




Sampling of Monitoring Wells

EPA
United States
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Agency

Thanks to:
Phil Harte, USGS

USGS
science for a changing world

Monitoring Well Sampling methods

United States Environmental Protection Agency | Office of Research and Development | Office of Solid Waste and Emergency Response | EPA/540/S-95/504 April 1996

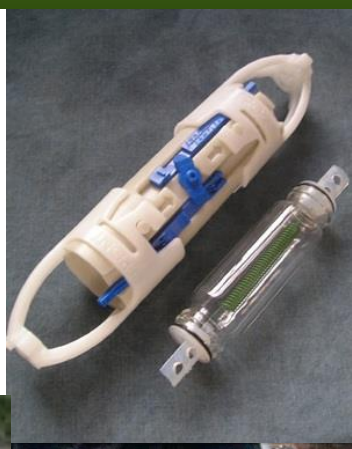
EPA **Ground Water Issue**

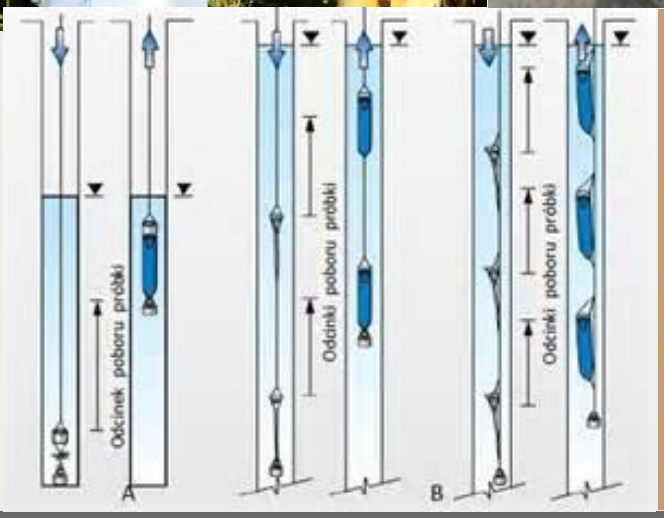
LOW-FLOW (MINIMAL DRAWDOWN) GROUND-WATER SAMPLING PROCEDURES

by Robert W. Puls[1] and Michael J. Barcelona[2]

Background

The Regional Superfund
group of ground-water scientists,
Regional Superfund Offices, organ
information related to ground-wate
sites. One of the major concerns
sampling of ground water to suppo
remedial performance monitoring
intended to provide background in
development of low-flow sampling
application under a variety of hydr
hoped that the paper will support





Major Monitoring Well Sampling Divisions

- **Bulk mixed sample**
  - Typically high volume purge
  - One sample per well
  - E.g., conventional pumping
- **Partially mixed sample in open hole**
  - Micropurge or low flow (rate or volume)
  - Multiple samples per well
  - E.g., point thief sampling, passive sampling
- **Discrete, less mixed sample**
  - Variable volume
  - E.g., passive sampling with packers, flute, straddle packer, hydraulic control sampling

Review of Sample Methods

- **Bulk sample (open borehole)**
  - High volume purging (some low volume also)

- **Hybrid discrete (open borehole)**
  - Thief (grab sample)
  - Vertical passive sampling (open borehole)
  - Cumulative flow profiling

- **Discrete**
  - Straddle packer
  - Flute and sock systems
  - Passive with packers

Bulk Mixed Sampling

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Background

Regional Superfund Ground Water Forum is a nd-water scientists, representing EPA's erfund Offices, organized to exchange lated to ground-water remediation at Superfund the major concerns of the Forum is the round water to support site assessment and ormance monitoring objectives. This paper is ovide background information on the of low-flow sampling procedures and its der a variety of hydrogeologic settings. It is e paper will support the production of standard cedures for use by EPA Regional personnel and mental professionals engaged in ground-water

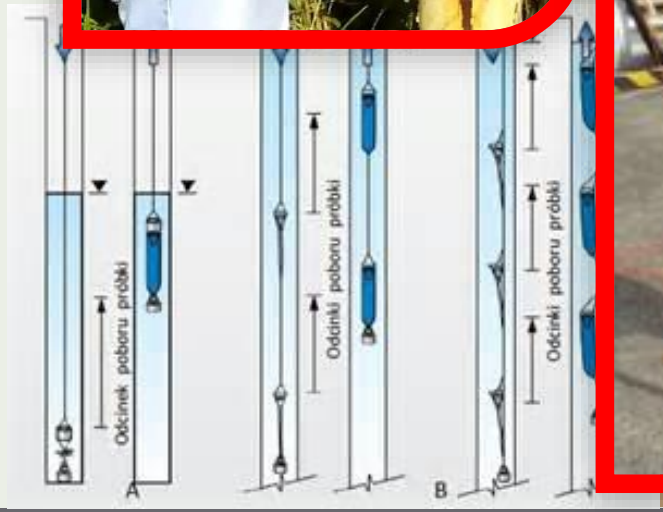
units were identified and sampled in keeping with that objective. These were highly productive aquifers that supplied drinking water via private wells or through public water supply systems. Gradually, with the increasing awareness of subsurface pollution of these water resources, the understanding of complex hydrogeochemical processes which govern the fate and transport of contaminants in the subsurface increased. This increase in understanding was also due to advances in a number of scientific disciplines and improvements in tools used for site characterization and ground-water sampling. Ground-water quality investigations where pollution was detected initially borrowed ideas, methods, and materials for site characterization from the water supply field and water analysis from public health practices. This included the materials and manner in which monitoring wells were installed and the way in which water

ormation contact: Robert Puls, 405-43 emediation and Protection Division, na.

methods and objectives of ground- ssess water quality have evolved o phasis was on the assessment of s sources of drinking water. Large

Superfund Techn Ground Water

National Risk Ma



Groundwater sampling "Black Box"

