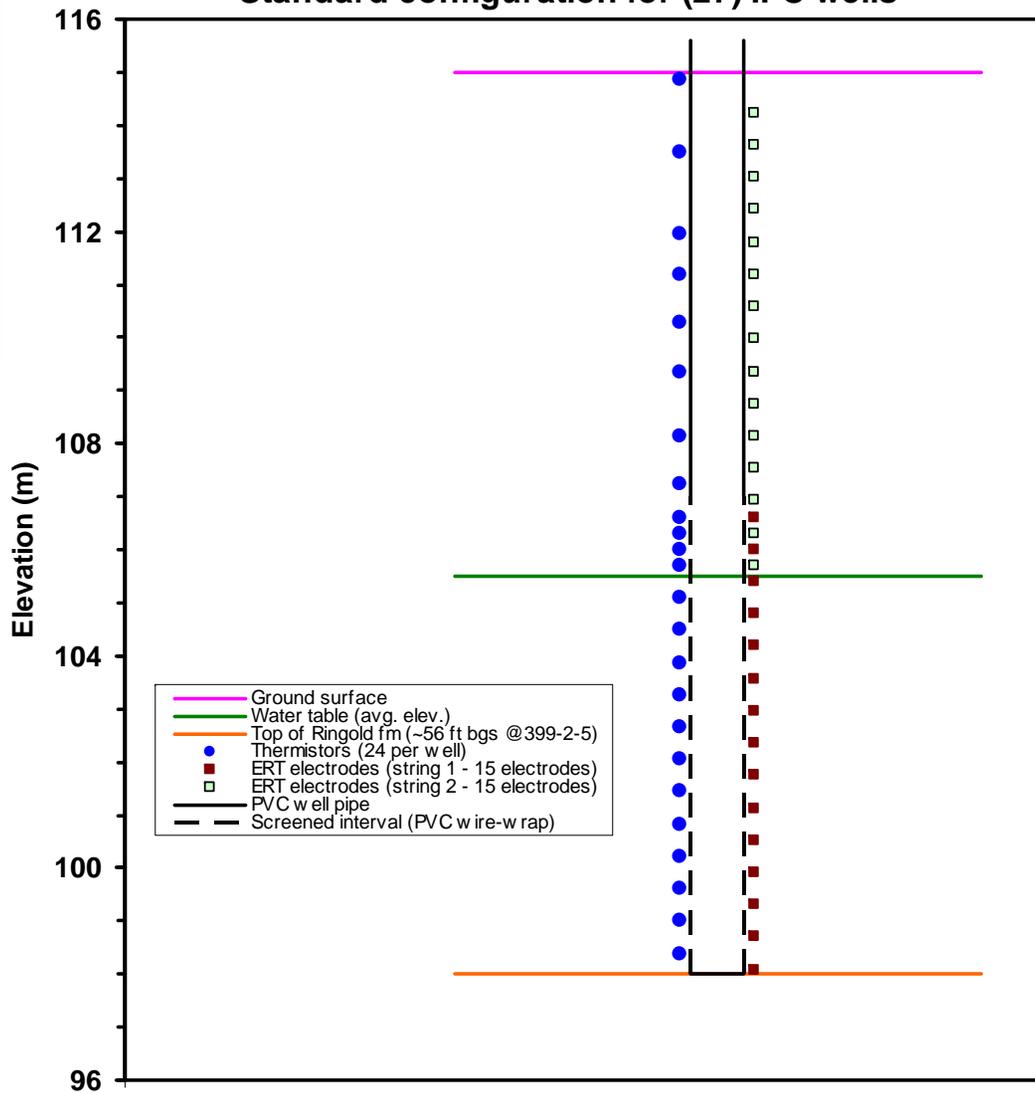
- 35 PVC cased wells
  - 8-in borehole
  - 4-in completion
- 24 Thermistors
  - Variable spacing
  - 0.1 °C resolution
- 30 ERT Electrodes
  - Vertical electrode array
  - Two 15-conductor cables
  - Stainless steel electrodes
- Neutron "moisture"
- Spectral Gamma
- Crosshole GPR
- Worth Consideration
  - EMI
  - Acoustic Televiewer
  - Electron Capture Spectroscopy
  - Dual Neutron/Density Gamma
  - Line source temperature logging
  - High resolution slug testing
  - NMR ??

Legend (chart):
- Ground surface
- Water table (avg. elev.)
- Top of Ringold fm (~56 ft bgs @399-2-5)
- Thermistors (24 per well)
- ERT electrodes (string 1 - 15 electrodes)
- ERT electrodes (string 2 - 15 electrodes)
- PVC well pipe
- Screened interval (PVC wire-wrap)

Elevation (m): 96, 100, 104, 108, 112, 116

Instrumentation
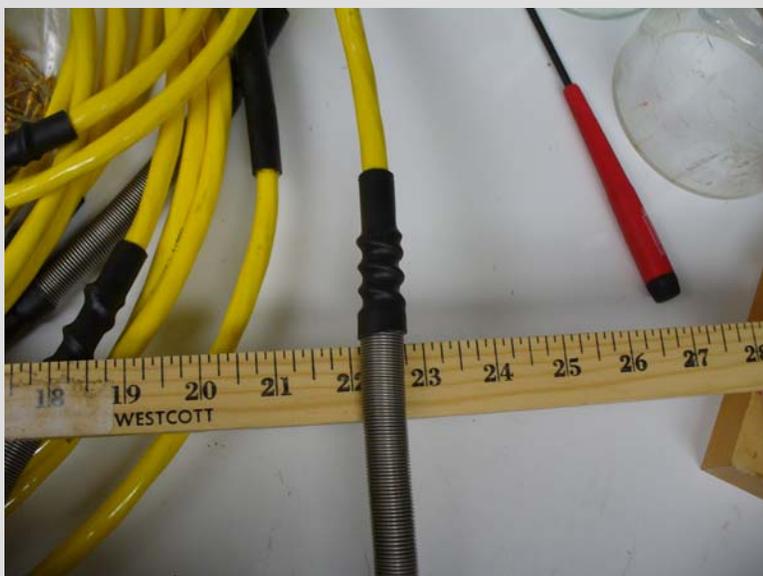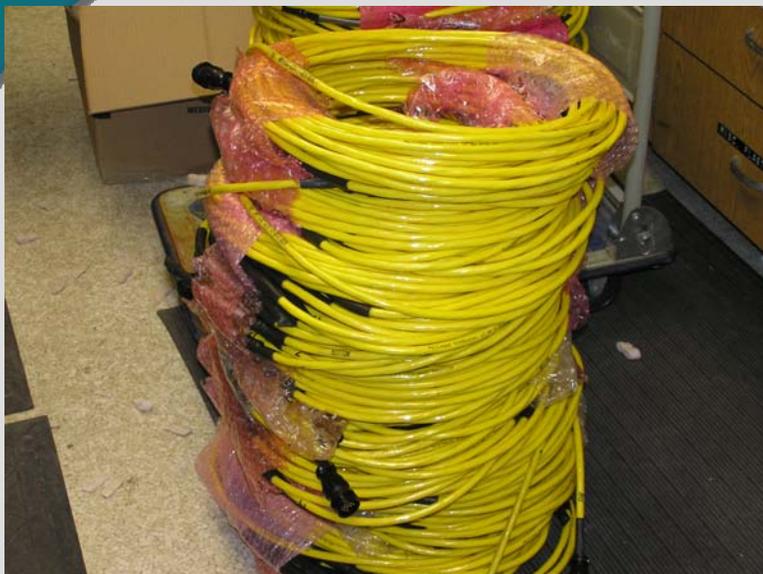
Borehole C5708

