

# Performance of Permeable Reactive Barriers

SAWEA 2007

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Industrial Supplies Centre/Vertex Environmental

**ISC**



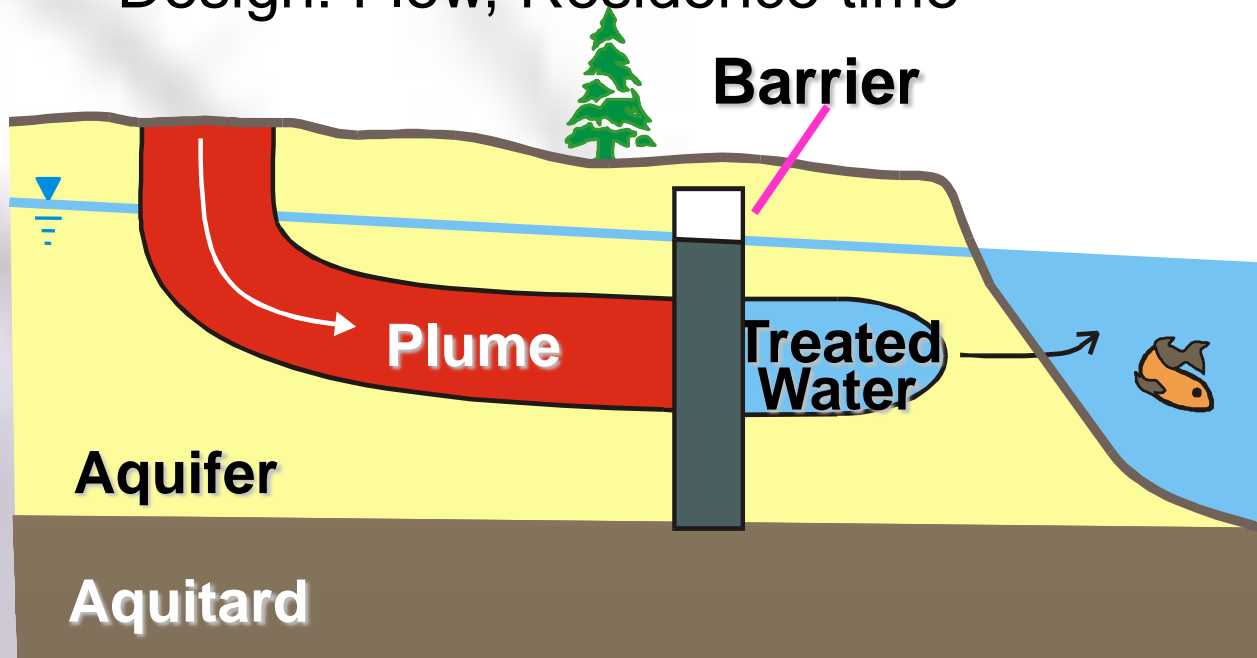
# Agenda



- Overview of PRBs
- Case Studies
  - BTEX
  - MTBE
  - Heavy Metals & As
- Questions

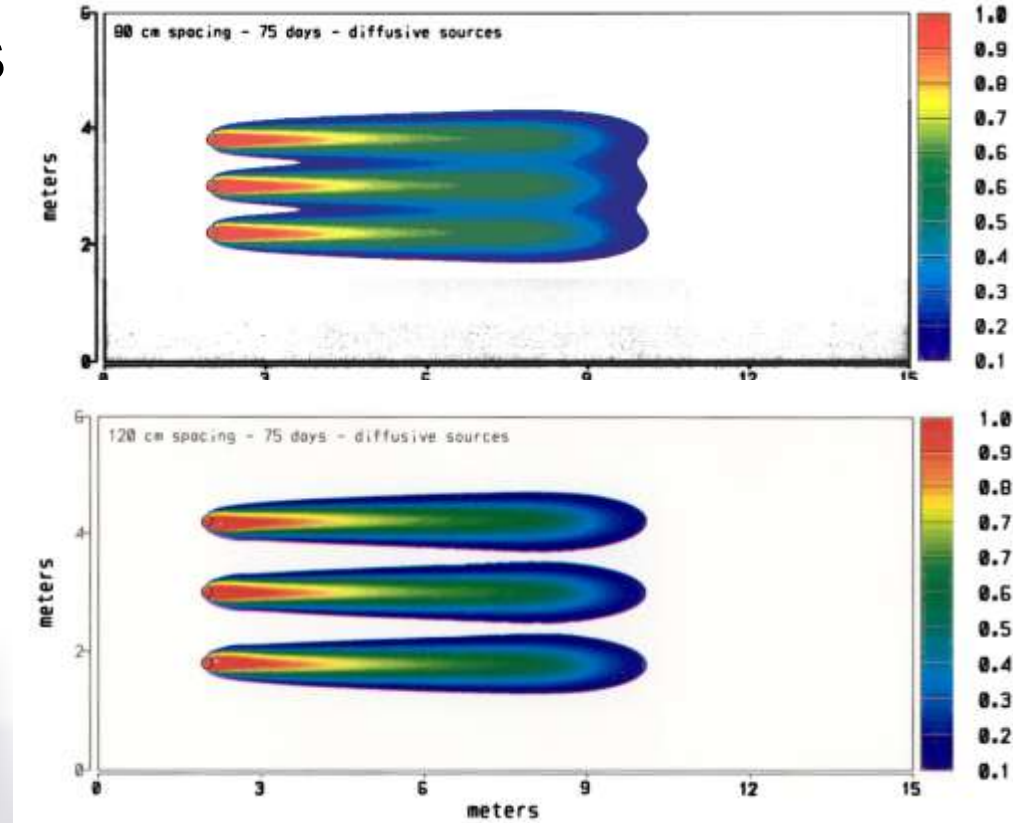
# Permeable Reactive Barriers

- Key Components
  - Reactive Material: Reacts quickly, Cheap, Long lasting
  - Permeability: No plugging,  $>$  aquifer
  - Design: Flow, Residence time



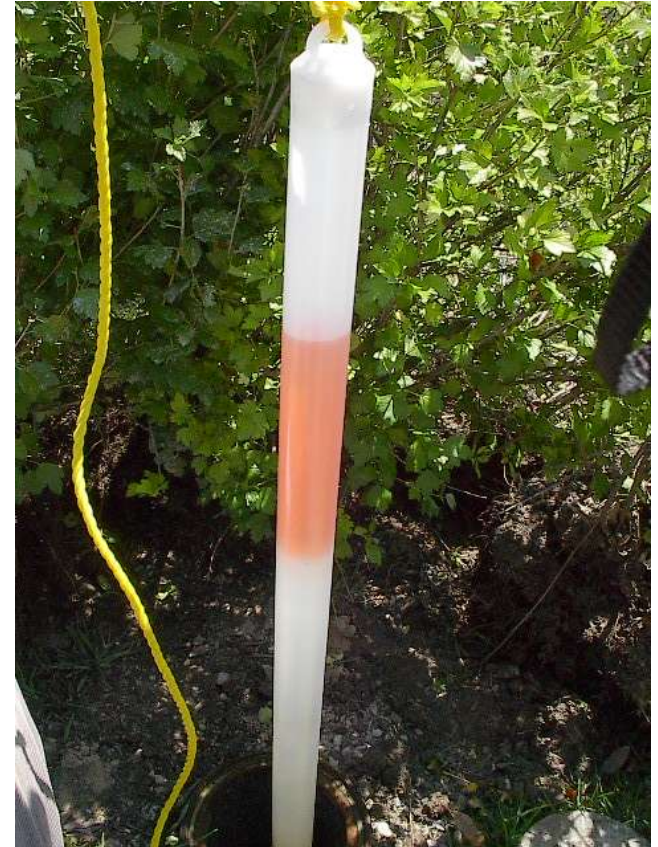
# Permeable Reactive Barriers

- Design Configurations
  - Funnel and gate
    - Changeable “media”
  - Continuous
    - Hanging
    - Keyed
  - Reactive zone
    - Wells
    - Injection zones



# PRBs - Hydrocarbons

- Solid oxygen releasing compounds
  - e.g. ORC
- Diffusive emitters
  - O<sub>2</sub> and other gases, nitrate, carbon substrates, oxidisers, tracers
- Solid carbon source
  - compost, wood chips, leaf mulch, sewage sludge, sheep manure and sawdust