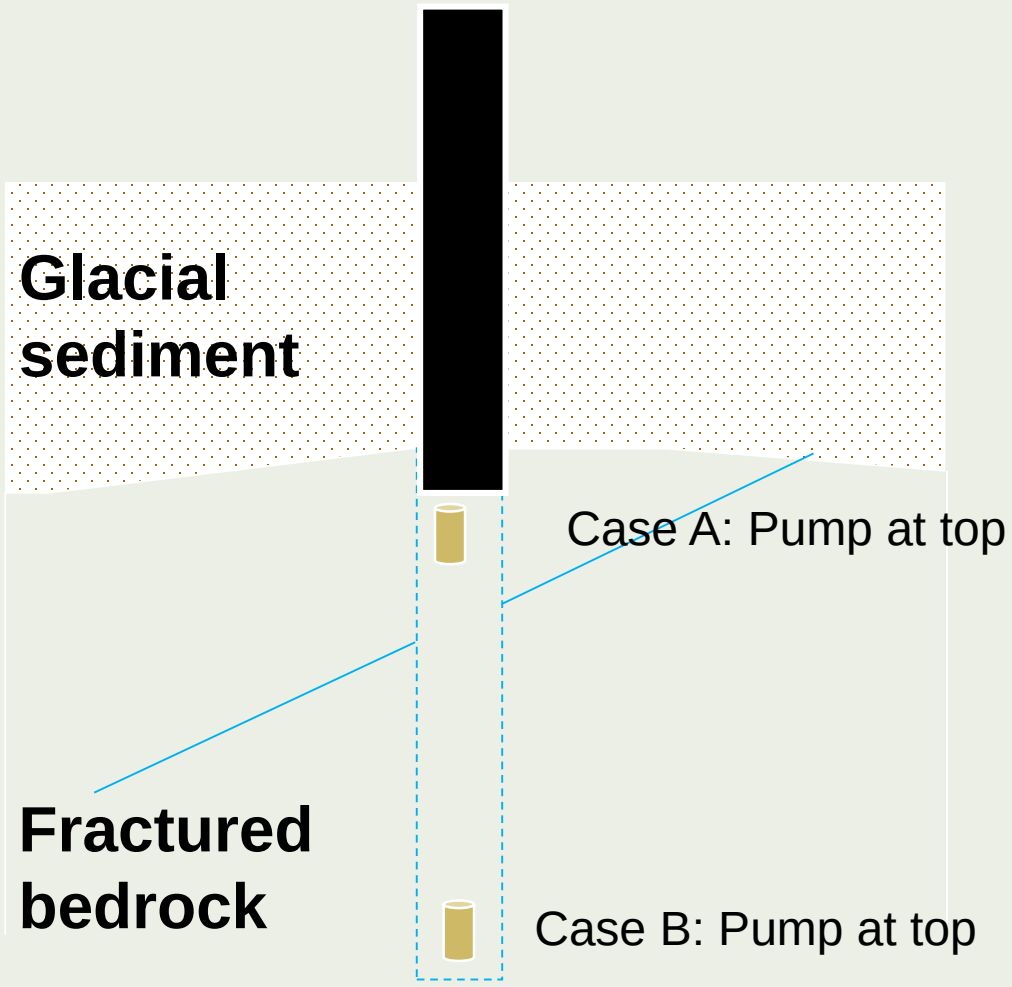
- **Why purge?**
  - Regulatory requirement?
  - "Representativeness?"
  - Tradition?
  - We like to work hard?

Bulk Mixed Sampling

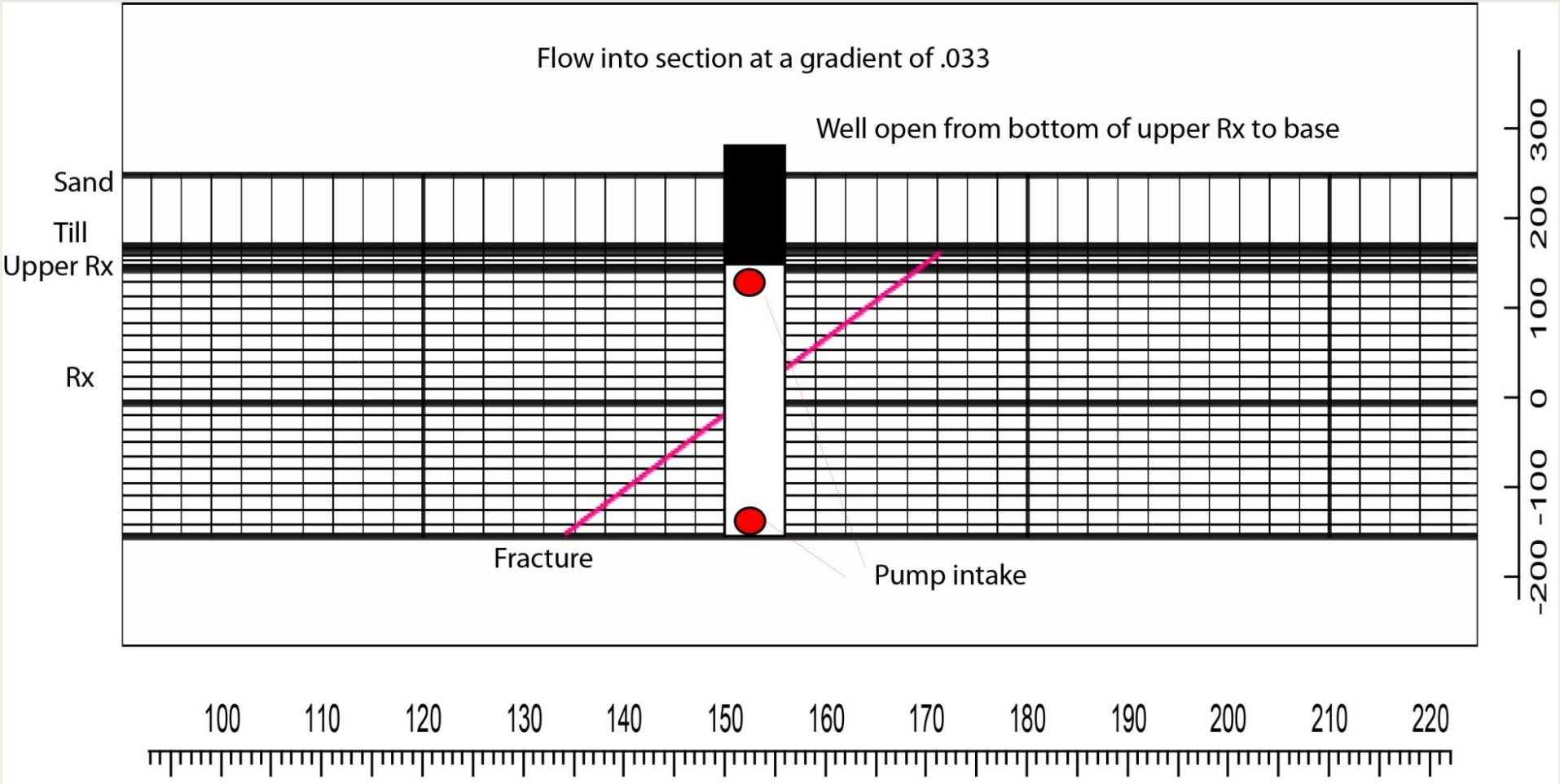
- Typically high volume purge
- Mixed sample ("averaged" sample)
- Early time, purge capture depends on pump intake position
- Early time, head-weighted, borehole storage
- Late time, purge capture pump independent
- Late time, flow-weighted, fracture (high transmissive zone) yield