Strata Beneath South Process Pond
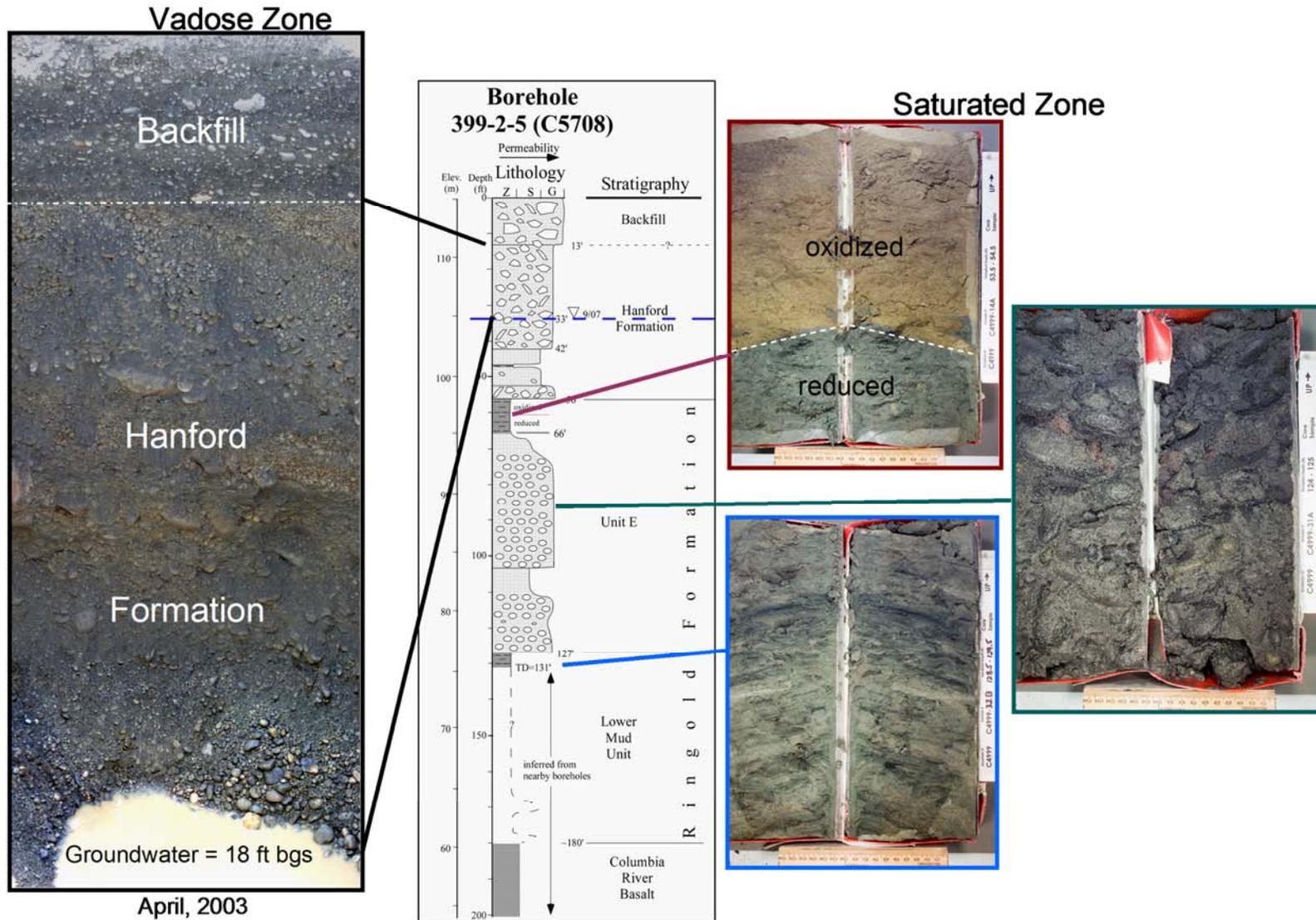
What we will get- Example from C5708
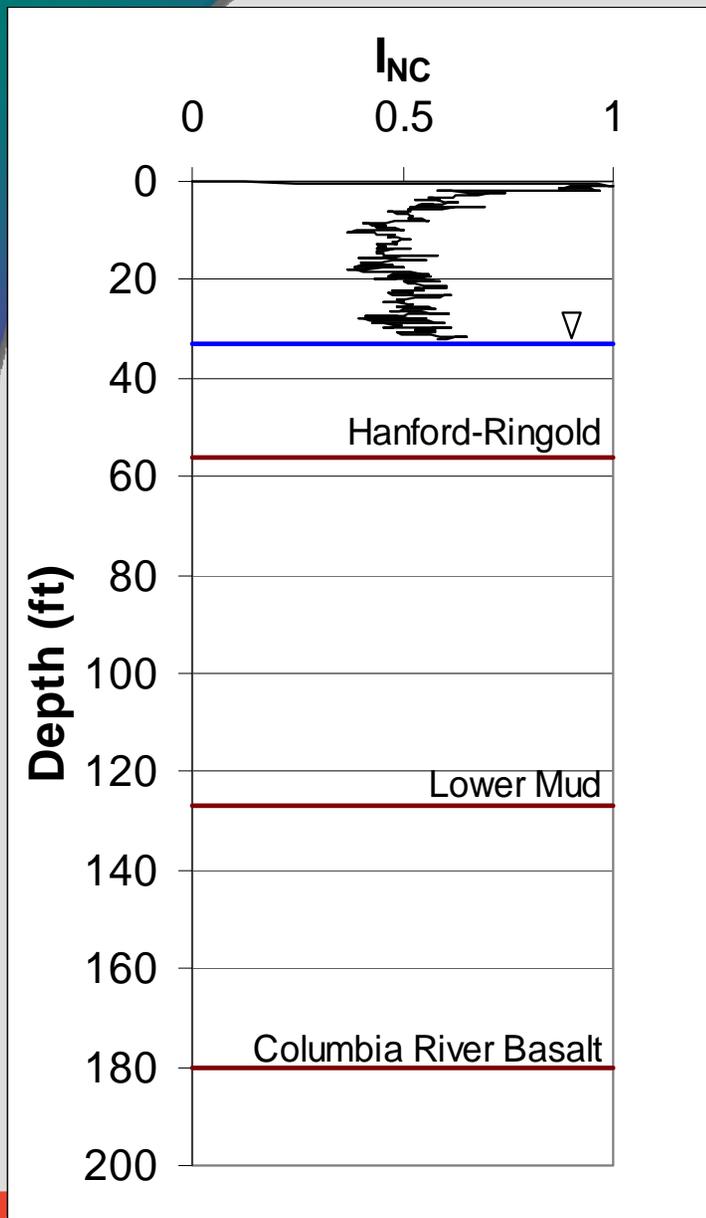
- ▶ Neutron "moisture"
  - 50 mCi Am-Be source
  - Zone 15 cm (wet), 70 cm (dry)
  - Vadose zone only
  - Typical $\Delta z \sim 3$ inches