# Hydrocarbons - Hydrogeology

Material	Fine sand, minor silt
Thickness	7.6 m
Water Table	3.5 mbgl
Hydraulic Conductivity	$2.6 \times 10^{-3}$ cm/s
Vertical Gradient	0.37 to (-)0.03
Horizontal Gradient	0.04
Groundwater Velocity	87 m/a

# Hydrocarbons - Chemistry

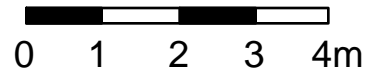
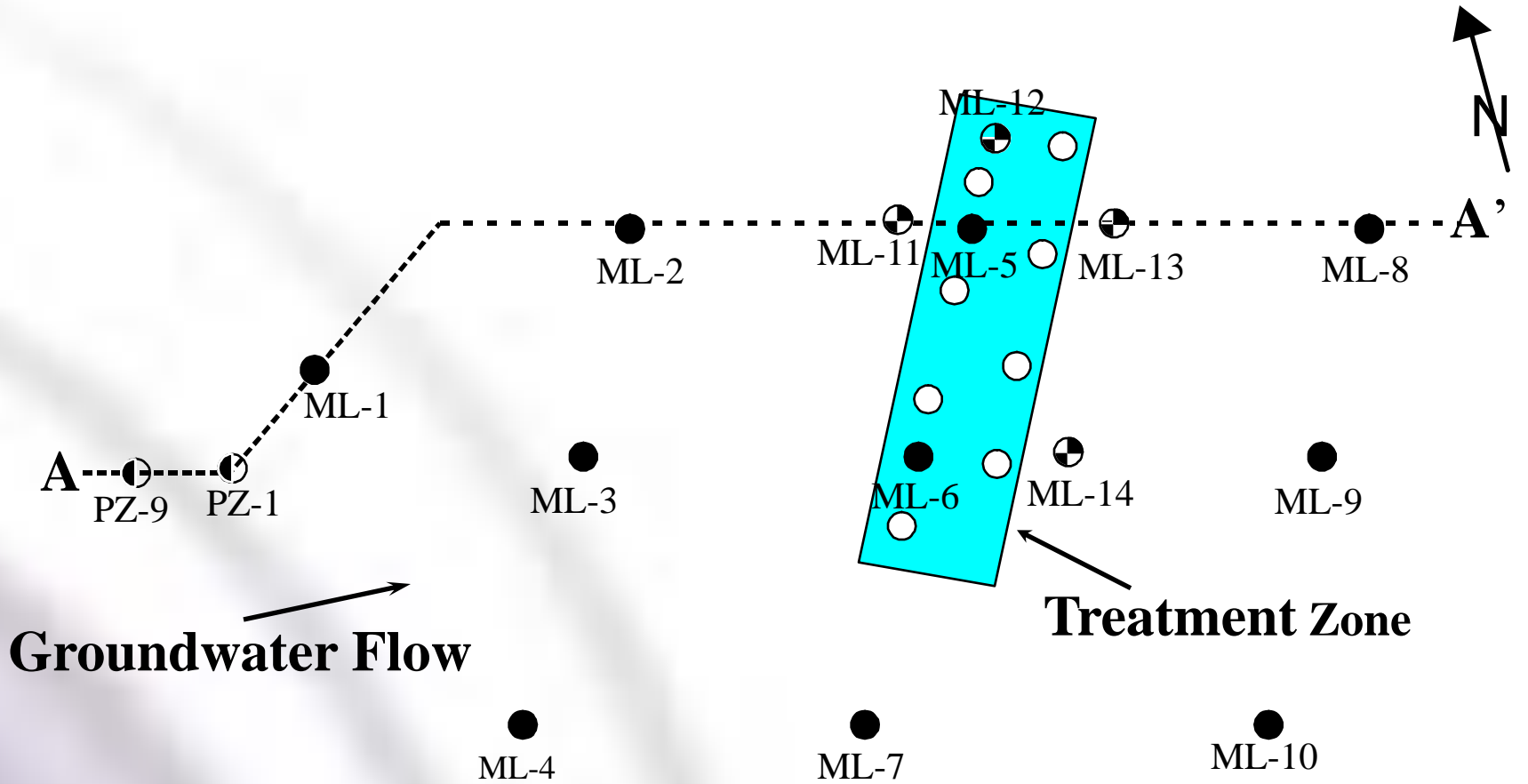
Parameter	Background	Plume Core	Leading Edge
BTEX	<0.002	4.2	0.252
Dissolved O <sub>2</sub>	9.0	0.2	5.2
E <sub>H</sub> (mV)	342	107	345
pH	6.40	5.98	6.29
Fe(II)	0.25	2.51	0.35
Nitrate	10.7	<1.5	7.0
Sulphate	38.0	3.35	27.7
Alkalinity	58	252	98

all units mg/L, except pH and E<sub>H</sub>

**ISG**







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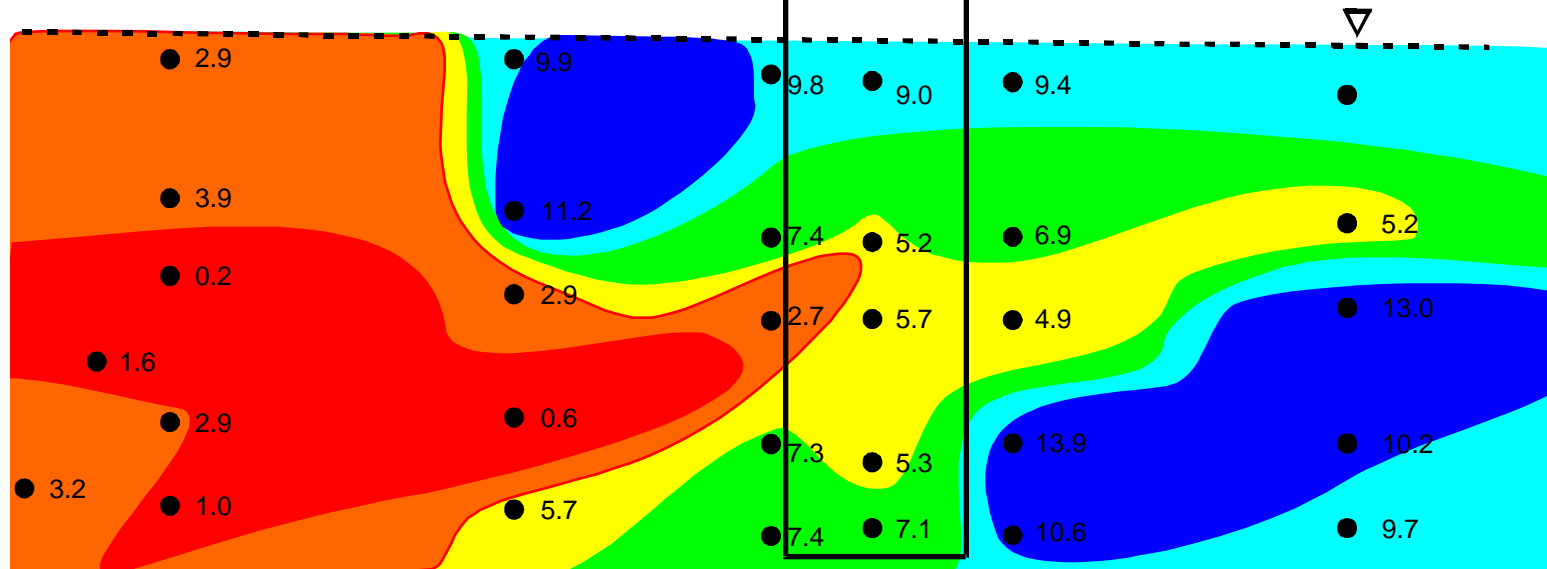
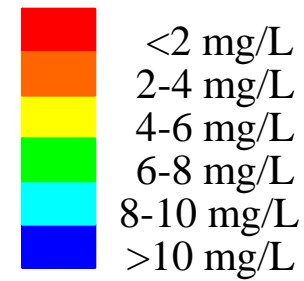
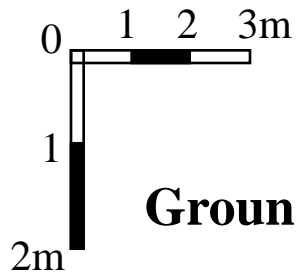