“High” purge volume and pump placement

{Single or multiple fracture system with mixing, flow-weighted flow}



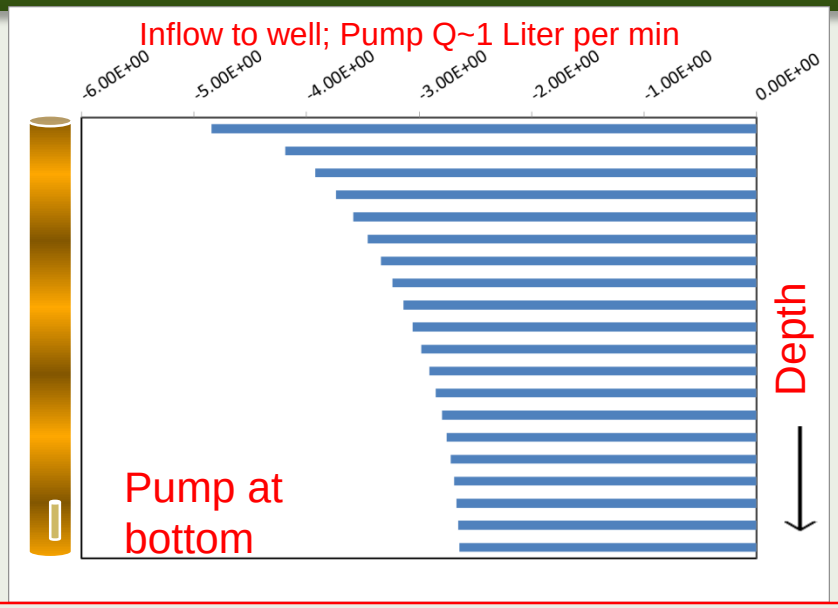
Generic model and flow

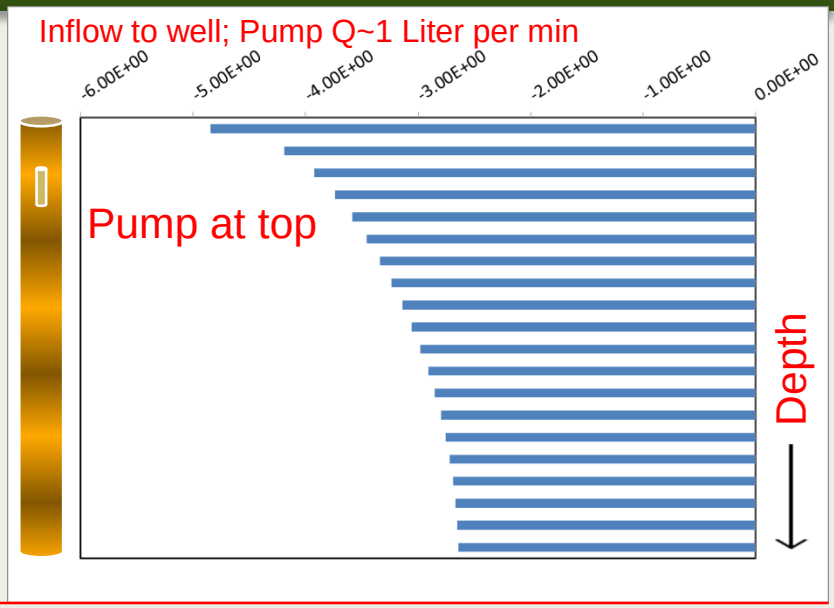


Red dots denote pump locations

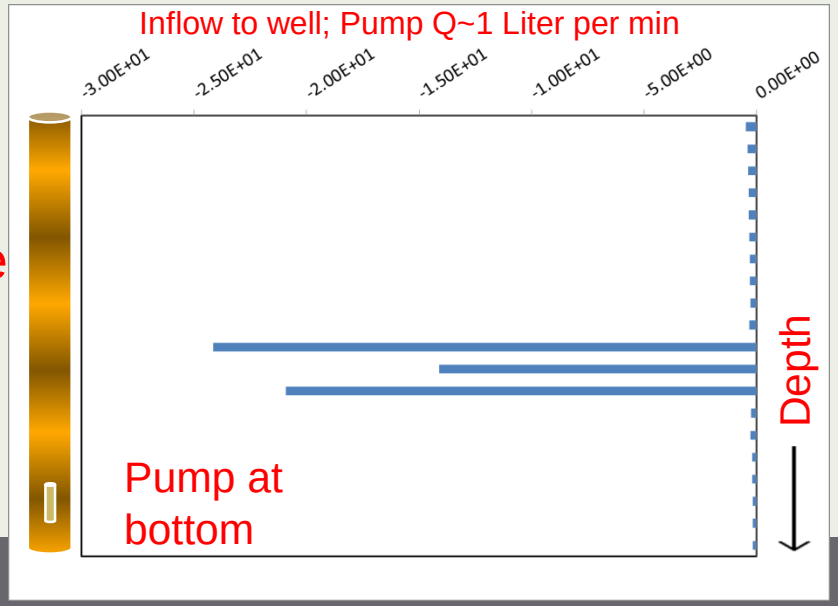
