



2003 AFCEE Technology Transfer Workshop

San Antonio, Texas

Promoting Readiness through Environmental Stewardship

Source Zone Characterization Approaches Including Contaminant Mass Flux

Michael D. Annable and Kirk Hatfield
University of Florida
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Talk Outline

- Source Zone Characterization Techniques
- Field Data Examples
- Flux Based Assessment
- Methods available
- Recent flux measurements
- Summary / Questions

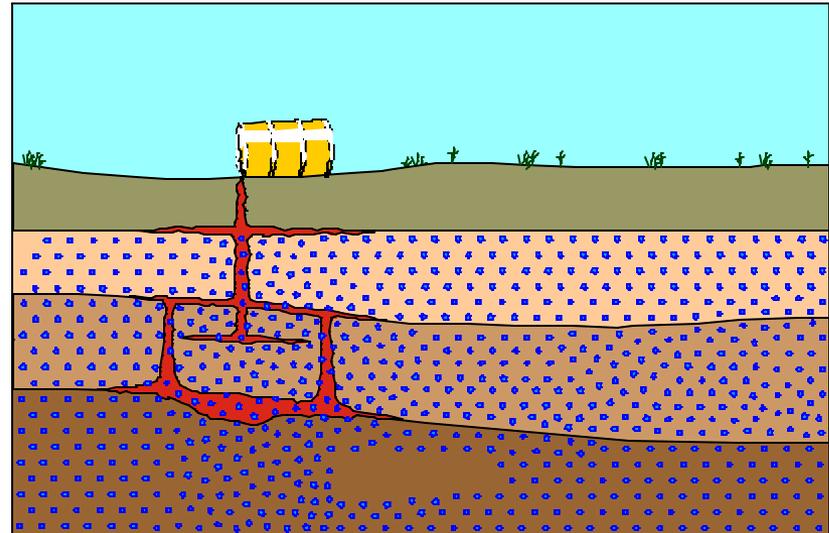


Source Zone Characterization

Methods

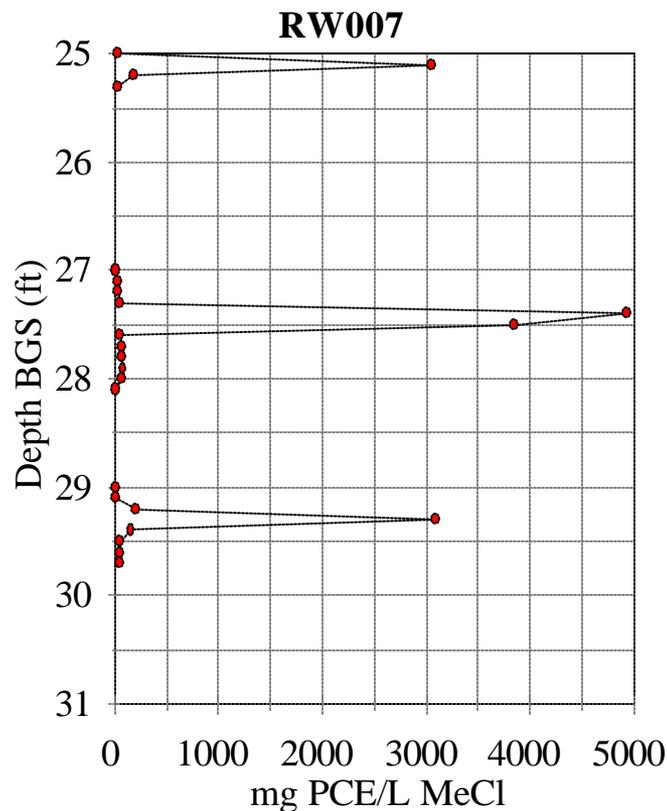
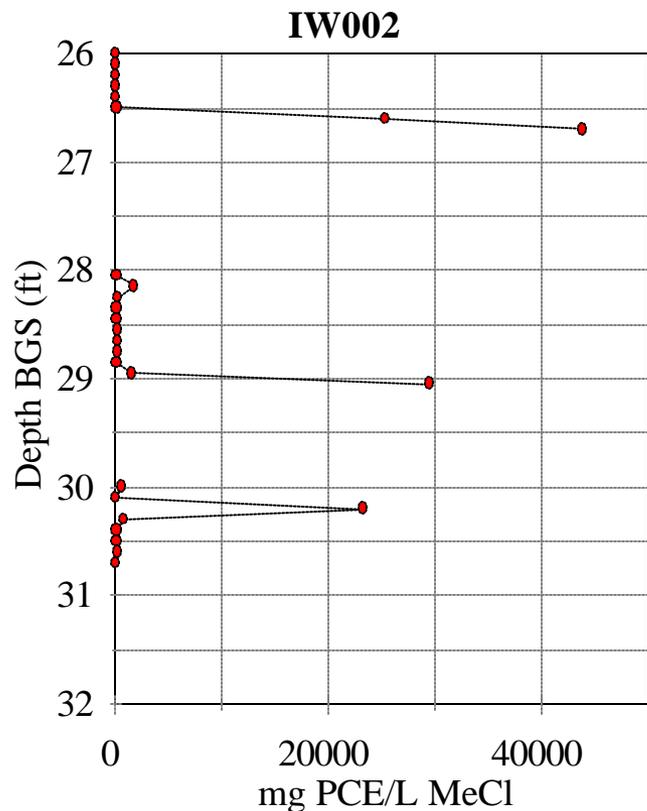
- Coring
- Direct Push Sensing
- Geophysical
- Chemical Tracers

Challenge: Sparsely distributed DNAPL's in heterogeneous media





High Frequency Soil Sampling at Sages





Full Core Extractions

An alternative core sampling approach where all core material is extracted in a solvent such as methanol

Thin layers of DNAPL are not missed but are integrated into the sample

Provides a better mass estimate



Direct Push Sensing Methods

- Laser Induced Fluorescence (LIF)
- Video Imaging
- Membrane Interface Probe
- Electrical Resistivity (MIP)
- Ribbon NAPL Sampler





Geophysical Methods

- Ground Penetrating Radar
- Seismic Reflection Methods
- Cross-Well Technologies
- Electrical Resistance Tomography

Generally average information to get gross scale information

If sensitivity to NAPL adequate, can estimate source zone extent



Tracer Methods

Partitioning tracers can quantify NAPL mass integrated over large volumes of the aquifer