PZ1

ML8

ORC Treatment Zone →

Dissolved O<sub>2</sub> -2 months



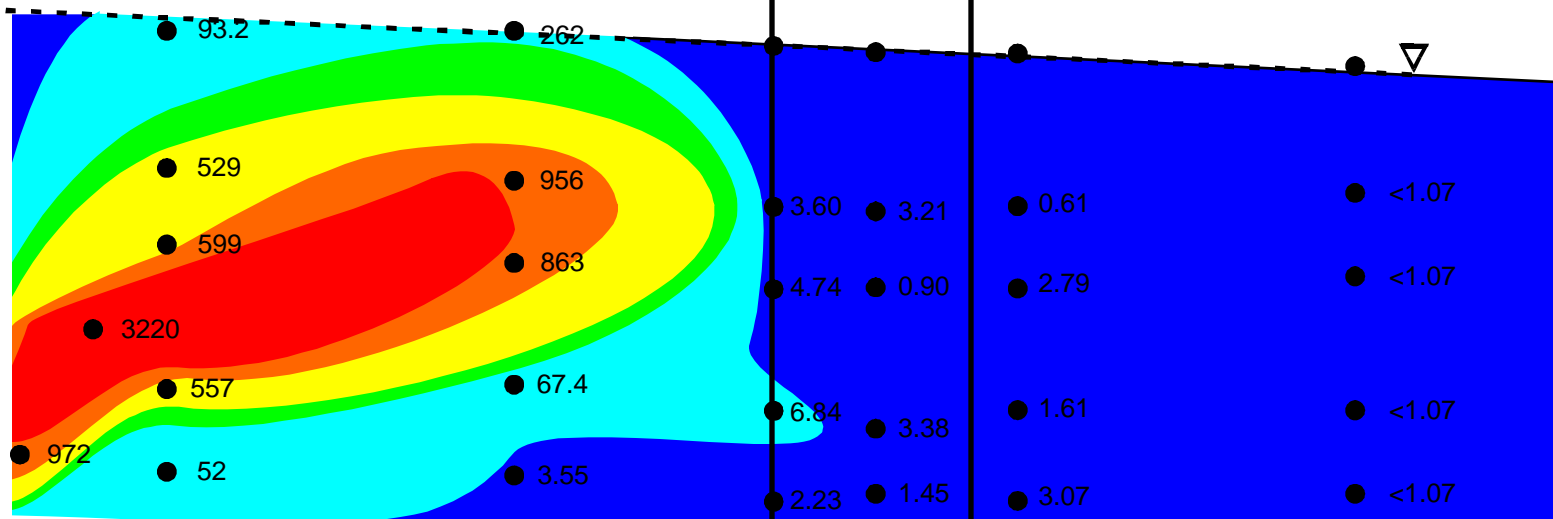
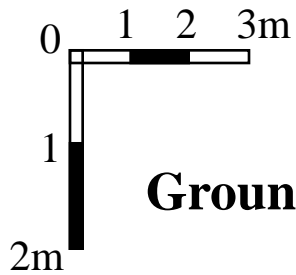


PZ1

ML8

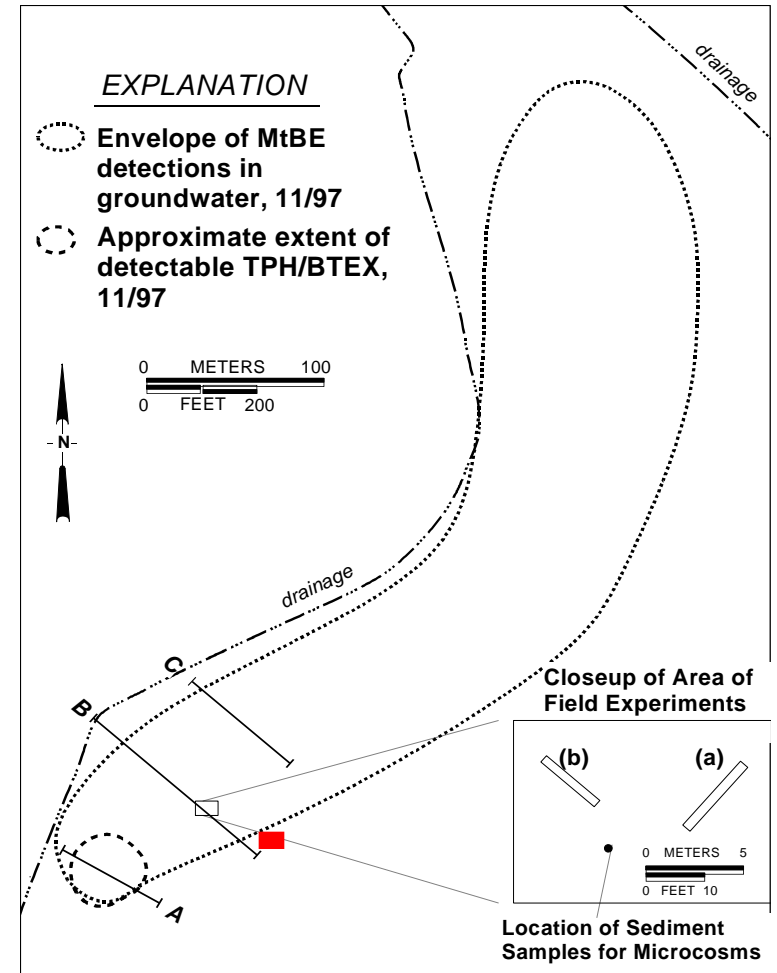
Treatment Zone →

m/p Xylene - 4 months



# MTBE Case Study

- **VAFB**
  - $Q \sim 0.3\text{-}0.6$  m/day
  - unconsolidated sands, silts and clays
  - $> 520$  m MTBE plume
  - $< 30$  m BTEX plume
  - no measurable DO inside or outside MTBE or BTEX plumes
  - Temp  $\sim 17\text{-}19$  C



# Site 60

## Former GSA Service Station

experimental  
area

tank excavation  
“source area”