Generic model and high volume purge

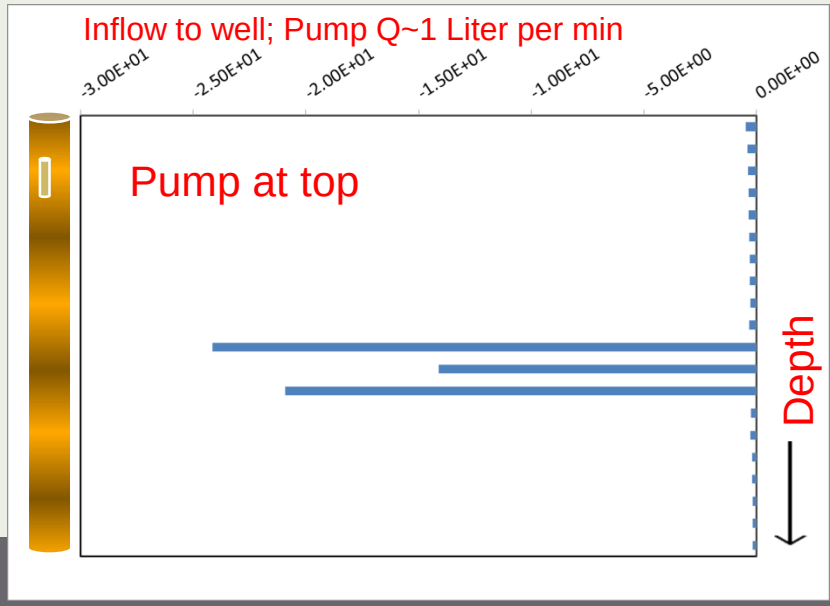
Uniform K





One Fracture





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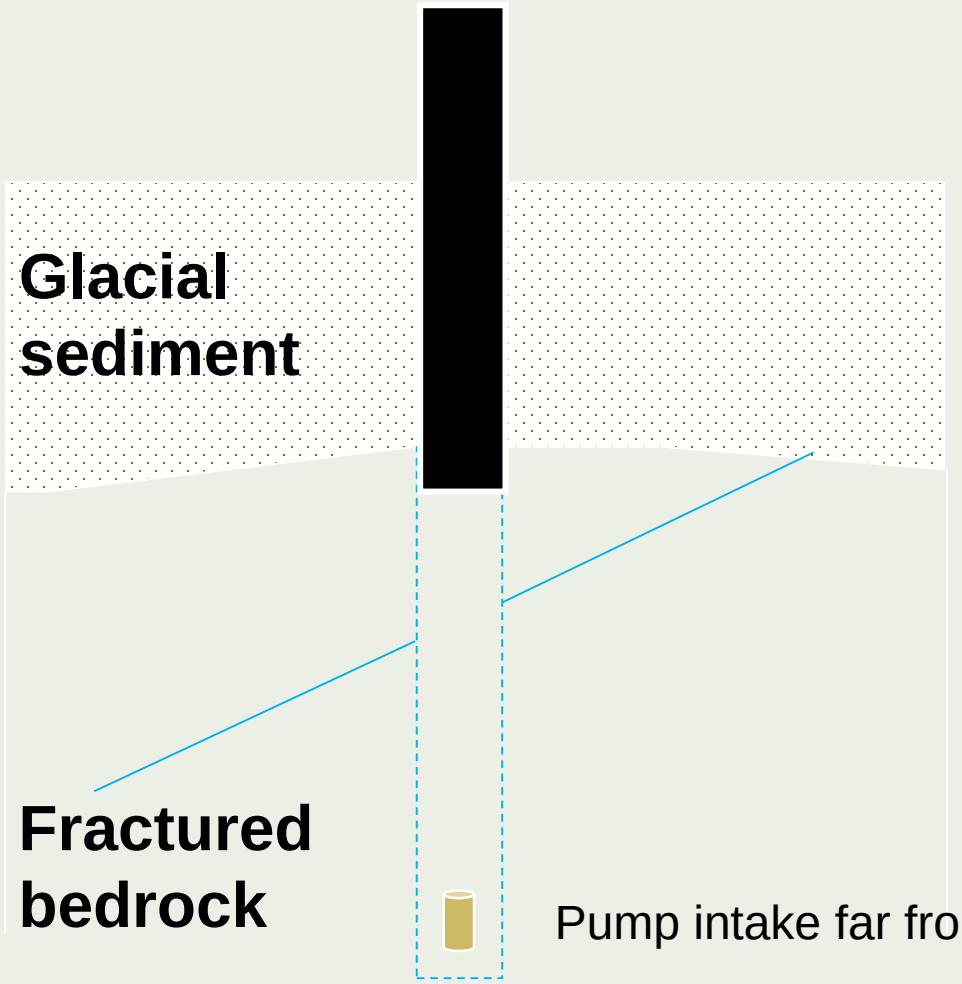
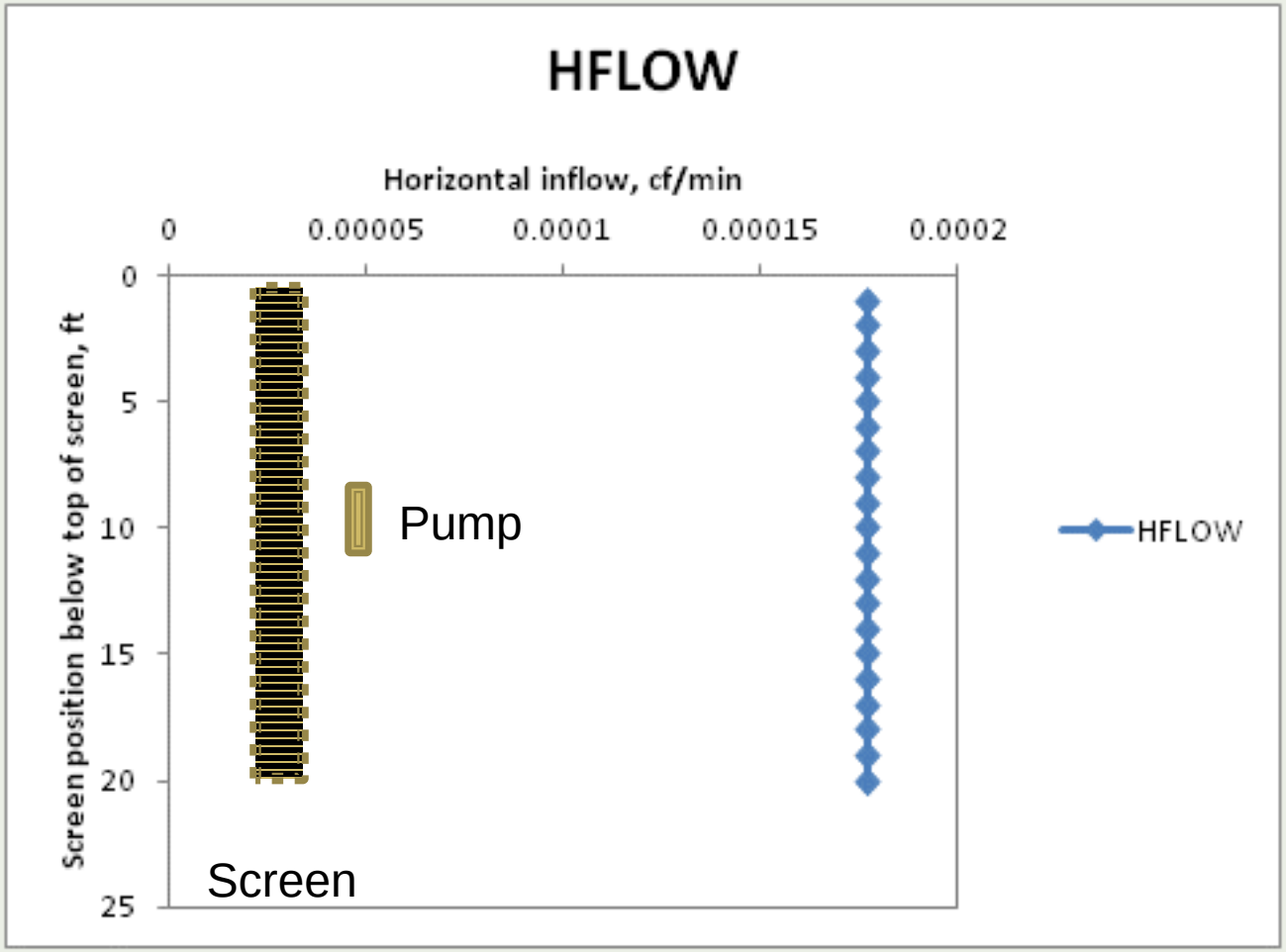
“Low” purge volume and pump placement