  - Calibrated for 6 and 8-in steel casing- Neutron counts
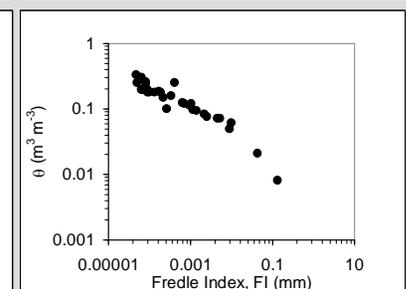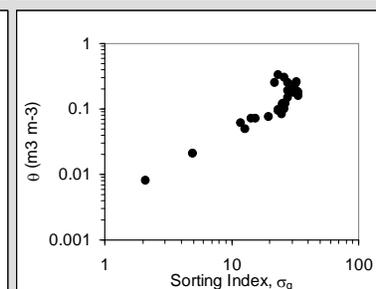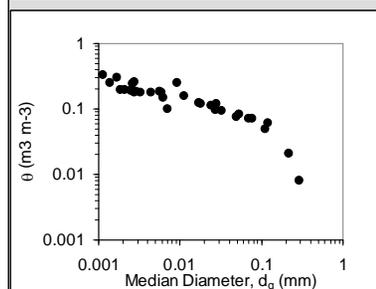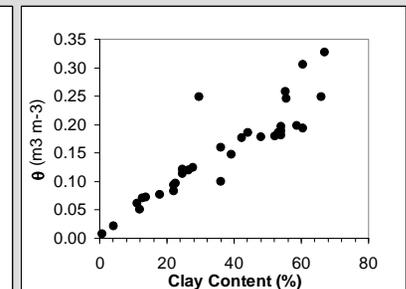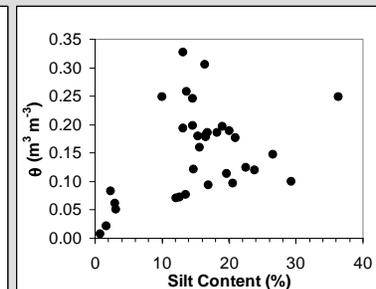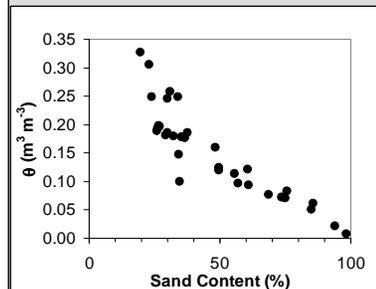