Additional spatial information can be obtained using multilevel point samplers



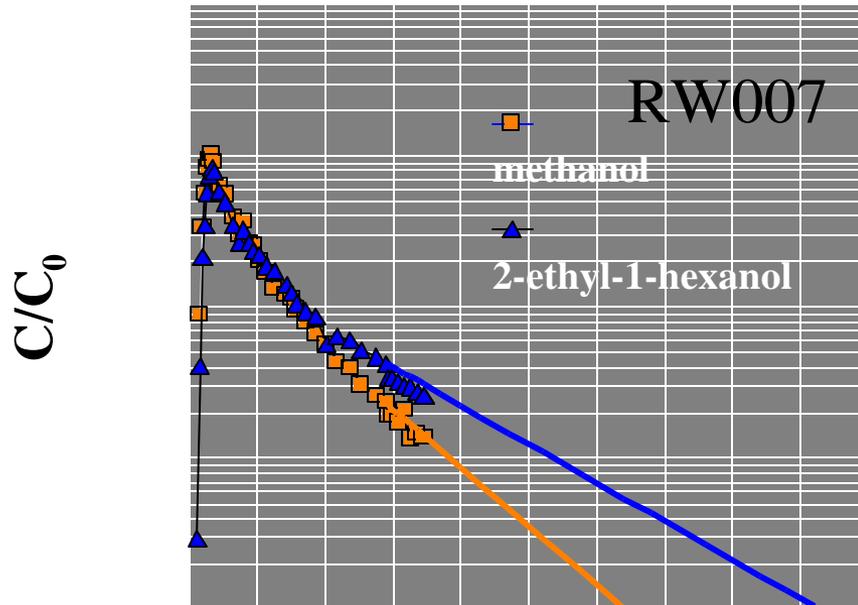
Sages Site



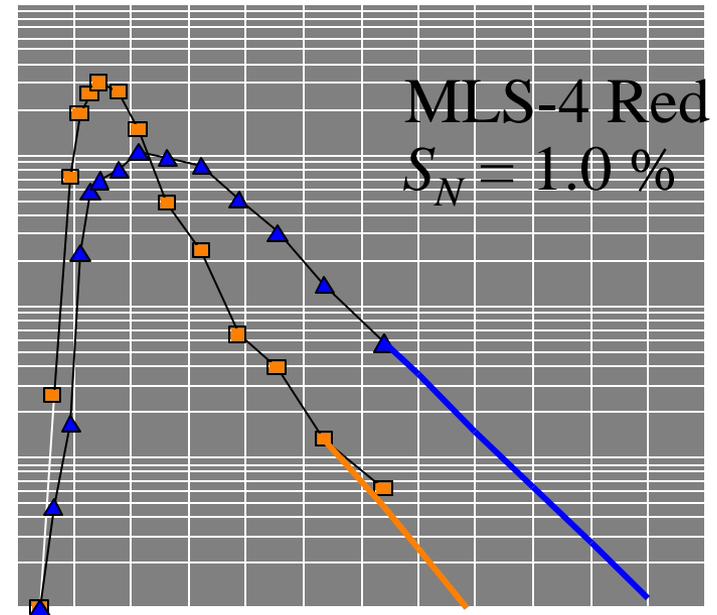
Partitioning Tracer Test:

$$S_N = 0.26 \%$$

$$V_{PCE} \approx 50 \text{ L}$$



Volume (kL)



Time (d)



Sages Site Approximate Errors

	Pre-remediation	Post-remediation	Percent removal
Cores	60 L \pm 30	21 \pm 10	65 \pm 40
Tracers	68 L \pm 15	26 \pm 6	63 \pm 20

Very difficult to predict percent removal



Flux Based Approach

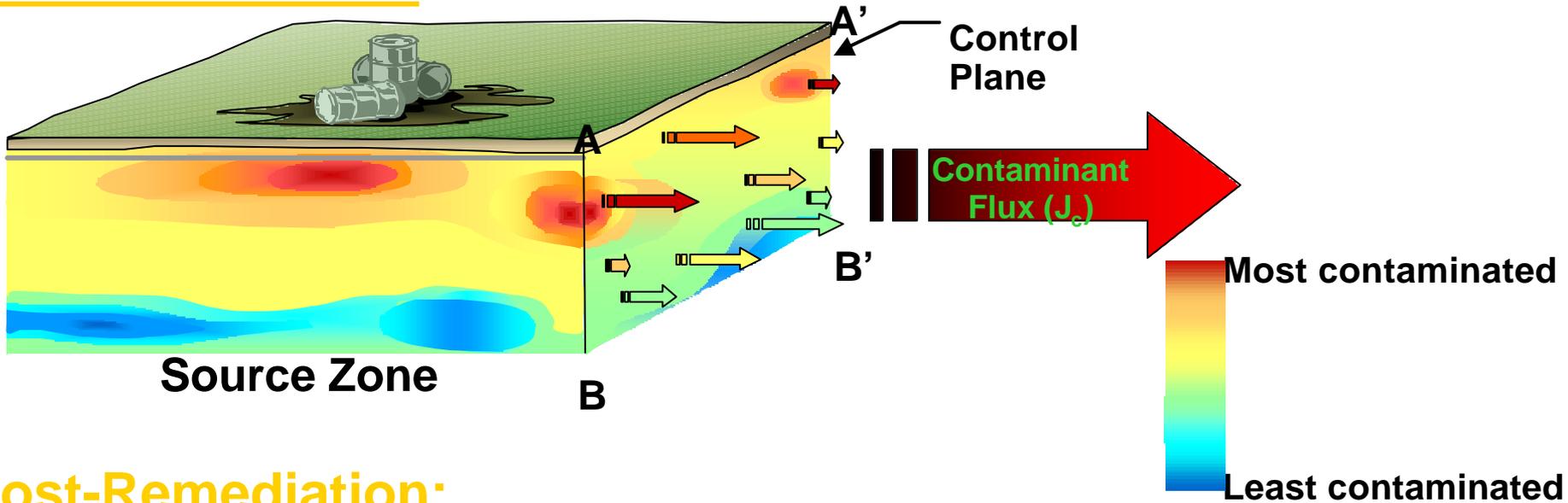
Is knowledge of pre- and post-mass in the source zone critical?