{single fracture dominated system and idealized piston flow}



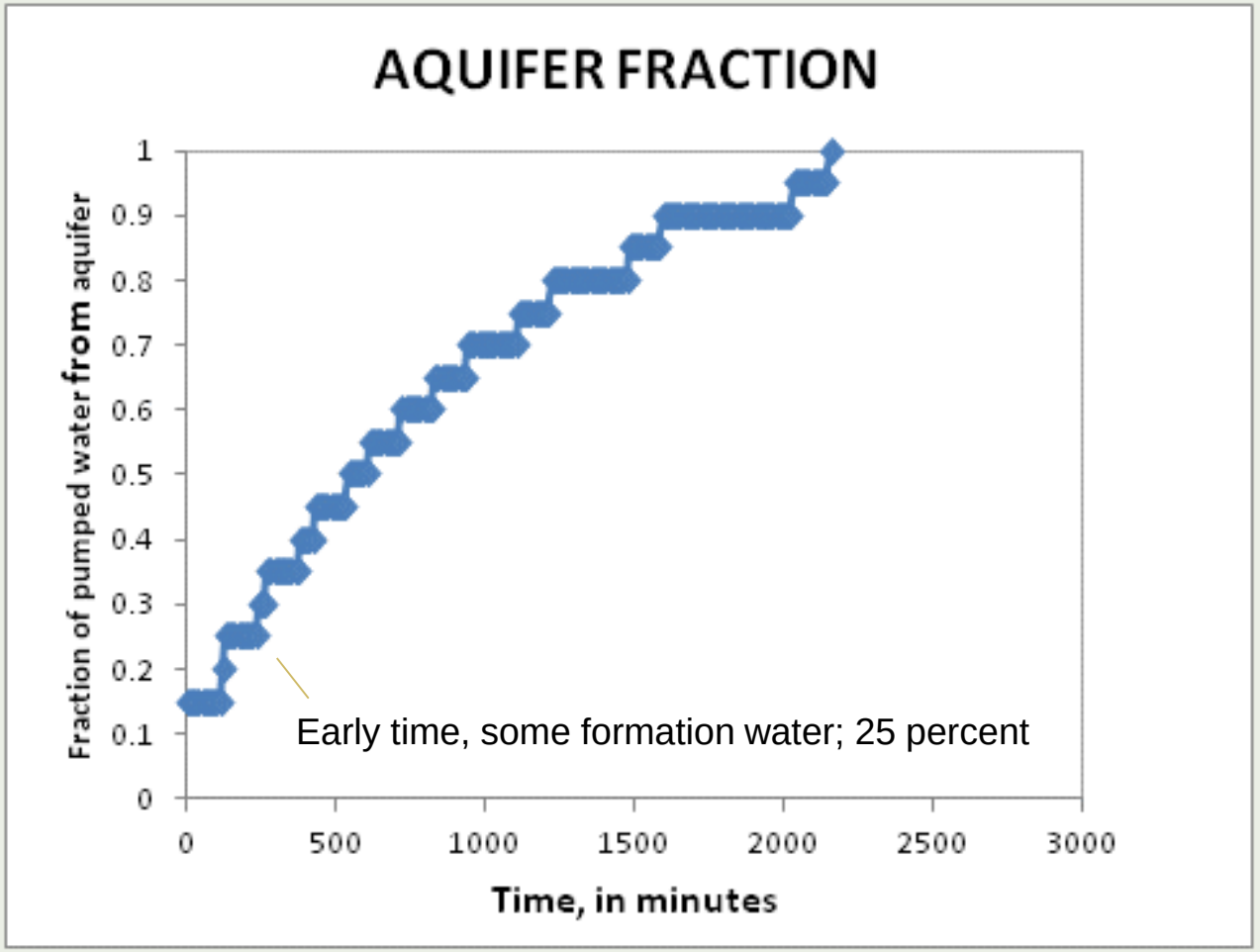
Porous Media Inflow - Low Flow

- Purge rate at 0.3 L/min
- 6-inch well
- Uniform inflow into 20 ft screen



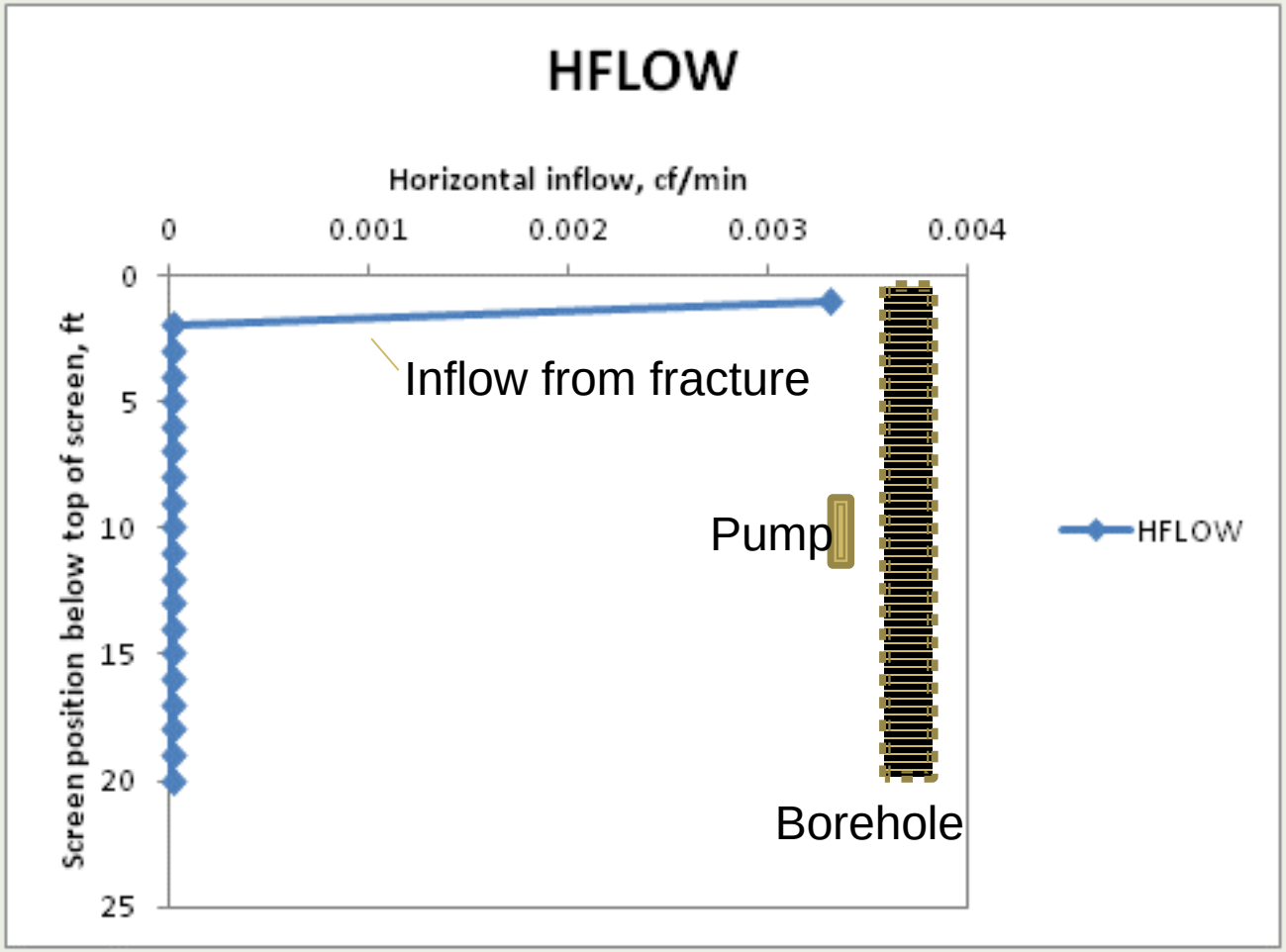
Porous Media - Low Flow Purge

- Results from same test
- Amount of aquifer water flowing to pump
- Gradual increase in capture of aquifer water