# Physically-based PTM- Specific Surface Area
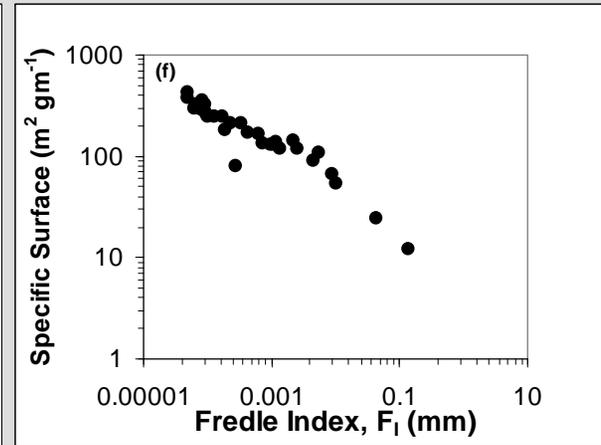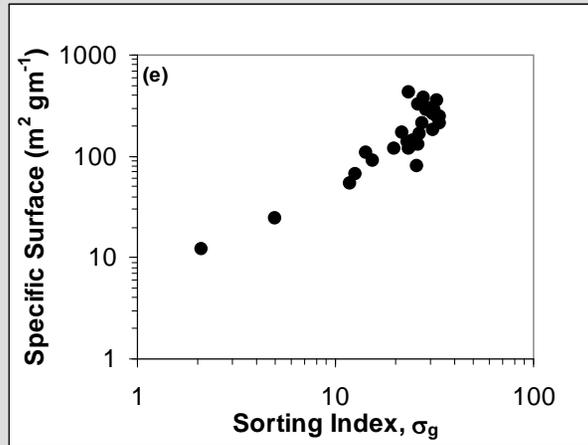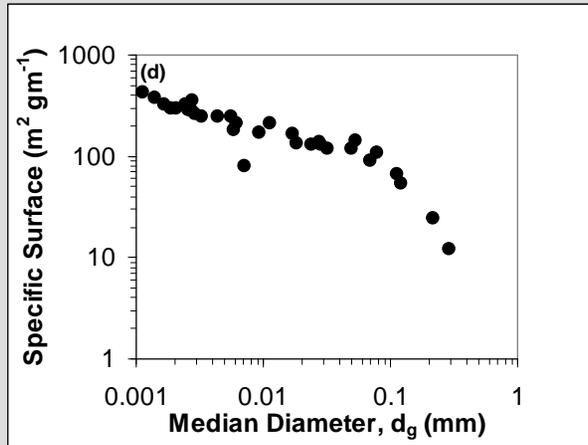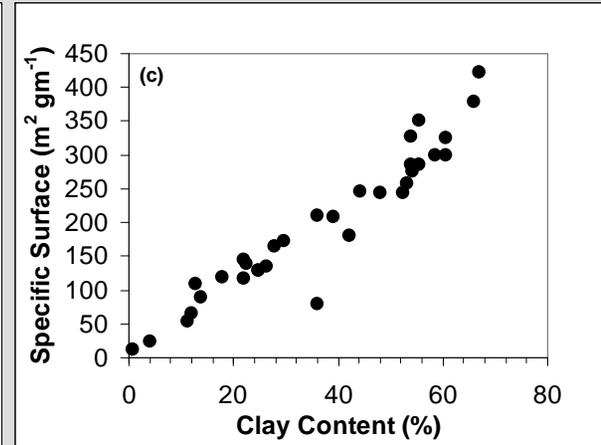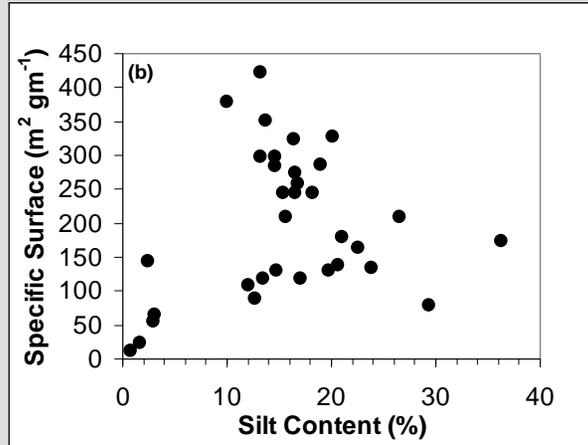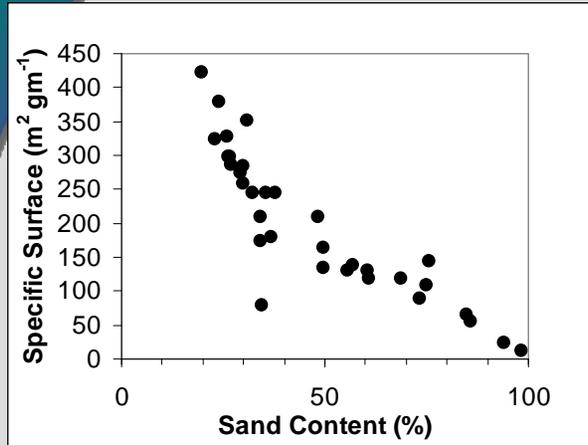