Because of the difficulties measuring mass in source zones, may want to consider an alternative approach to characterization

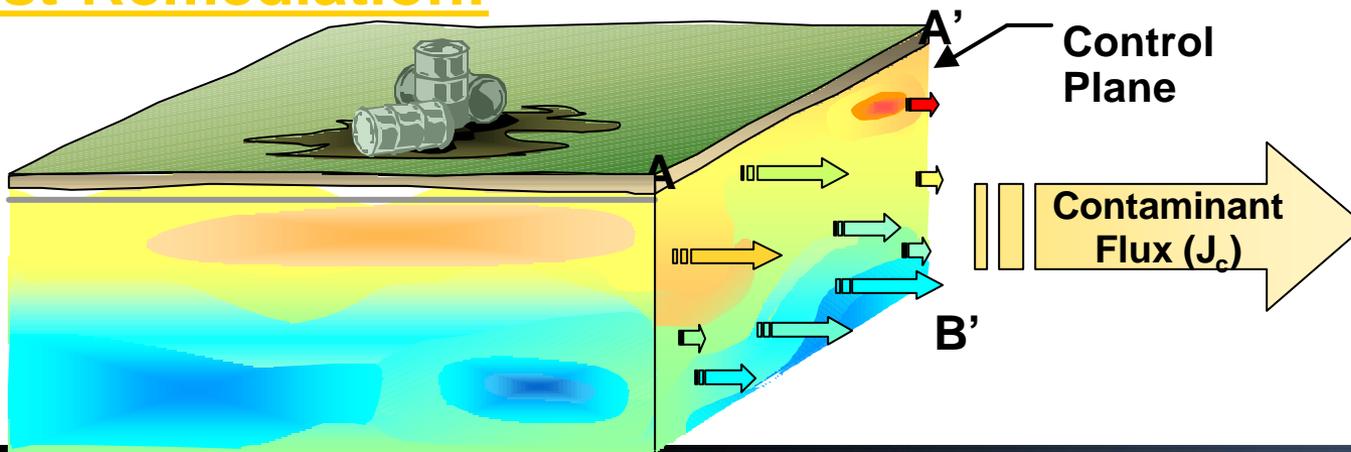


Source Management Strategies

Pre-Remediation:



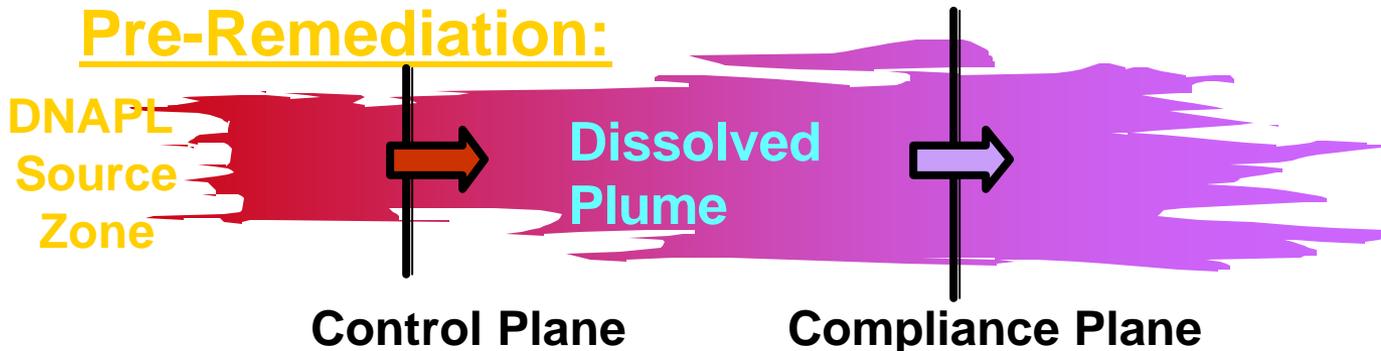
Post-Remediation:



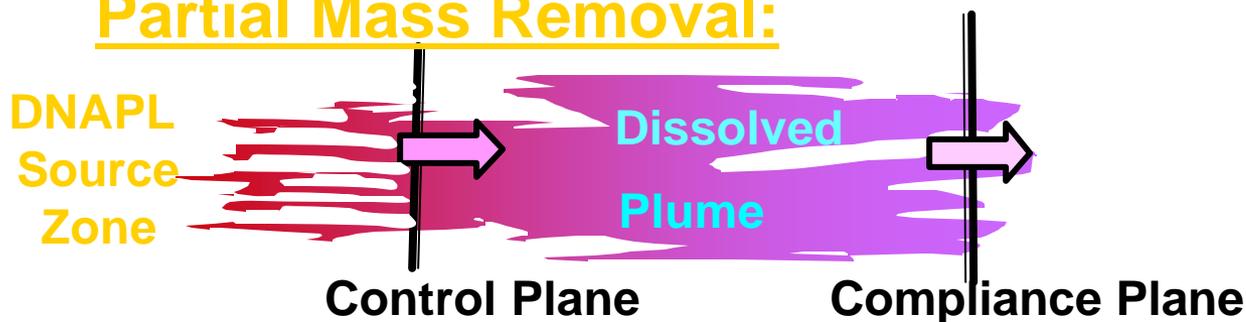


Flux Contributes to Plume Behavior

Pre-Remediation:



Partial Mass Removal:



Partial Mass Removal + Enhanced Natural Attenuation:





Can Contaminant Flux be Measured?

- Traditional monitoring methods have limitations.
- Several new approaches are being developed and field tested (Flux Meter; Tuebingen Pump Tests).
- Only limited field data are available to date.
- How reliable are these new methods?
- Are the monitoring costs lower?
- What are the alternatives?