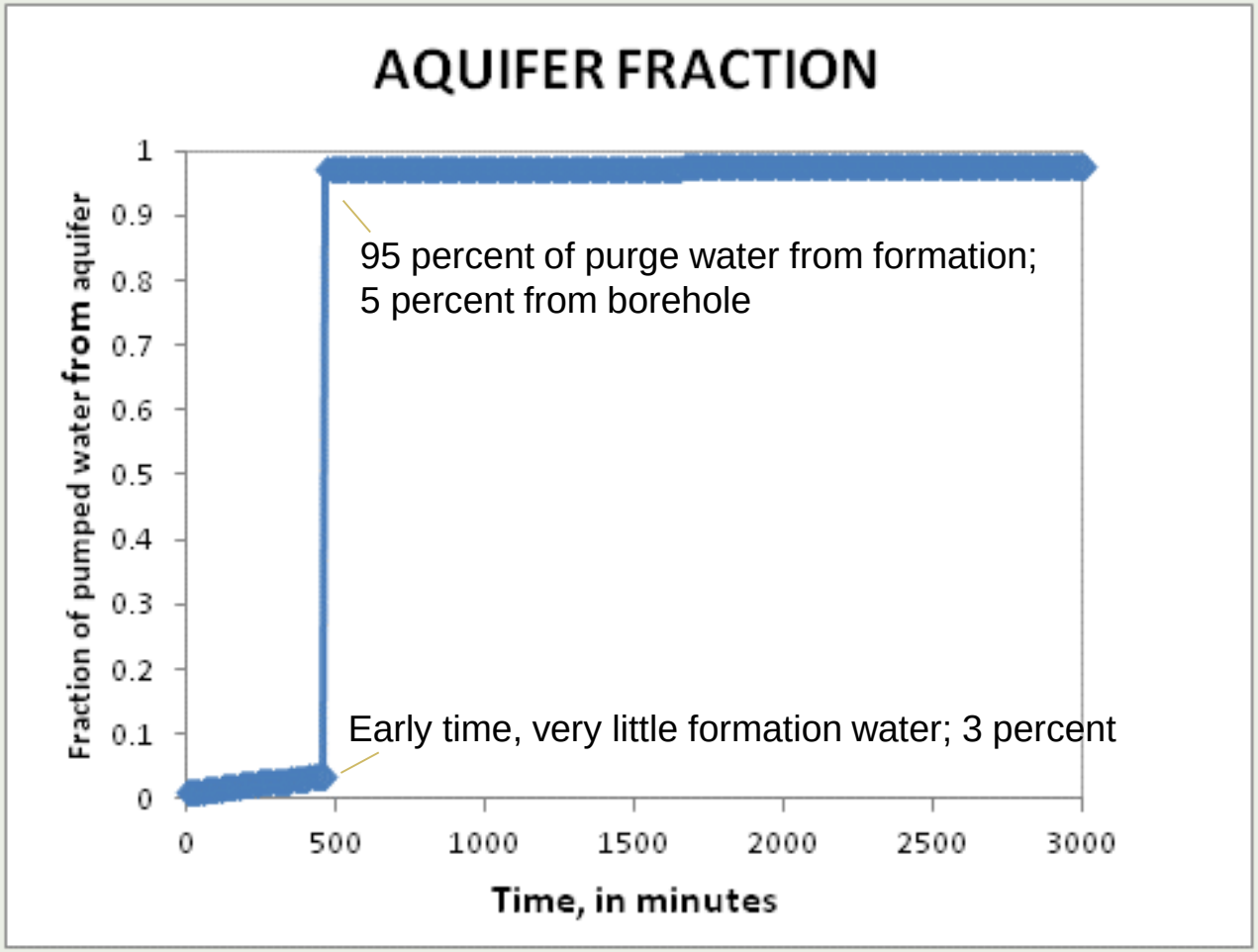
Inflow with fracture 9 feet above pump

- Purge rate at 0.3 L/min
- 6-inch well
- Nonuniform inflow into 20 ft well

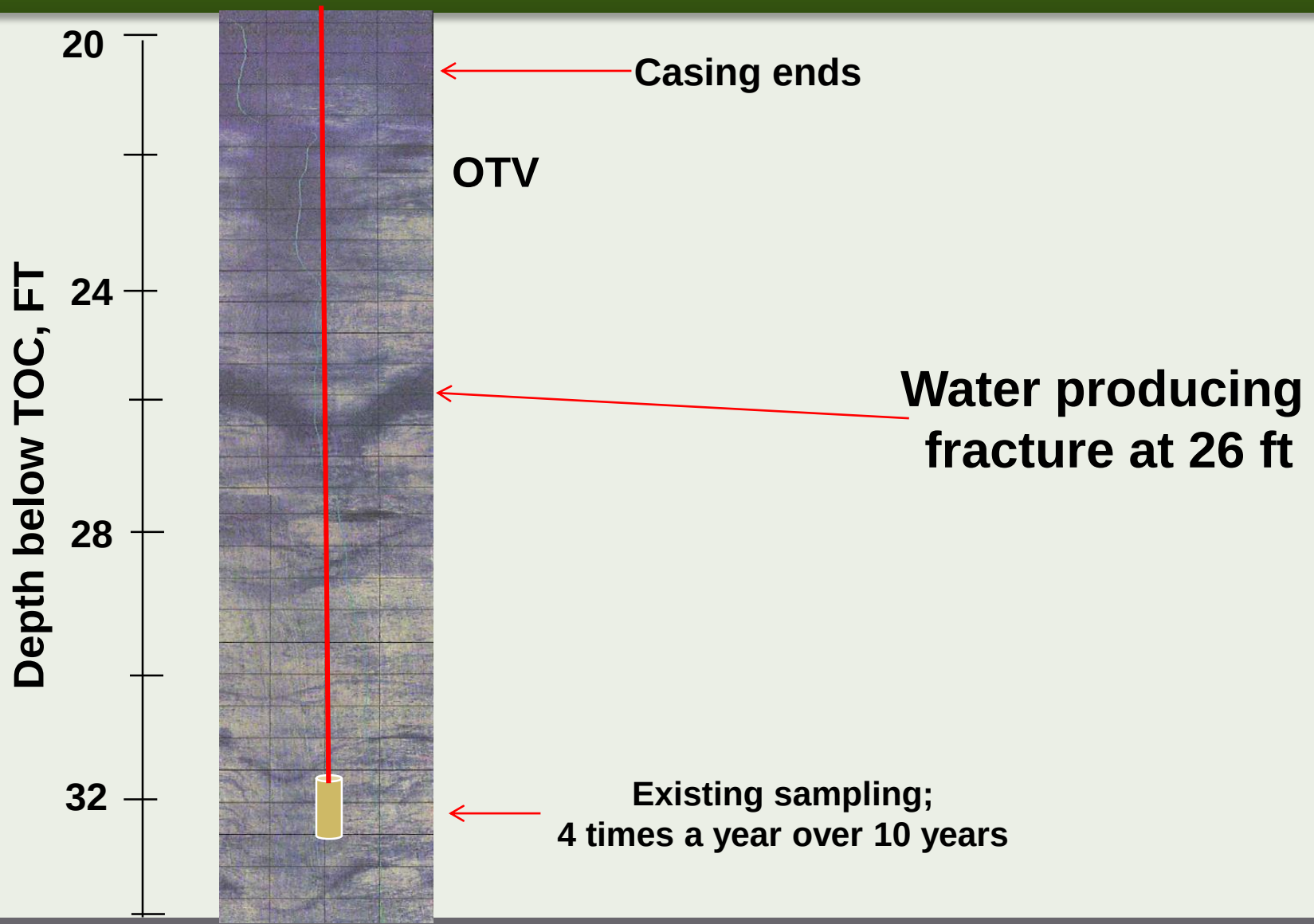


Fracture Rock - Low Flow Purge

- Results from same test
- Amount of aquifer water flowing to pump
- Sharp increase in aquifer water to pump