What we will get- Example from C5708
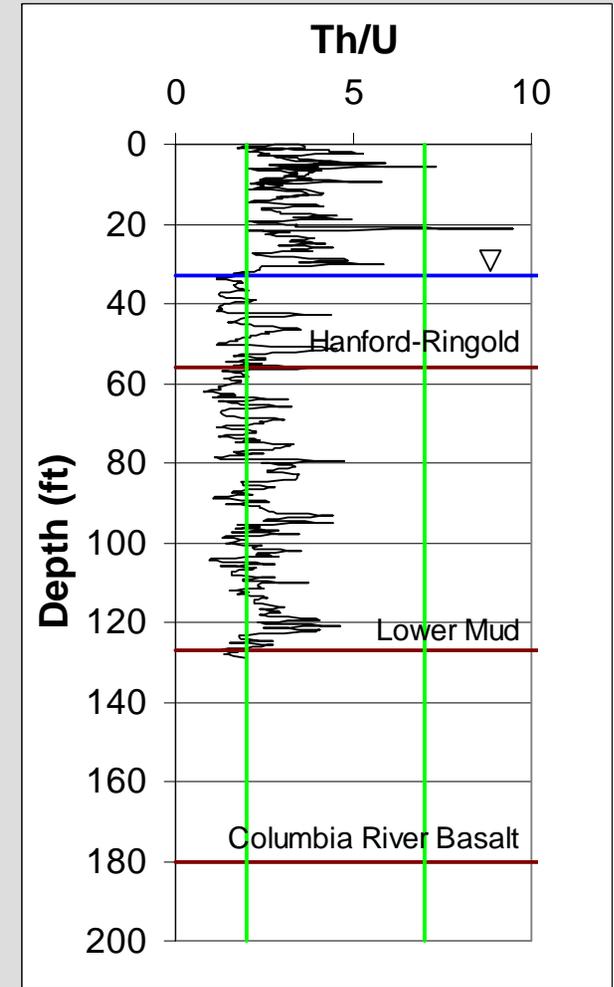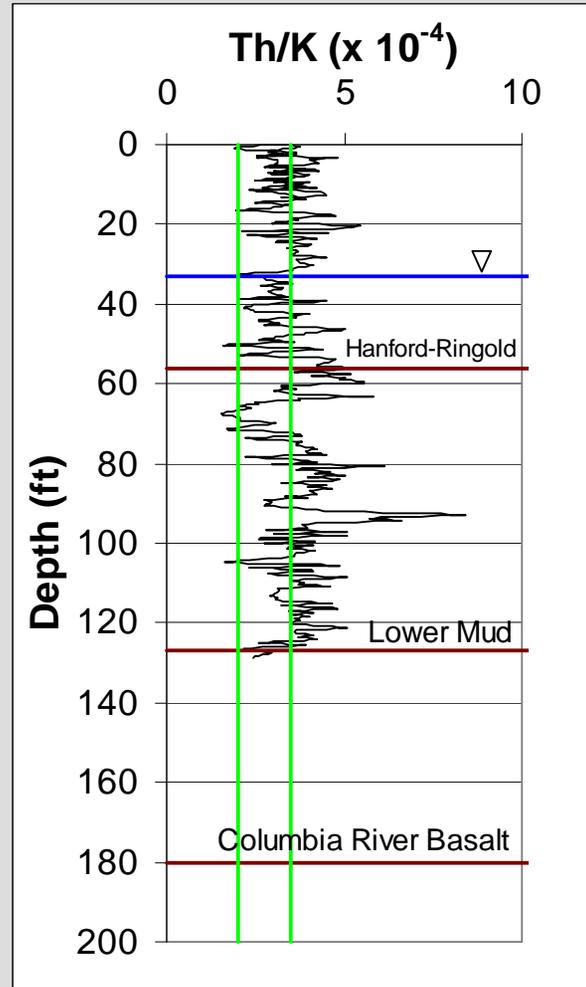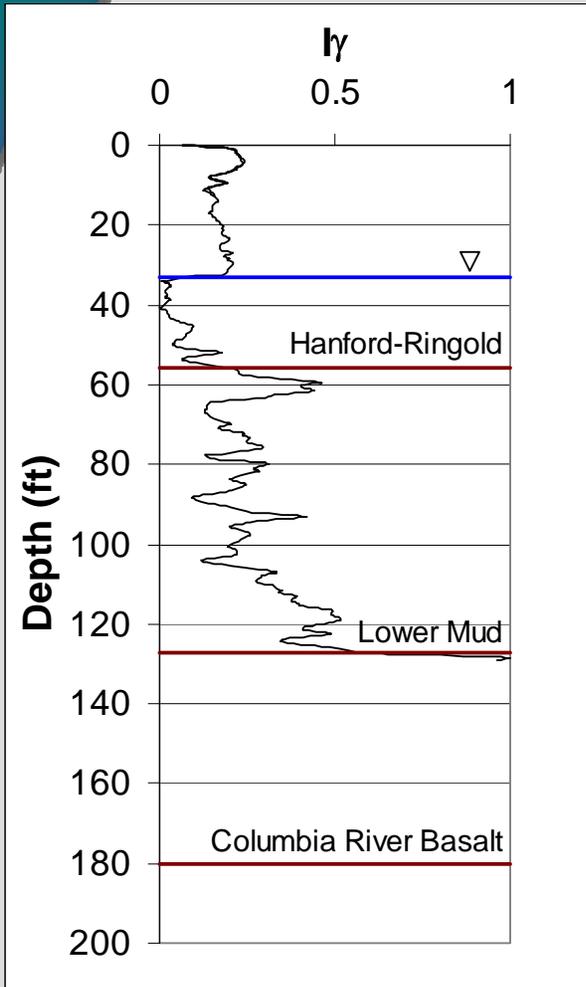
Mineralogy/Chemistry- C5708
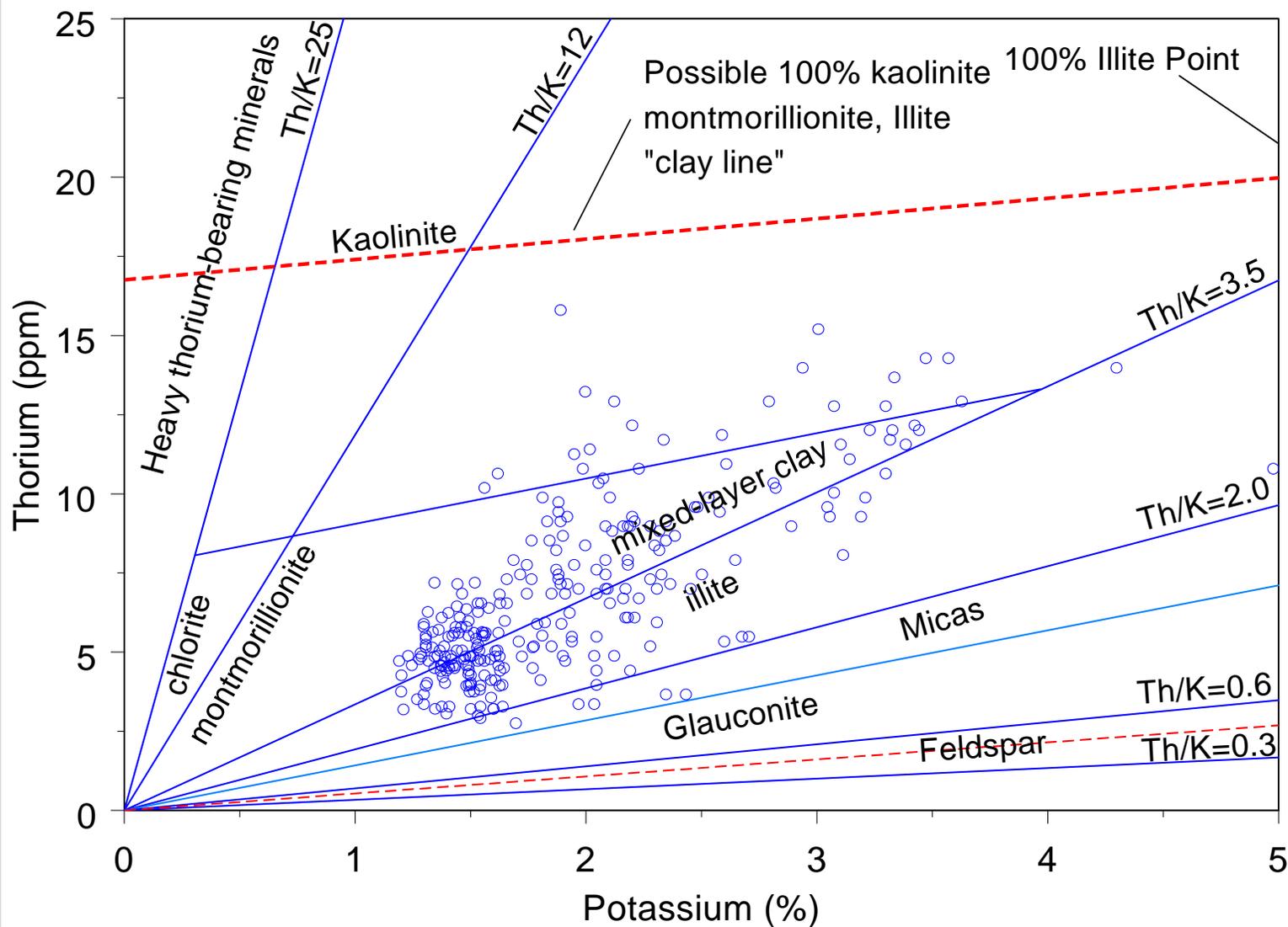
Radioactivity of Soils and Rocks