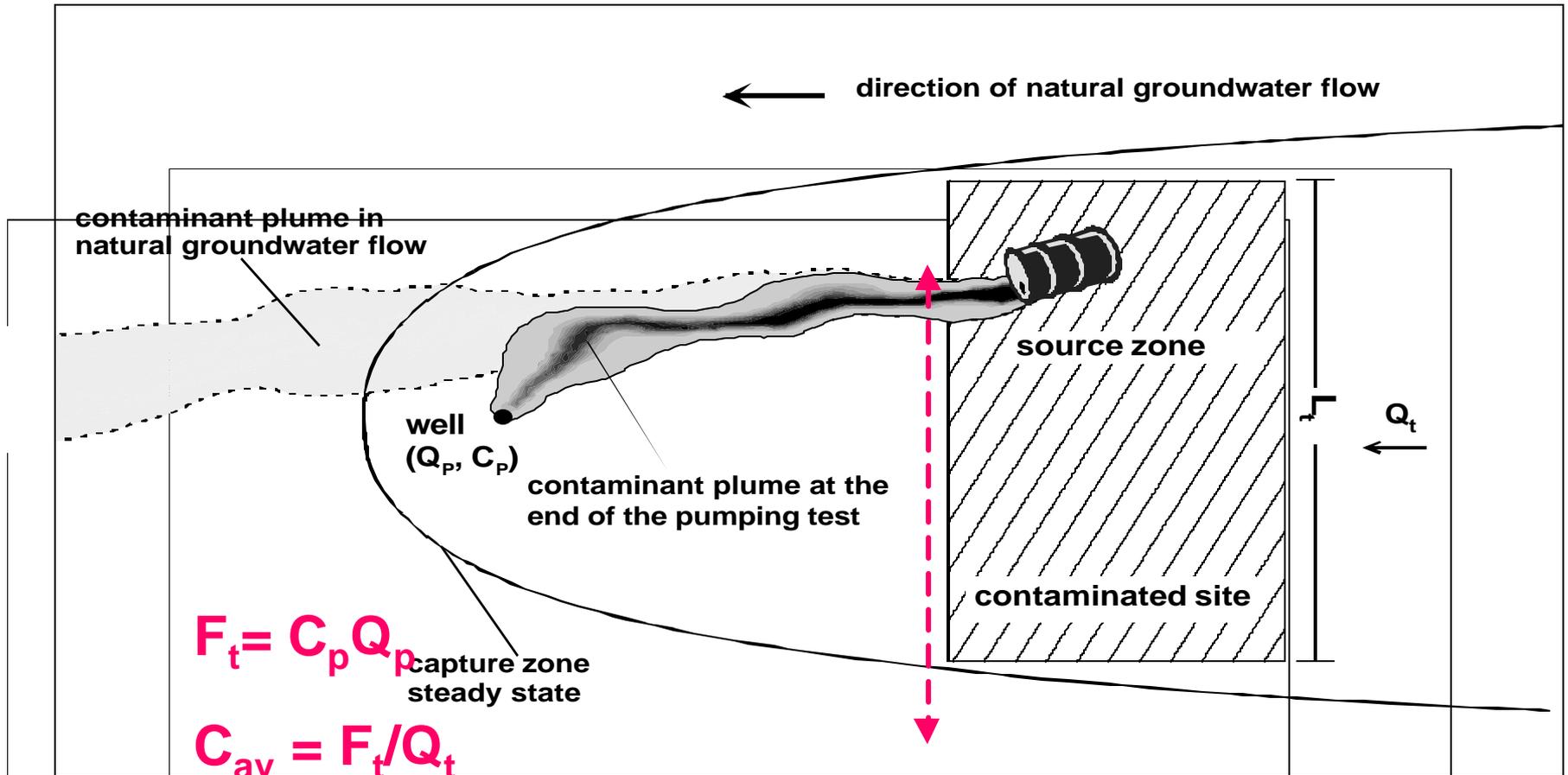


Current Options

- Transect of fully screened wells and hydraulic tests
- Transect of multilevel samplers with measured K field
- Integrated pumping test (Tuebingen method)
- Transect of borehole flux meters (Florida method)