Extreme Case of Vertical Flow



Review of Sample Methods

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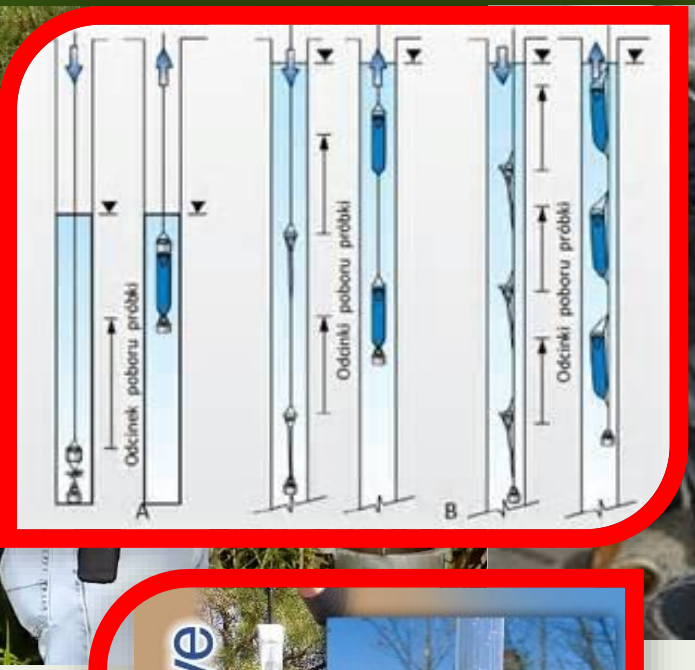
  - » Cumulative flow profiling

- **Discrete**
  - » Straddle packer
  - » Flute and sock systems
  - » Passive with packers

Hybrid discrete (open borehole)