# Conceptual sketch of treatment zone

permeable  
contactor

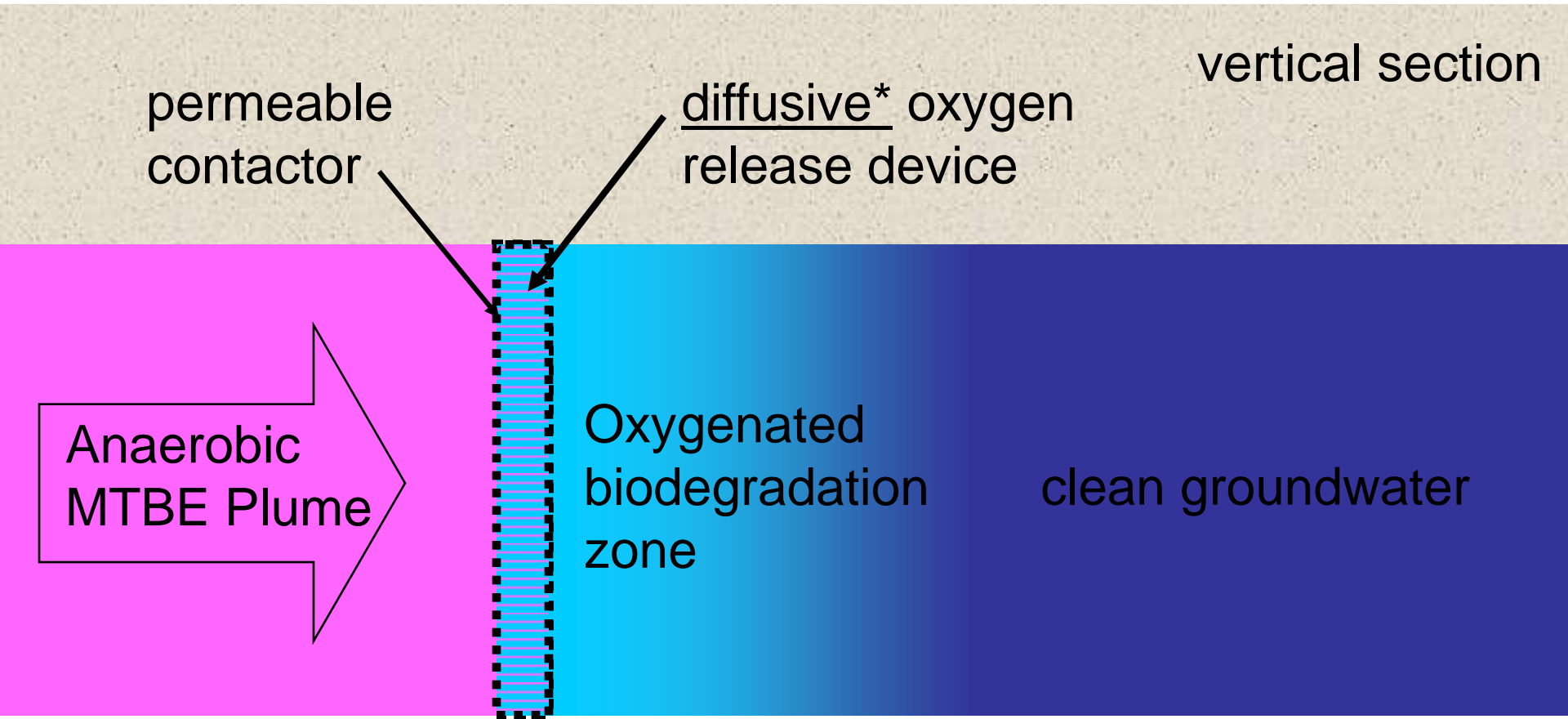
diffusive\* oxygen  
release device

vertical section

Anaerobic  
MTBE Plume

Oxygenated  
biodegradation  
zone

clean groundwater



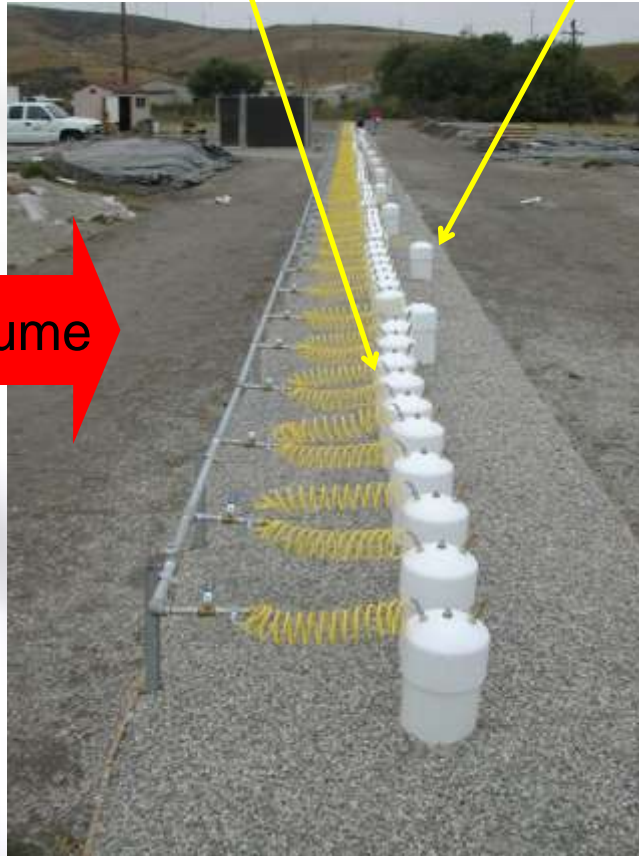


# MTBE Case Study

Emitter wells

Monitoring wells

plume

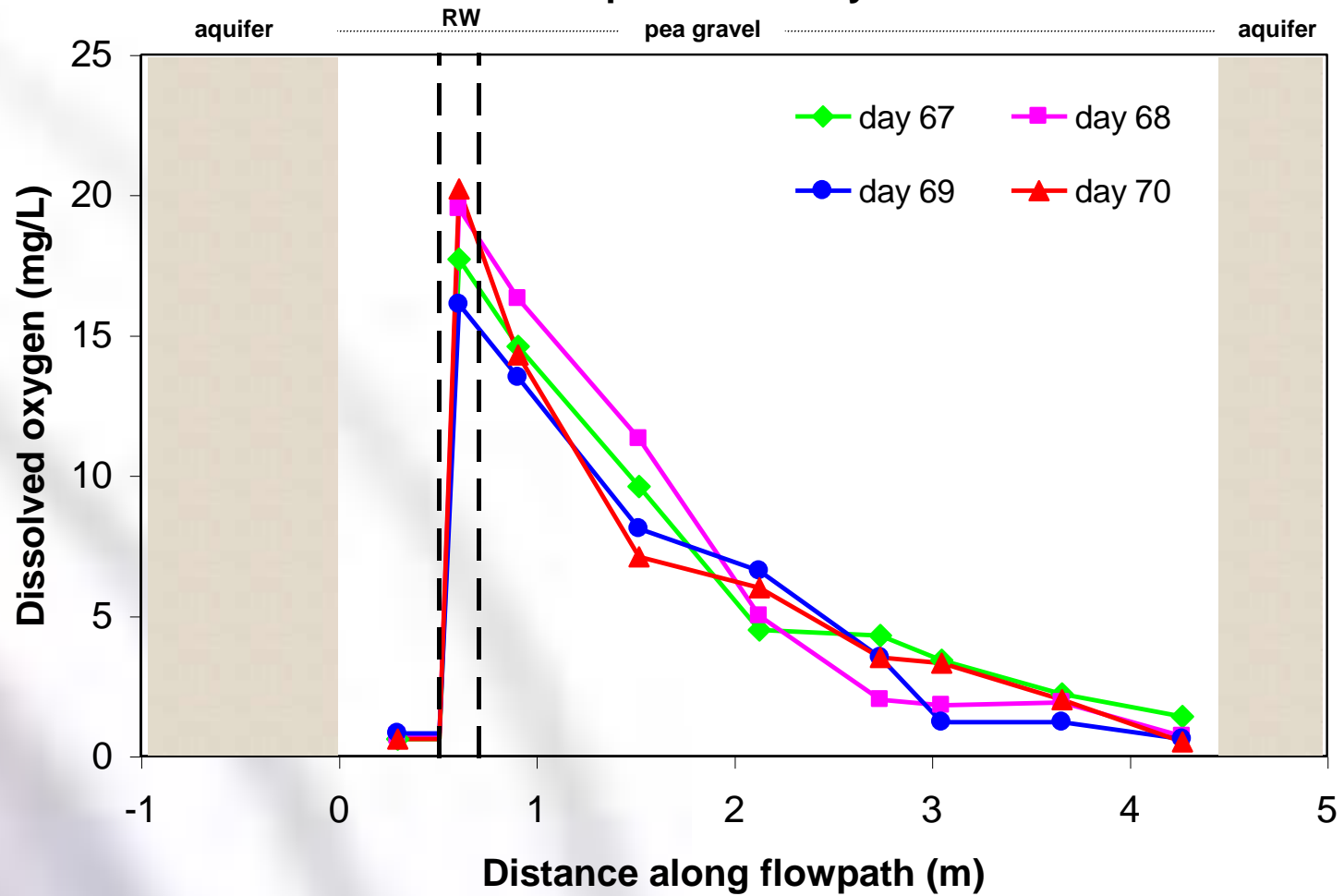


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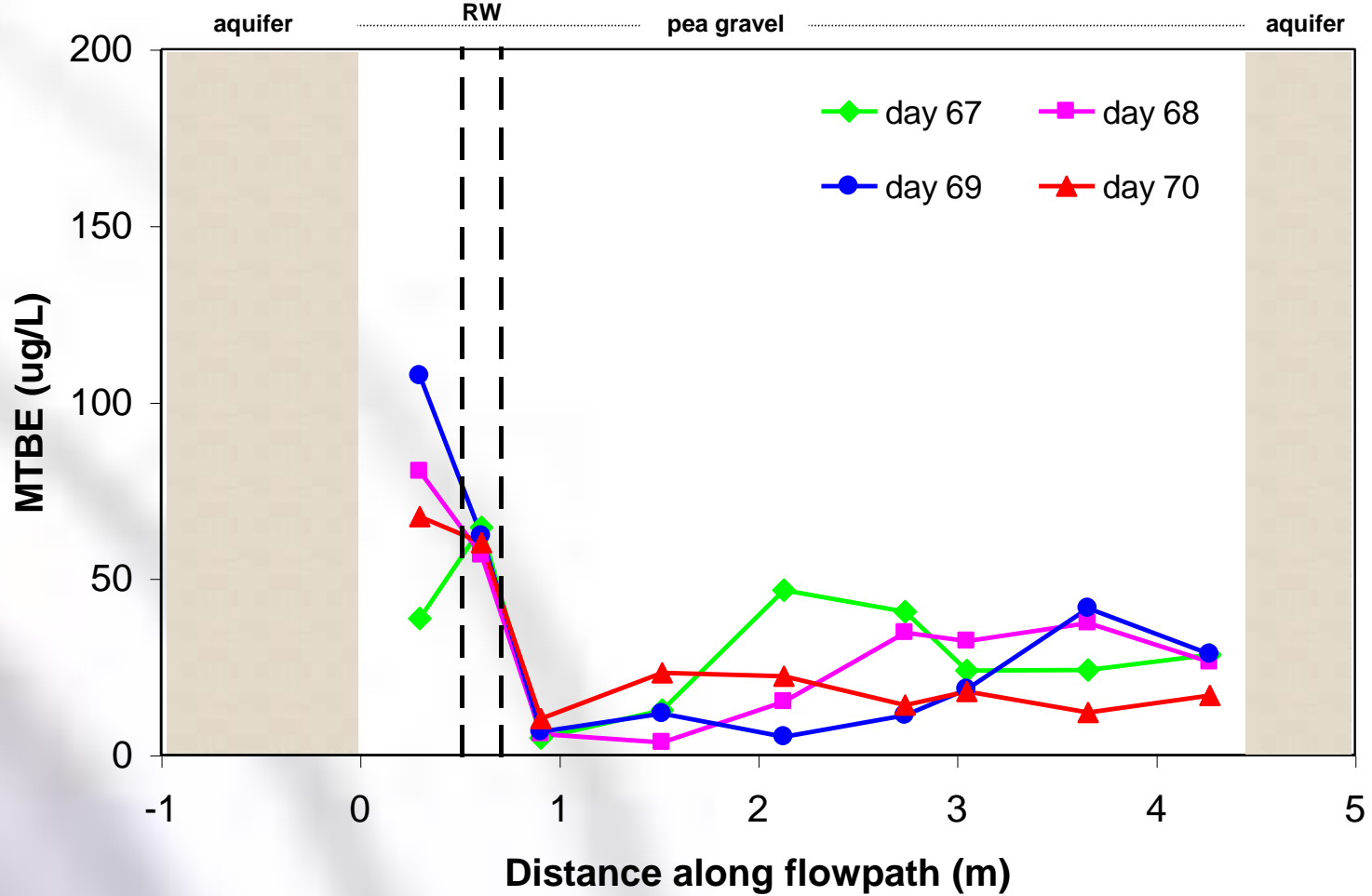




### Oxygen release ON since Day 1 Samples taken Day 67-70

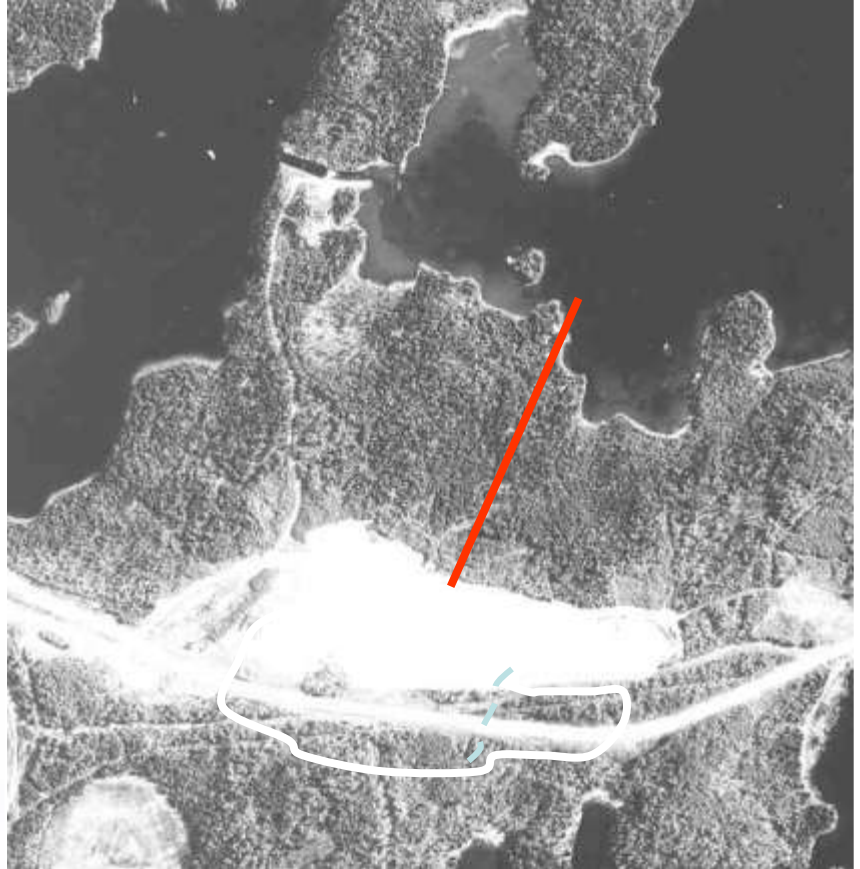