Integral-Scale Flow-Rate Measurement Tuebingen Integral Pump Test

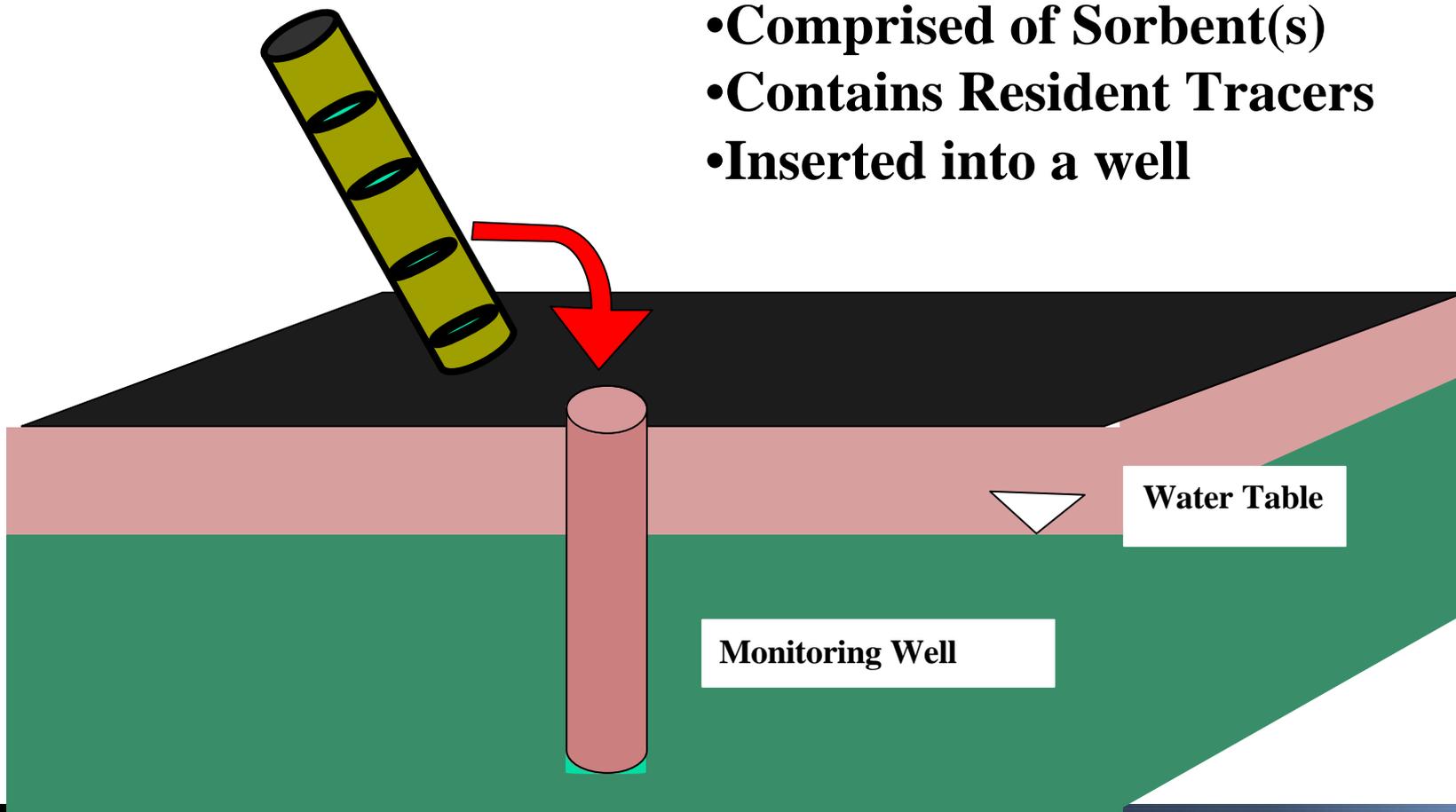


Teutsch et al., 2000



Conceptual Model Flux Meter Technology

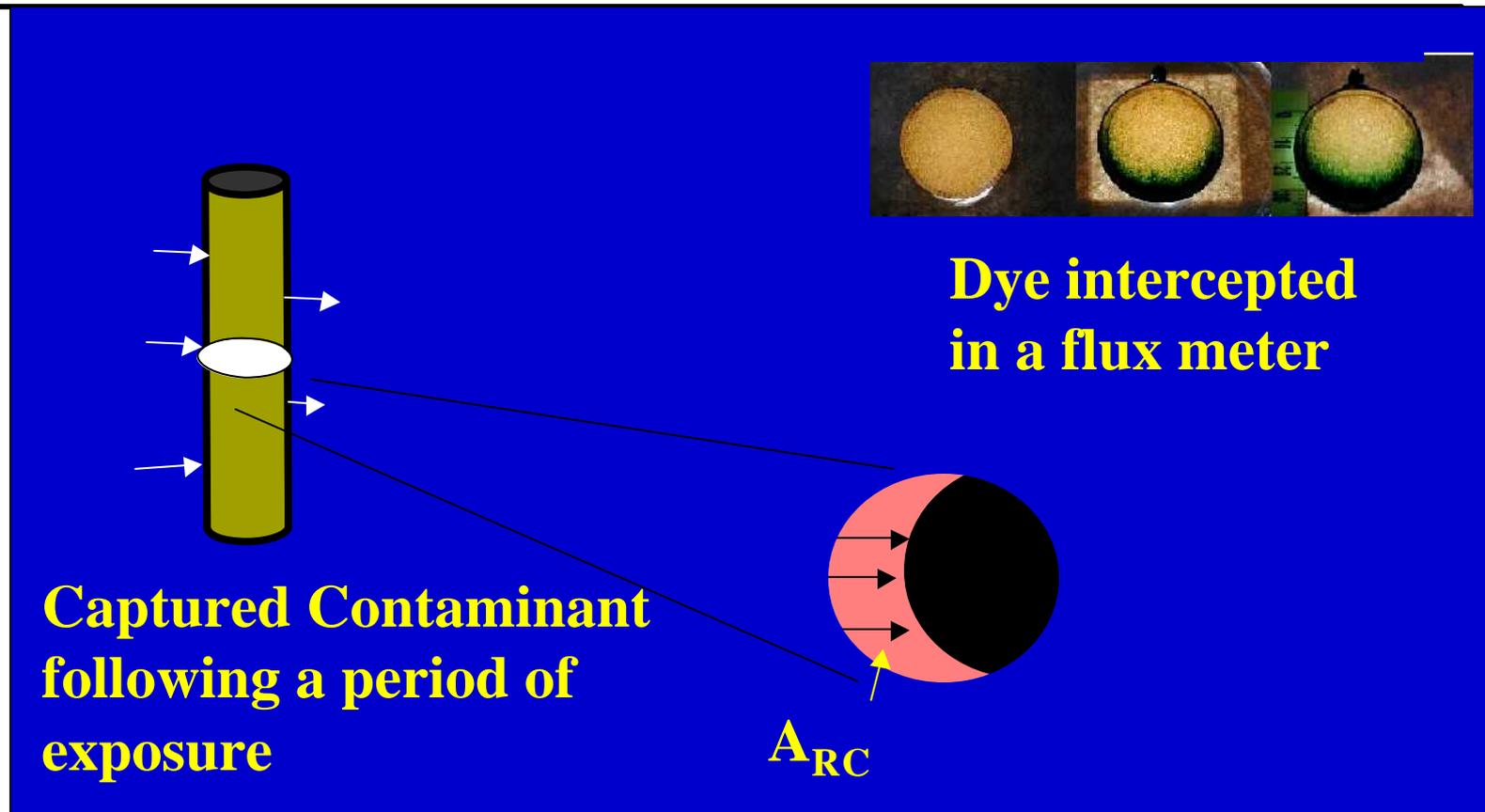
- **Segmented Porous Device**
- **Comprised of Sorbent(s)**
- **Contains Resident Tracers**
- **Inserted into a well**



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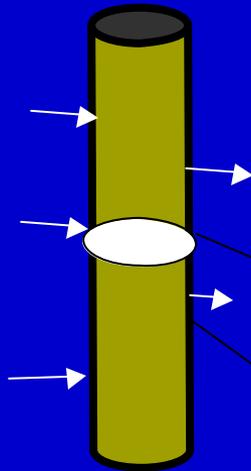
Conceptual Approach





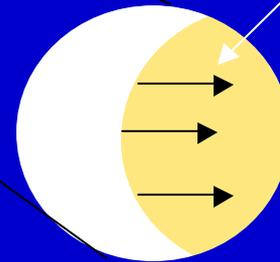
Conceptual Model

Cumulative Water Flux



Calculated from the mass of Resident Tracer retained on the sorbent after a known period of exposure.

Resident Tracer

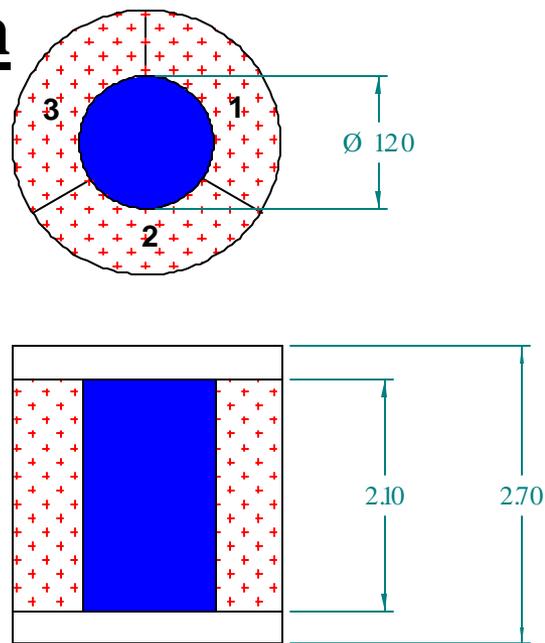




Laboratory Developments

Directional Flux Meter Design

- Outer sectors are packed with anion-exchange adsorbent
- Center well packed with adsorbent loaded with resident tracer