Rock Type	K (%)	U (10^{-4} %)	Th (10^{-4} %)	Th/U
Shale and Clay	3.2	4.0	11.0	2.8
Sandstone	1.2	3.0	10.0	3.3
Limestone	0.3	1.4	1.8	1.3
Evaporites	0.1	0.1	0.4	4.0

| Soil Type	K (%)	Th (10^{-4} %)
Light and Medium sod-podzolic	1.2	3.3
Light-grey and grey forest Podzolized	1.6	4.8
Medium-humus chernozem	1.7	6.0
Dark chestnut soil	1.8	7.0

Surface Geophysics

- **Spatial changes**
  - Lateral/horizontal correlation lengths and transition probabilities of different facies
- **Temporal changes**
  - Time lapse for monitoring processes
- **Geophysical modalities to date**
  - Ground penetrating radar
  - Resistivity
  - induced polarization
  - Magnetometer
  - EMI (EM31, EM34)
- **Planned**
 - Feasibility of Reflection Seismic (KGS)
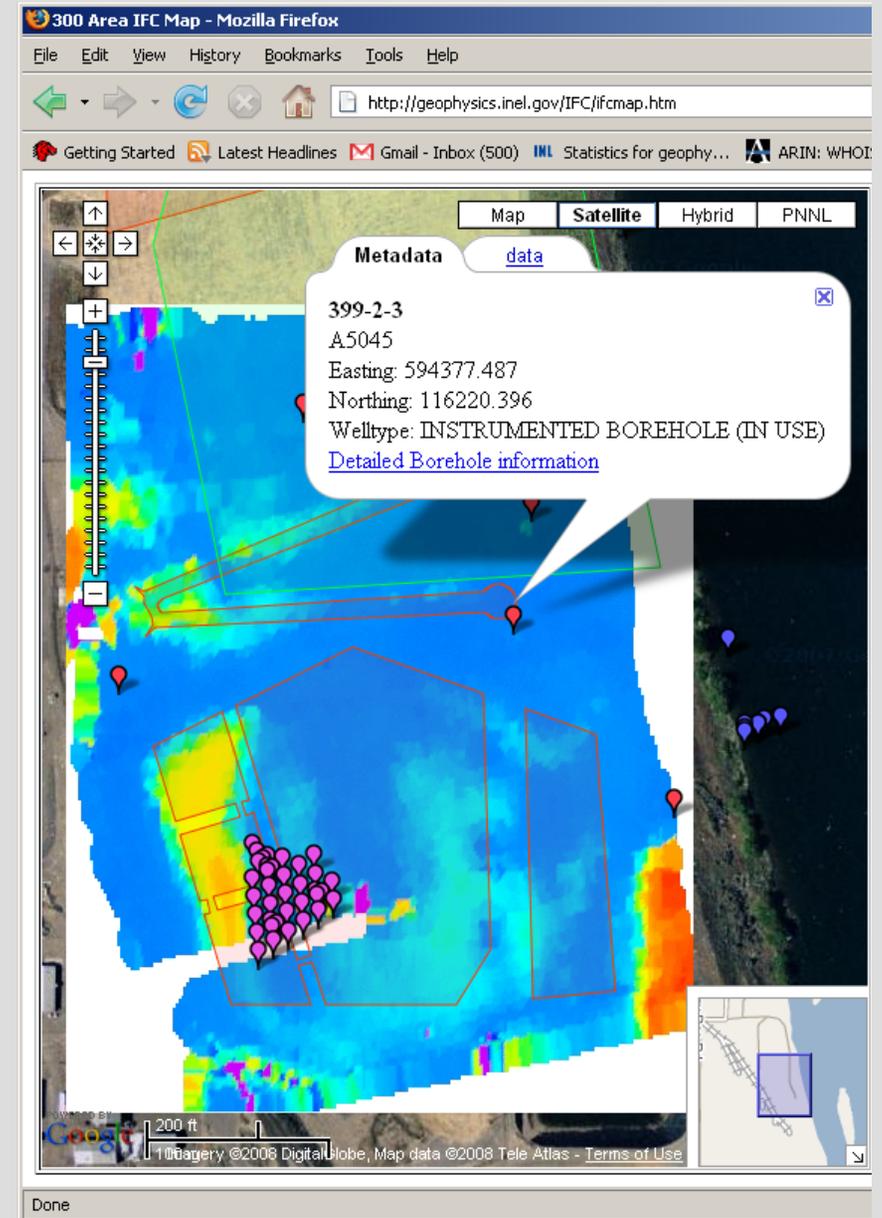
Ground Penetrating Radar