### Oxygen release ON since Day 1 Samples taken Day 67-70



# PRBs – Heavy Metals & As

- Northern Canada
- Disposal area
  - former sand and gravel pit
  - topographic high
  - 300,000 m<sup>3</sup> capacity
- Coal-combustion byproducts



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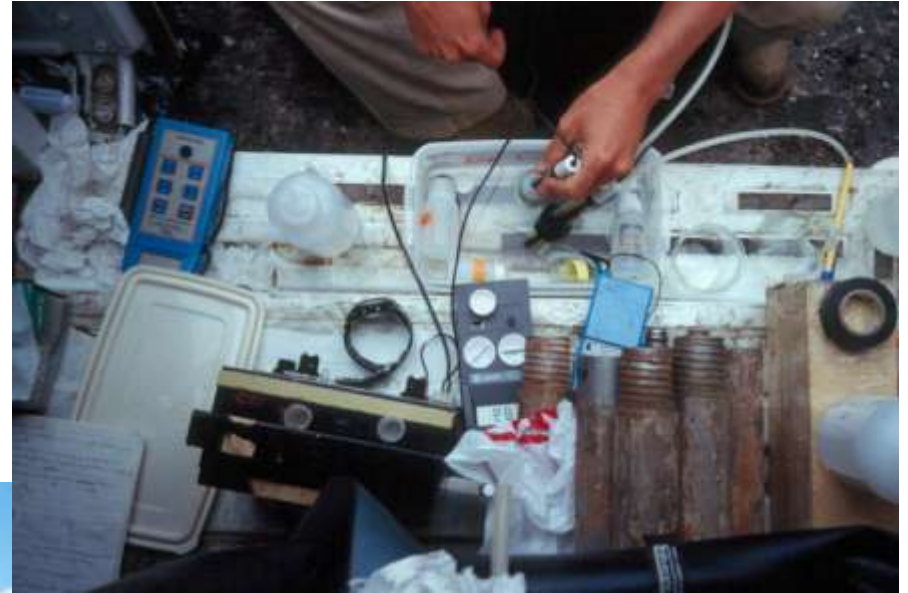
# Study Site - Hydrogeology



- Groundwater divide
- 3 pathways
  - NE (90%)
  - NW (5%)
  - S (5%)
- Sand and gravel
- Bedrock controlled
- Velocity 7 to 50 m/yr