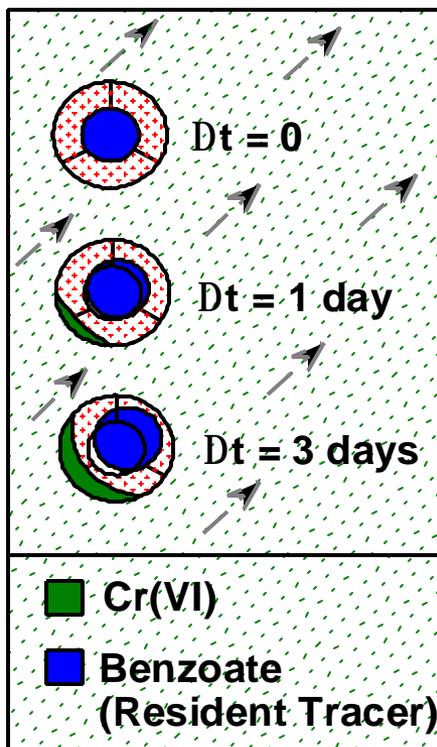


- AG1-X8 (HCO_3^-) resin
- AG1-X8 (HCO_3^-) resin loaded with benzoate (resident tracer)

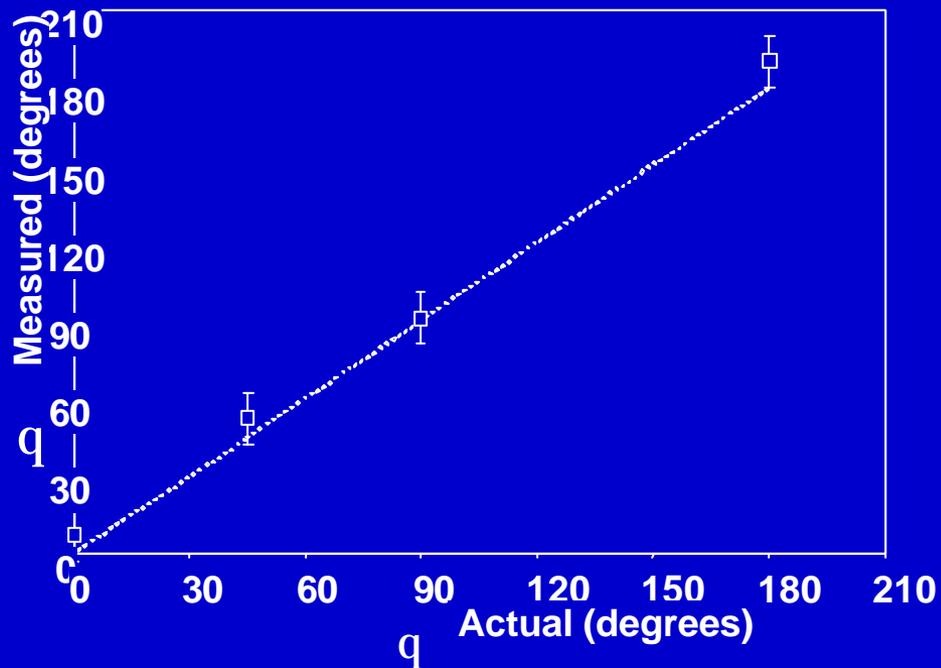


Laboratory Developments

Directional Flux Meter Design



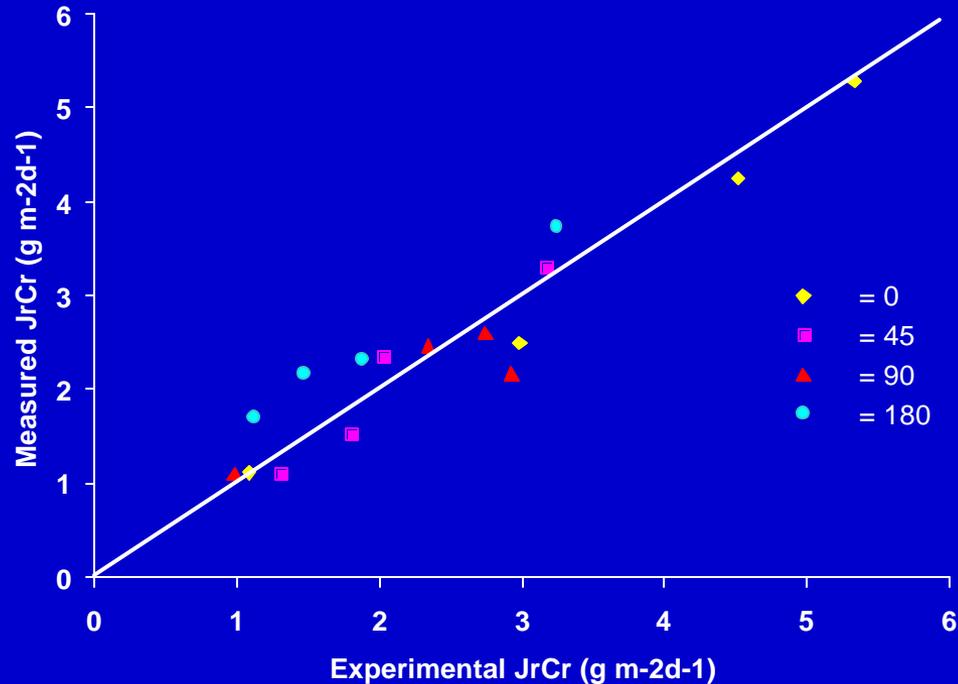
Direction of Flow