- ▶ **GPR reflection surveys**
  - 50, 100, 300 MHz
- ▶ **Spatial correlation structure**
  - radar reflections, radar stack velocity
- ▶ **Transects parallel and perpendicular to river**
  - Horizontal spacing of 5 m
  - 30 cm acquisition intervals
- ▶ **GPR Penetration limited to ~ 5 m even at 50 MHz (~ depth of pond backfill after excavation**
- ▶ **Crosshole radar**
 - Monitoring infiltration tests
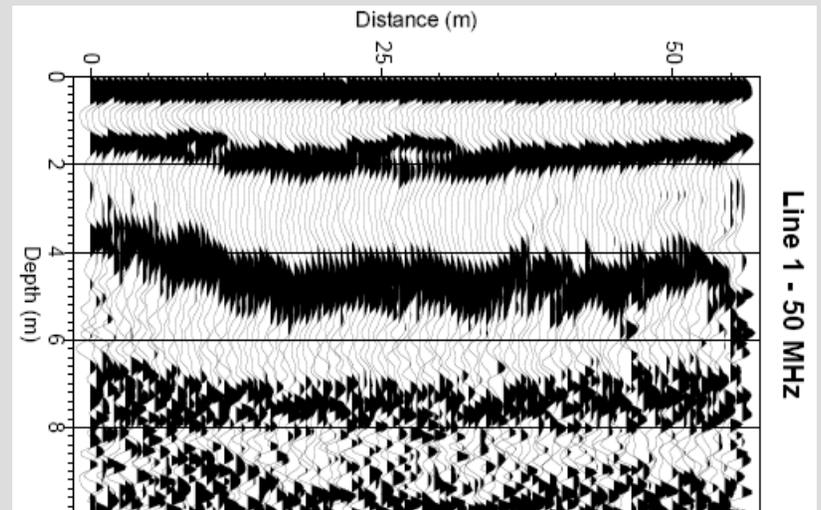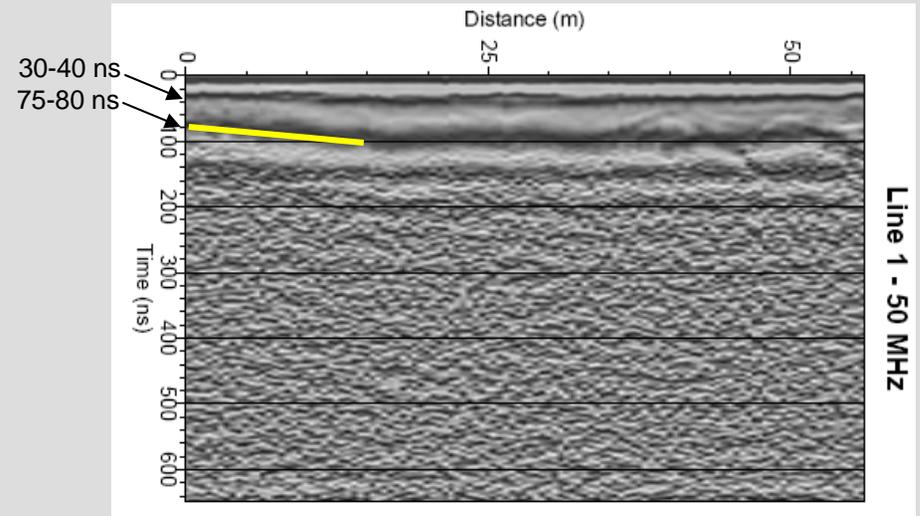
Resistivity and Induced Polarization

South End of South Process Pond
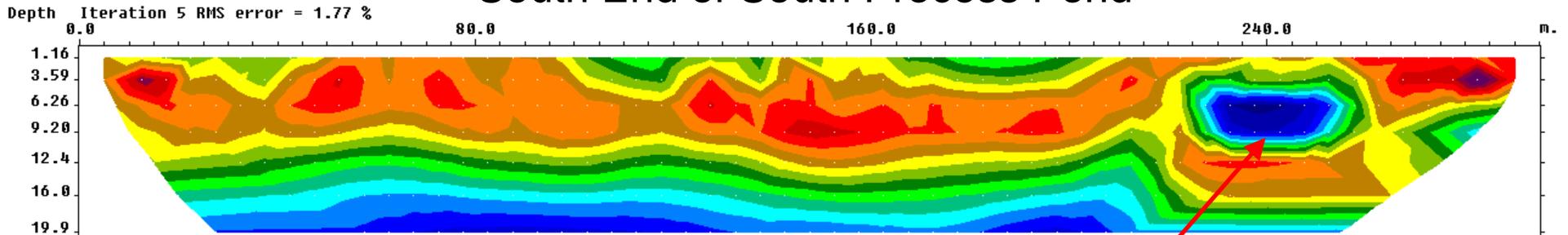
Possible Near-Surface Source
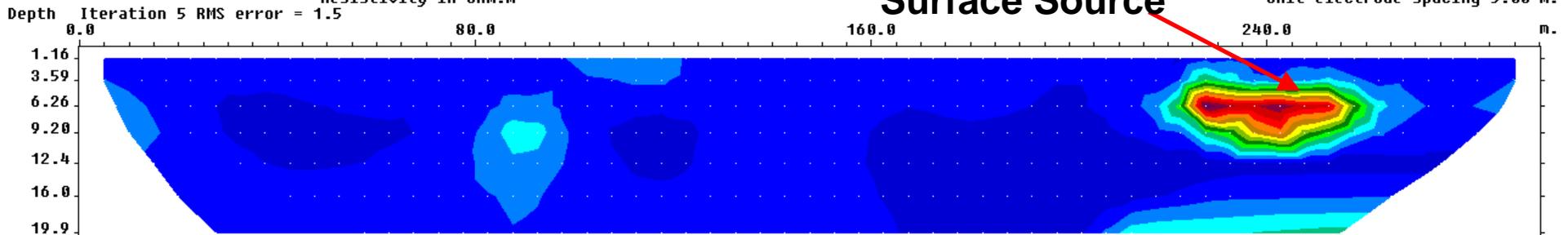
Field IP Response
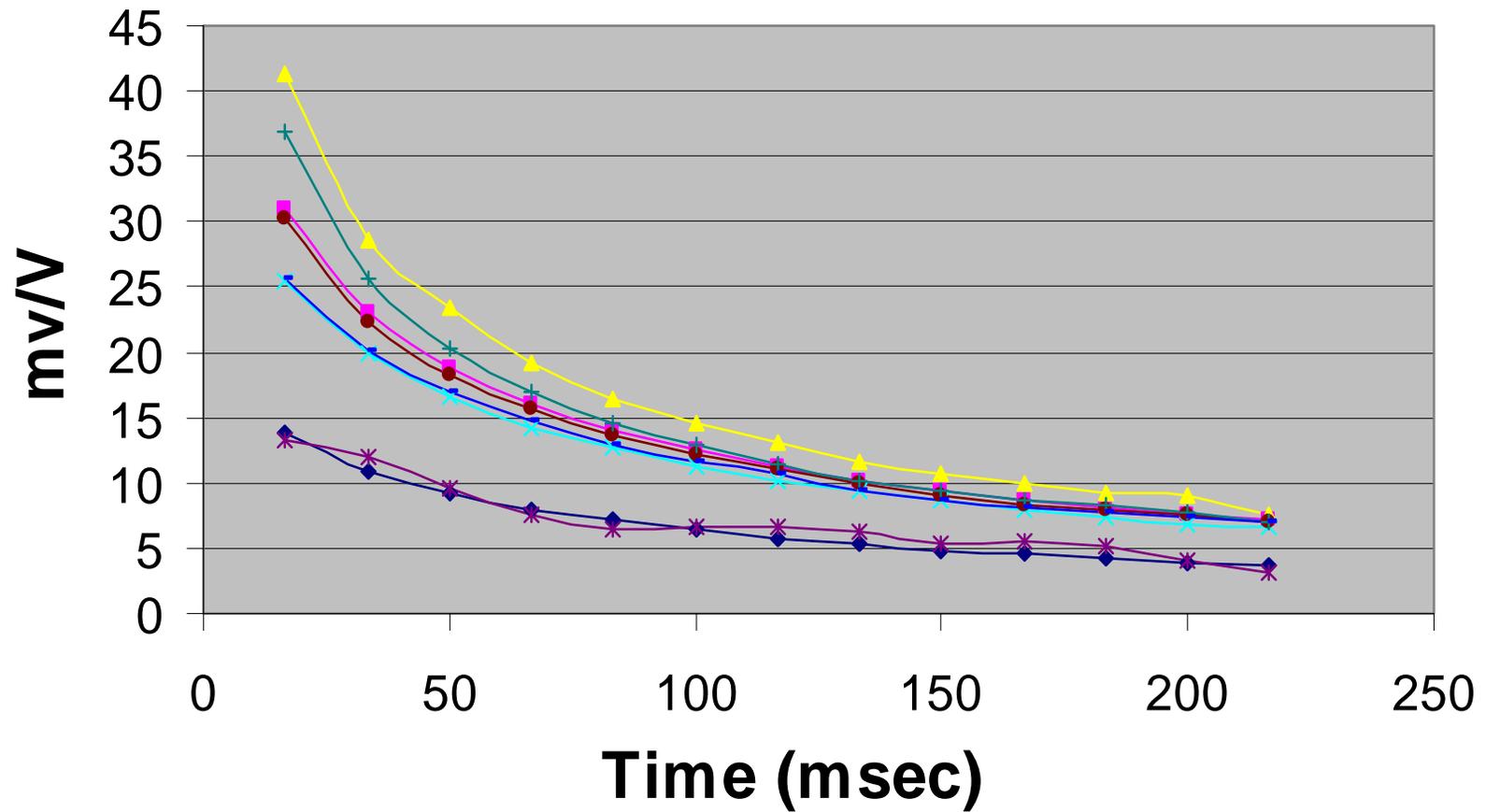
Heterogeneous Sediment
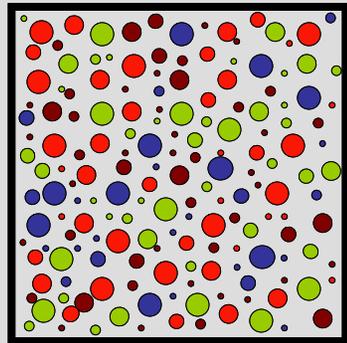
Sieving