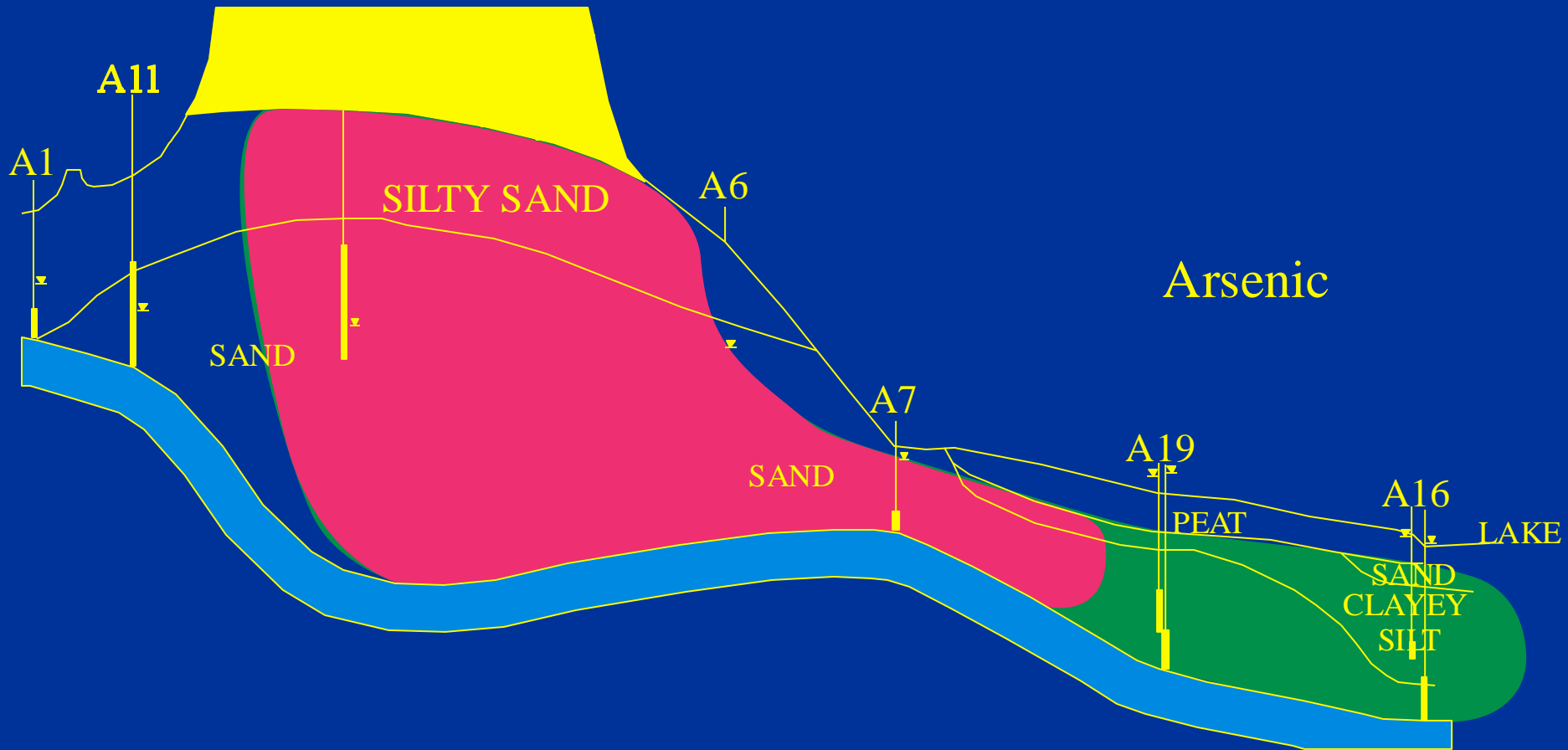
# Hydrogeochemistry

- Source
  - High pH (~12.8)
  - $E_H \sim 200$  mV
  - Alkalinity  $\sim 8,400$  mg/L as  $\text{CaCO}_3$



- $\text{SO}_4 \sim 1,600$  mg/L
- As  $\sim 1$  mg/L
- Fe  $\sim 2$  mg/L
- B, Cr, Mo, Se, V, Zn