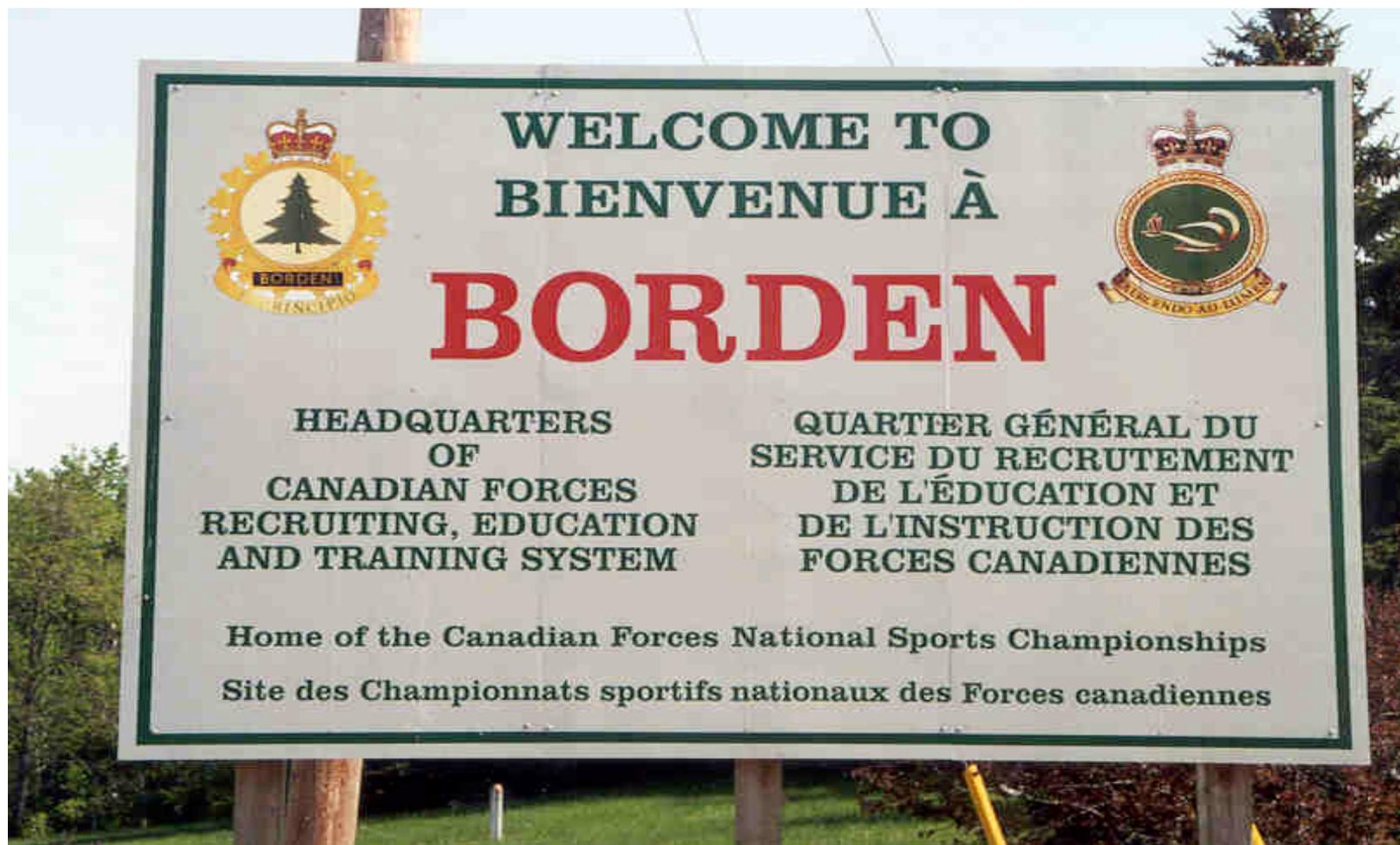
Laboratory Developments

Measured Chromium Fluxes





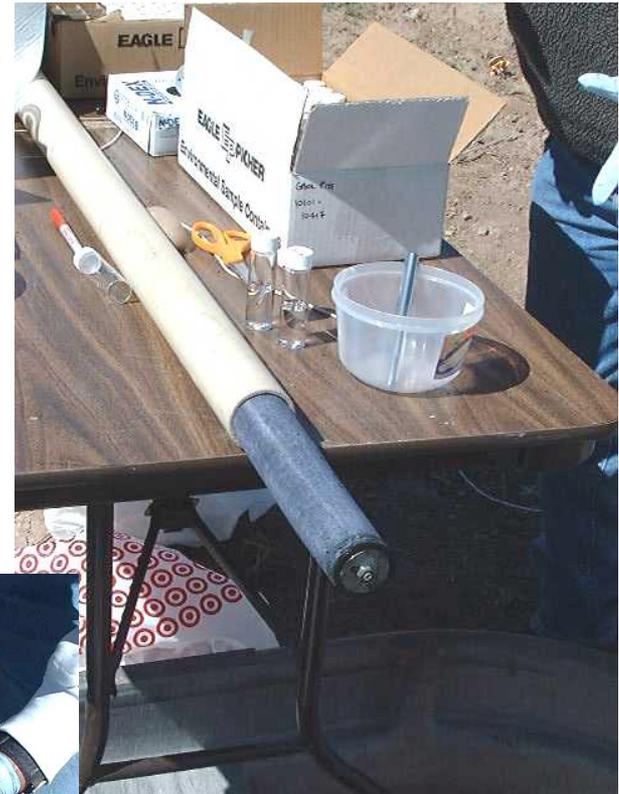
Field Experiments



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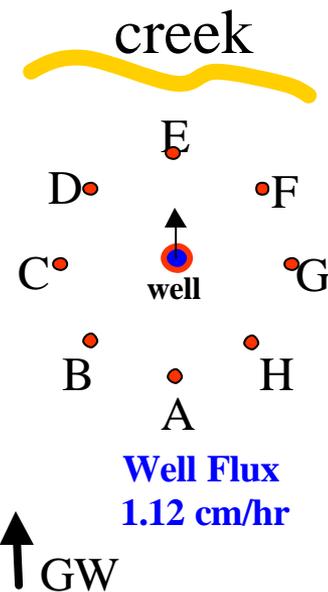
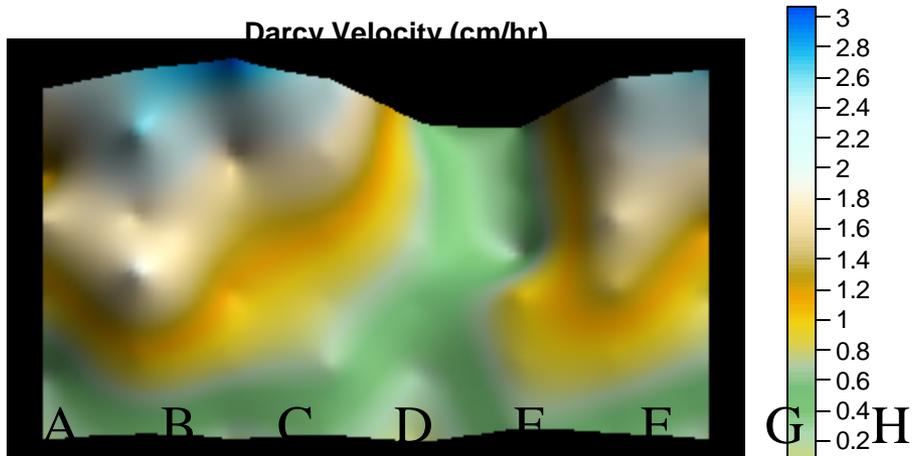
Field Installation and Sampling