Mass Fraction, x_{ij}, of Size Class and Lithocomponents

Grain Sub-classes	Mass Fraction of Lithocomponents			
	🟥	🟫	🟩	🟦
○	$x_{1,1}$	$x_{1,2}$	$x_{1,3}$	$x_{1,4}$
○	$x_{2,1}$	$x_{2,2}$	$x_{2,3}$	$x_{2,4}$
○	$x_{3,1}$	$x_{3,2}$	$x_{3,3}$	$x_{3,4}$
○	$x_{4,1}$	$x_{4,2}$	$x_{4,3}$	$x_{4,4}$
∘	$x_{5,1}$	$x_{5,2}$	$x_{5,3}$	$x_{5,4}$

Lithocomponents

Grain Size Classes
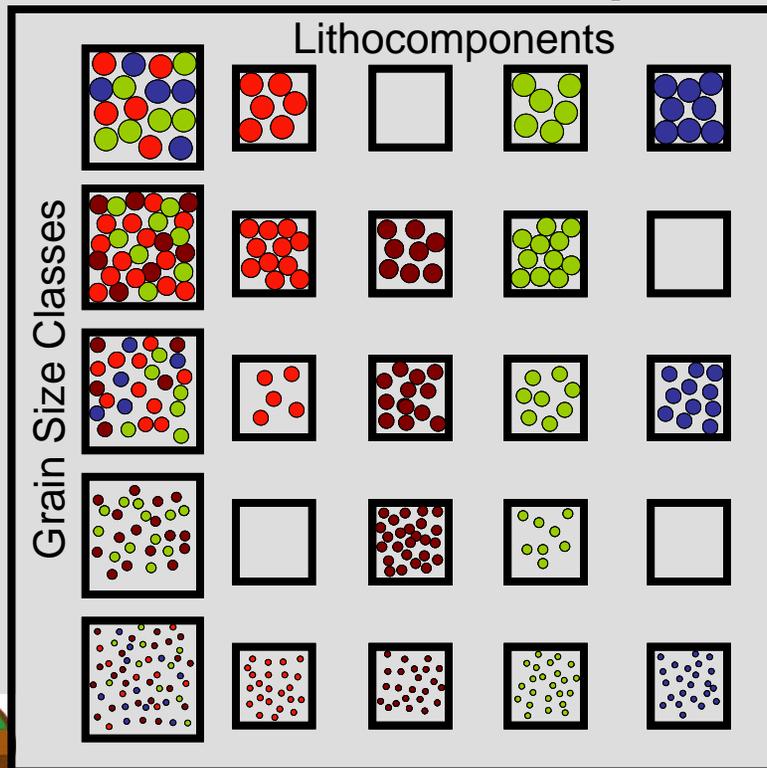
Physico-chemical properties

- Particle shapes
- Porosity
- Density (bulk, particle)
- Specific Surface Area
- Cation Exchange Capacity
- Water Retention ($\psi[S]$)
- Hydraulic conductivity (K_s, $K[S]$)
- Thermal properties (specific heat, thermal conductivity-saturation)

Electrical Properties

- Resistivity
- Induced polarization
- NMR (T_1, T_2) ??

Natural Isotopes (GEA)

- ^{40}K, ^{238}U, and ^{232}Th

Discussion

► Spatial Changes

- Surface
- Borehole
- Crosshole

► Temporal Changes

- Surface
- Borehole
- Crosshole

► Laboratory- Property Transfer Models

- What can we measure to help improve conceptualization and model parameterization