# Hydrochemistry-Arsenic





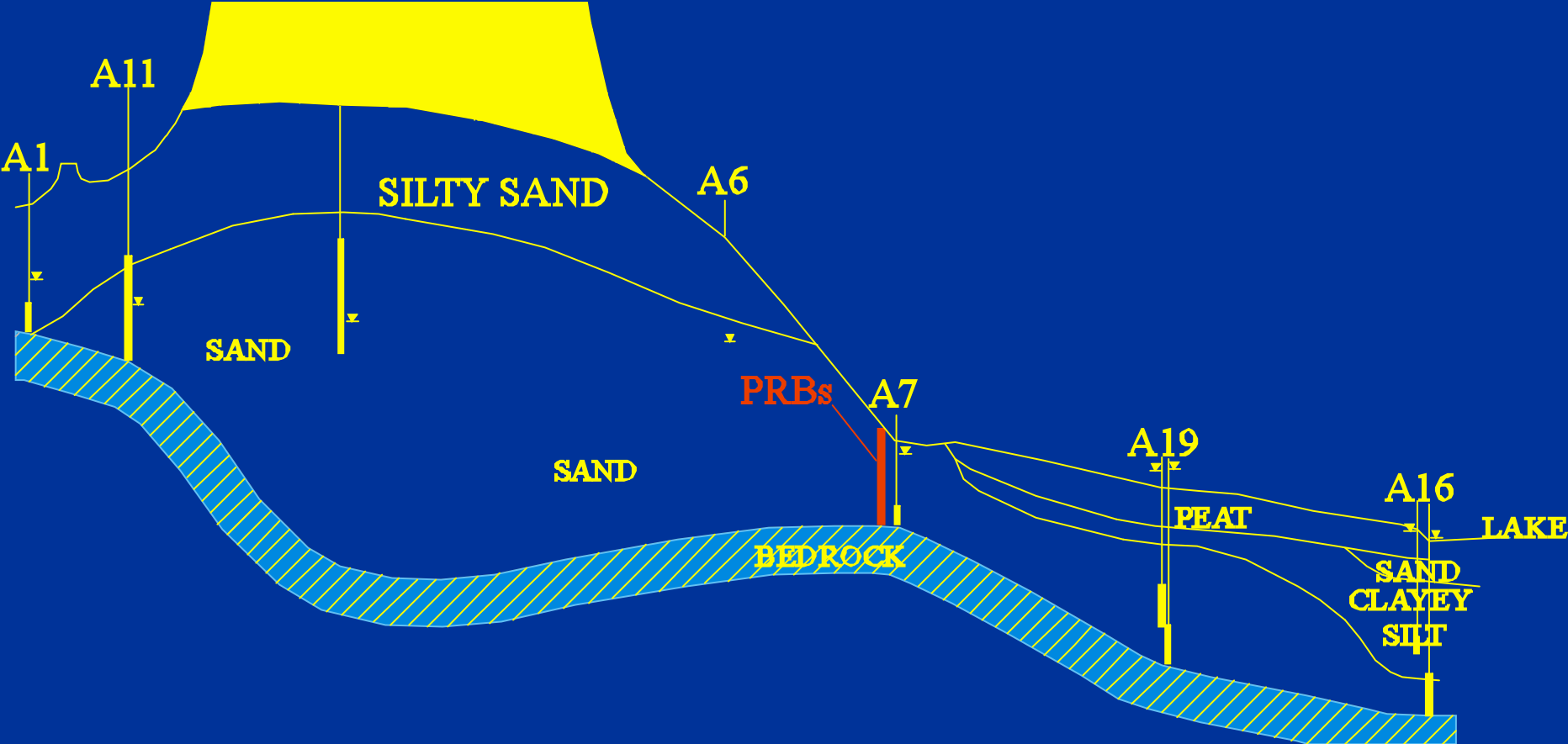
# PRB Installation

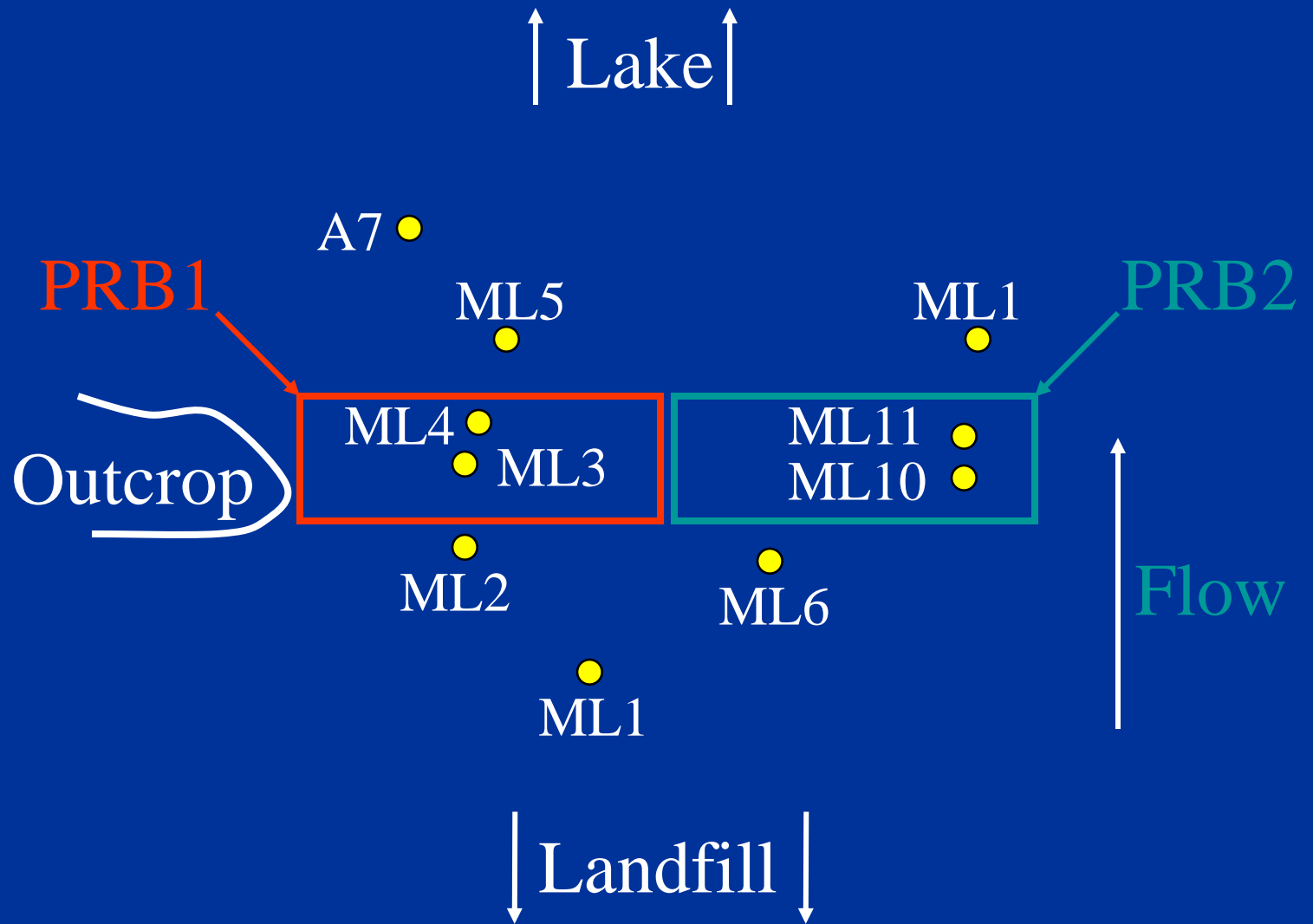
- Two PRBs
  - ZVI/Wood Chip
  - ZVI
- Cut & Full with Trench box
- 6.5 m x 2.0 m x ~3.0m
- Two week residence time