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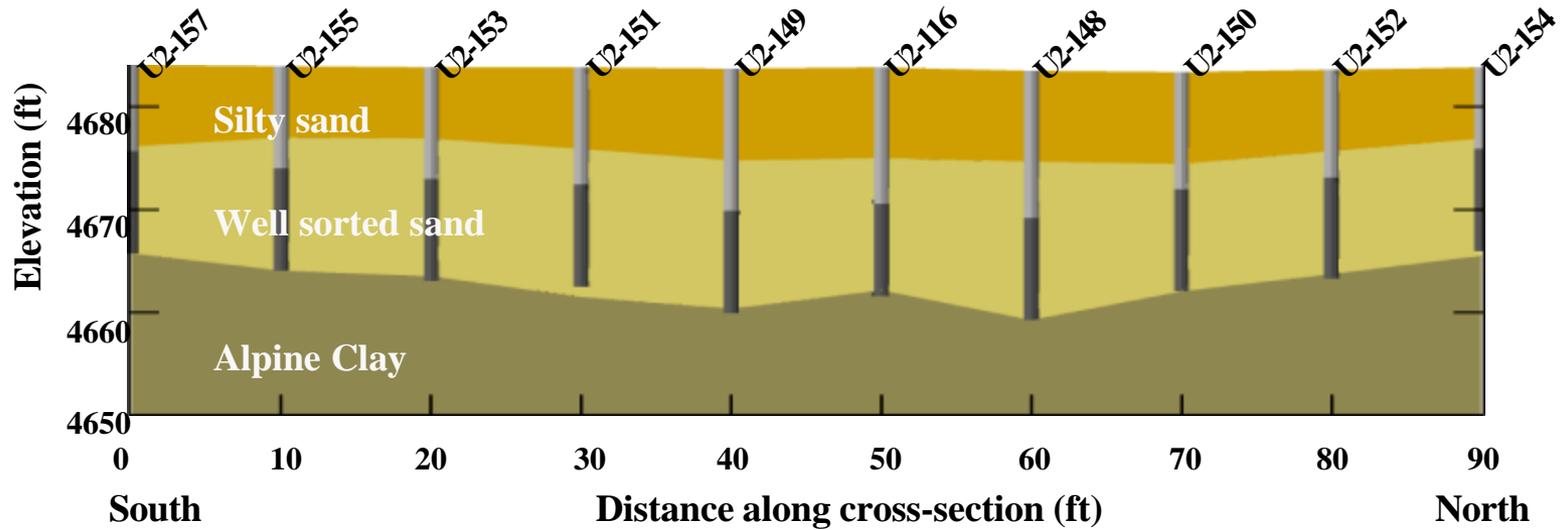


Borden Field Test





Hill AFB Test Site

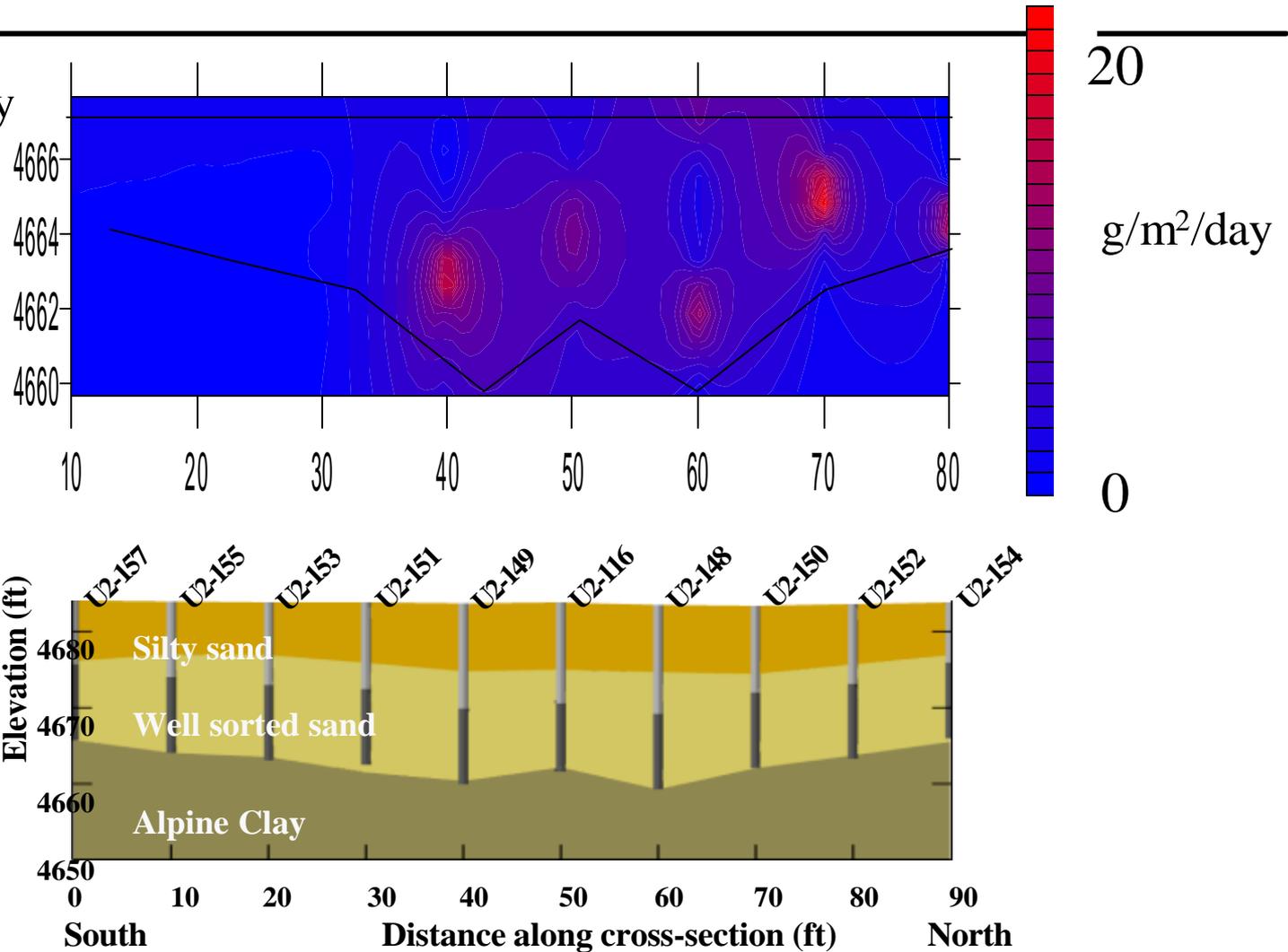


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Hill AFB Test Site

Total ≈ 180 g/day





Summary

Source zone characterization methods are improving and becoming more cost effective

An alternative approach using contaminant mass flux leaving the source zone may be appropriate for some sites

New methods for measuring mass flux are emerging



Thank You!

Questions?



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