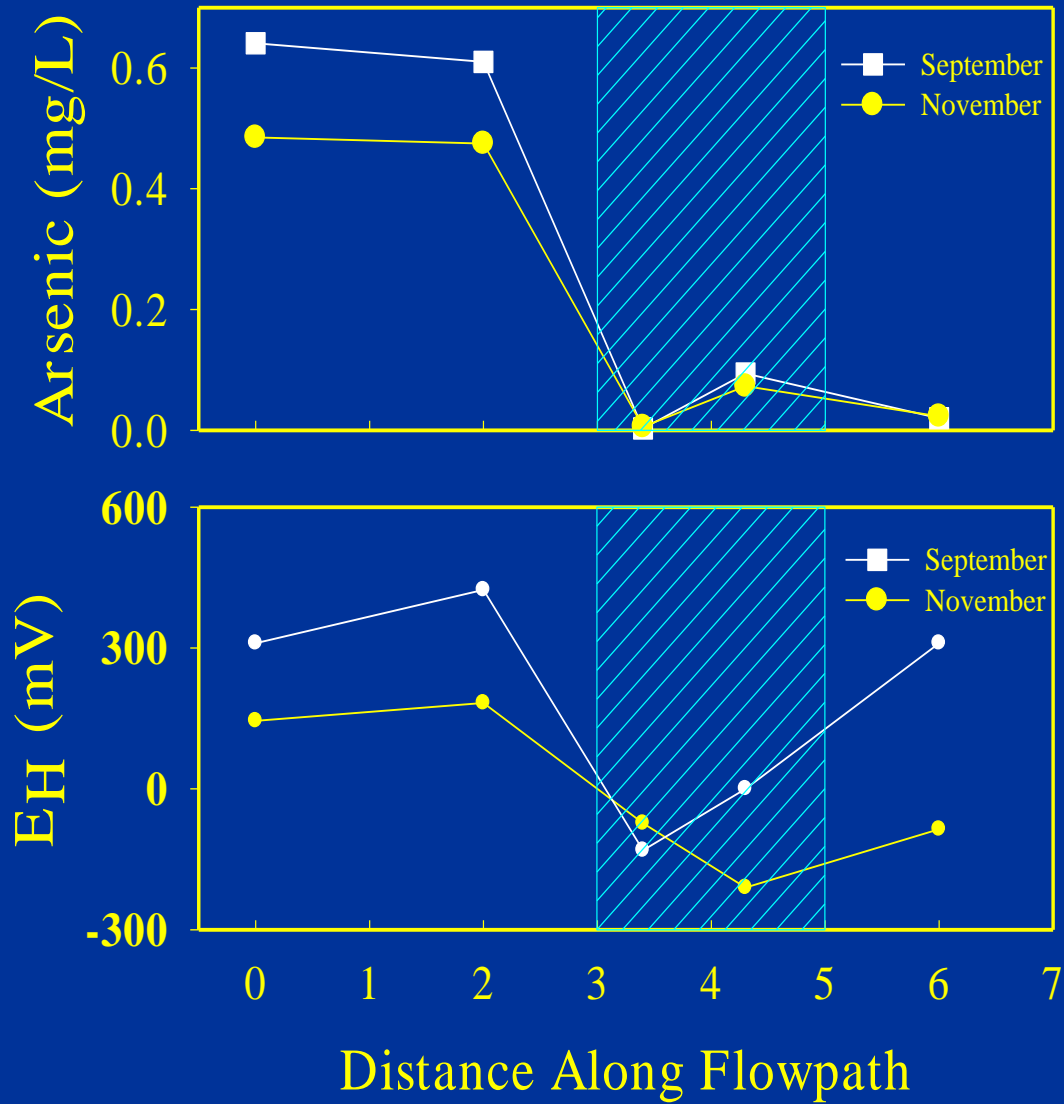


# PRB Location

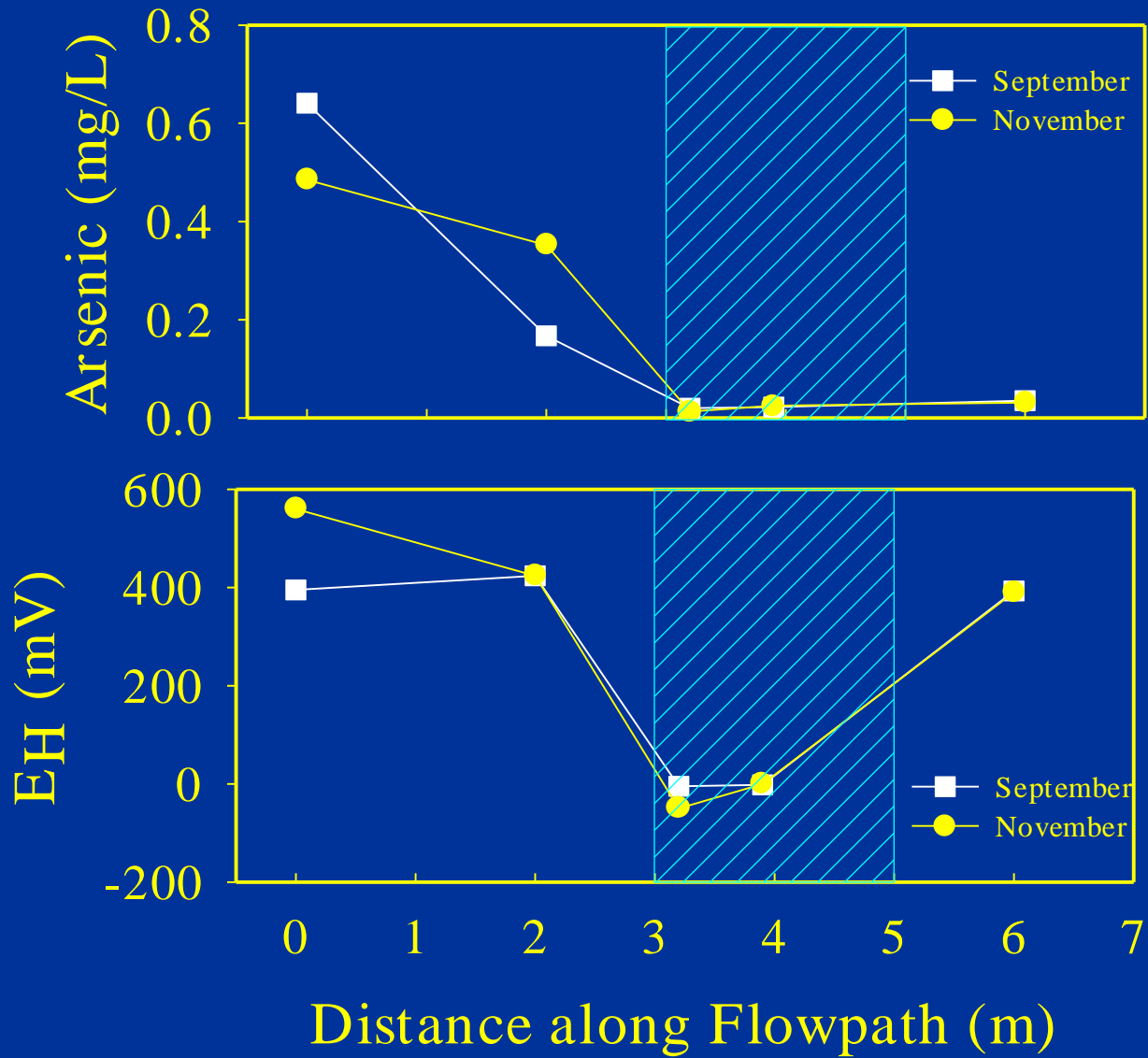


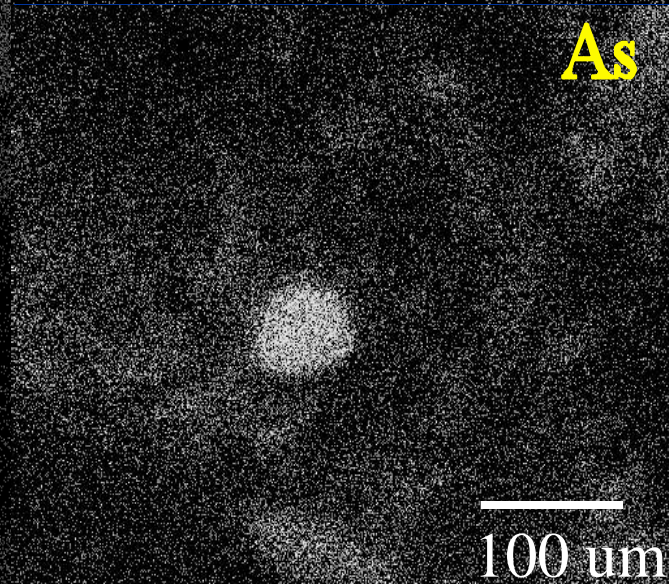
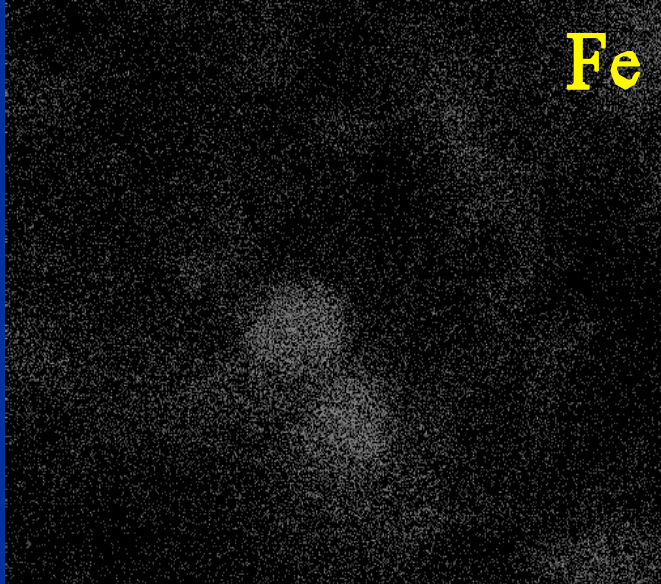
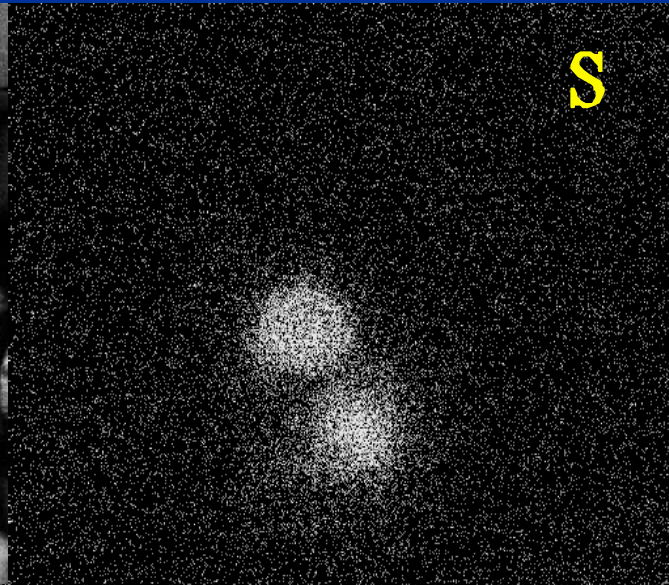
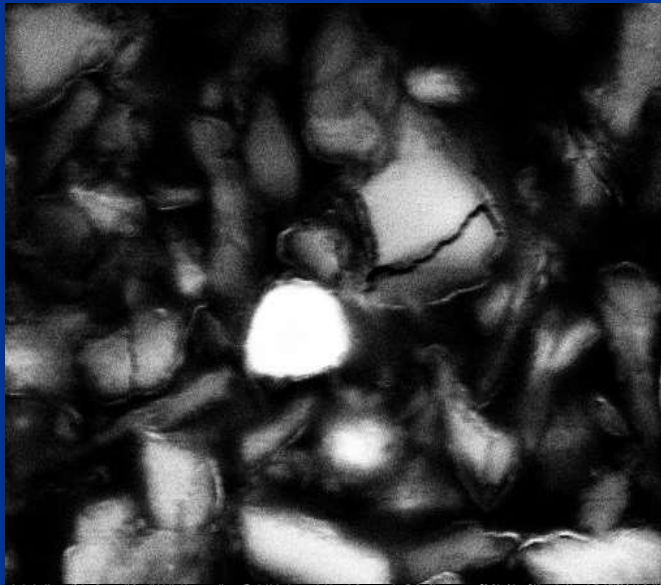


# PRB 1



# PRB 2





# Questions?

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