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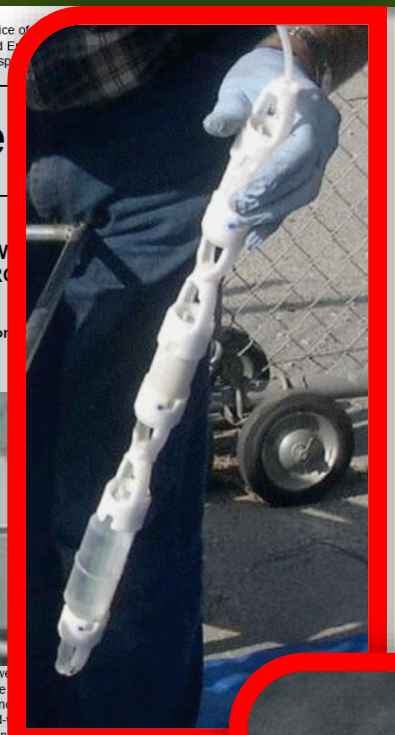
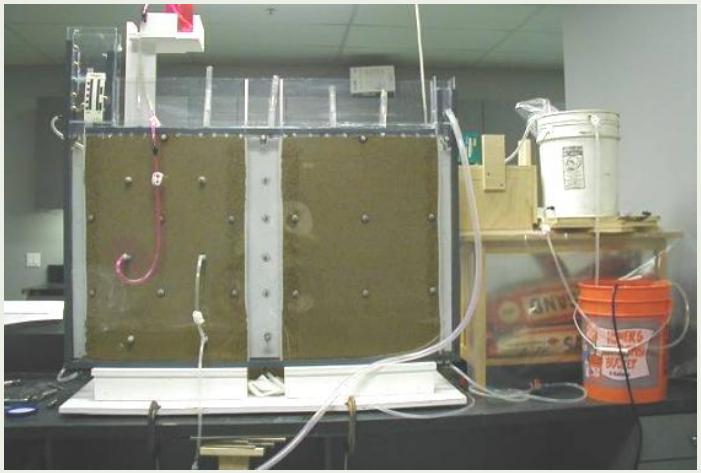
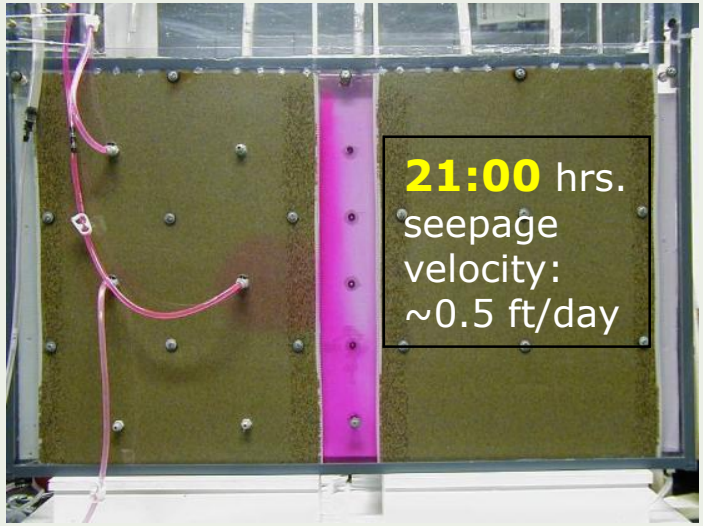
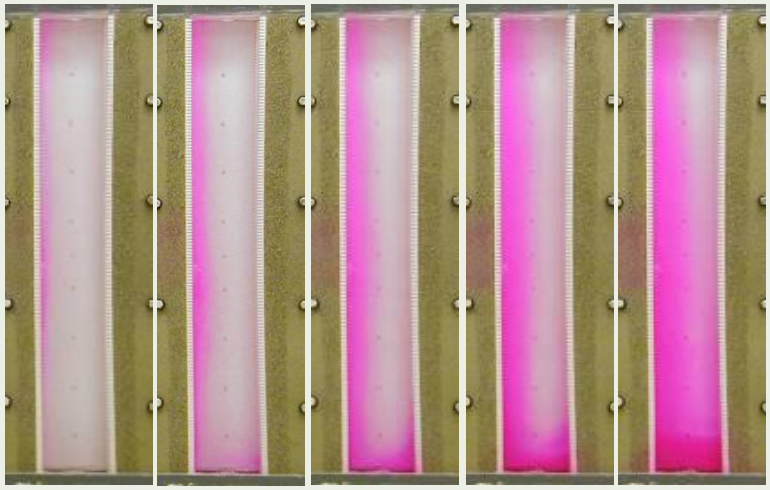
LOW-FLOW (MINIMAL DRAWDOW



In-well Mixing/Homogenization

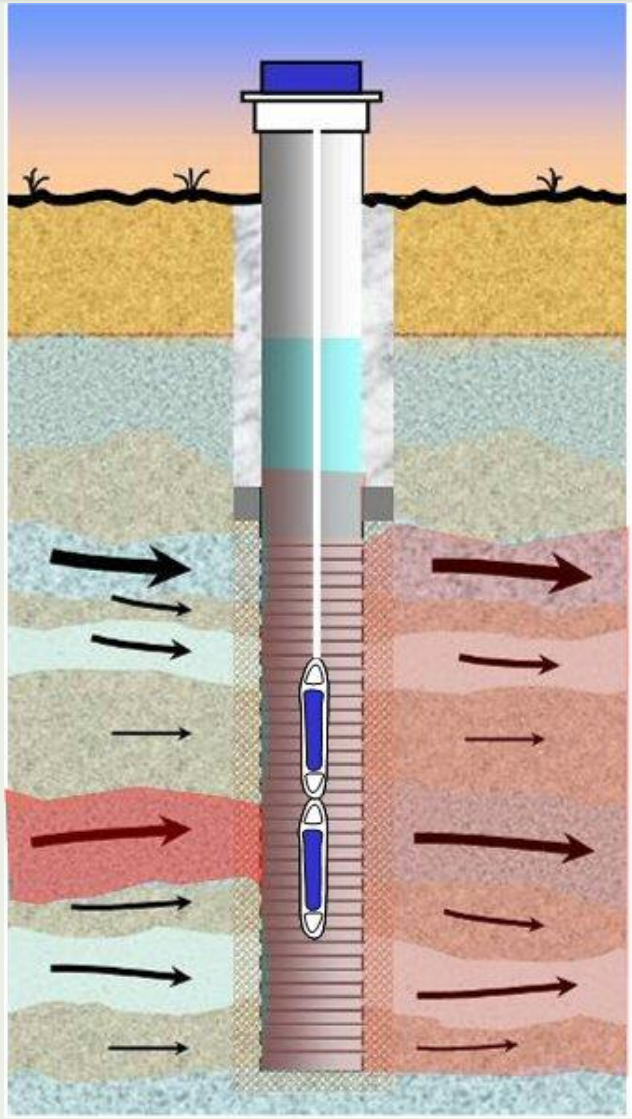






Passive equilibration - often very similar to purge sampling

- **A dedicated passive sampling system can take advantage of this phenomenon**
  - » Natural flow delivered to well
  - » Ambient / passive mixing according to native flow dynamics
  - » Flow-weighted averaging effect



Partially Mixed Sampling

- Typically low volume
- Could be an average of a combination of zones (partially mixed sample)
- Dependent on ambient head distribution

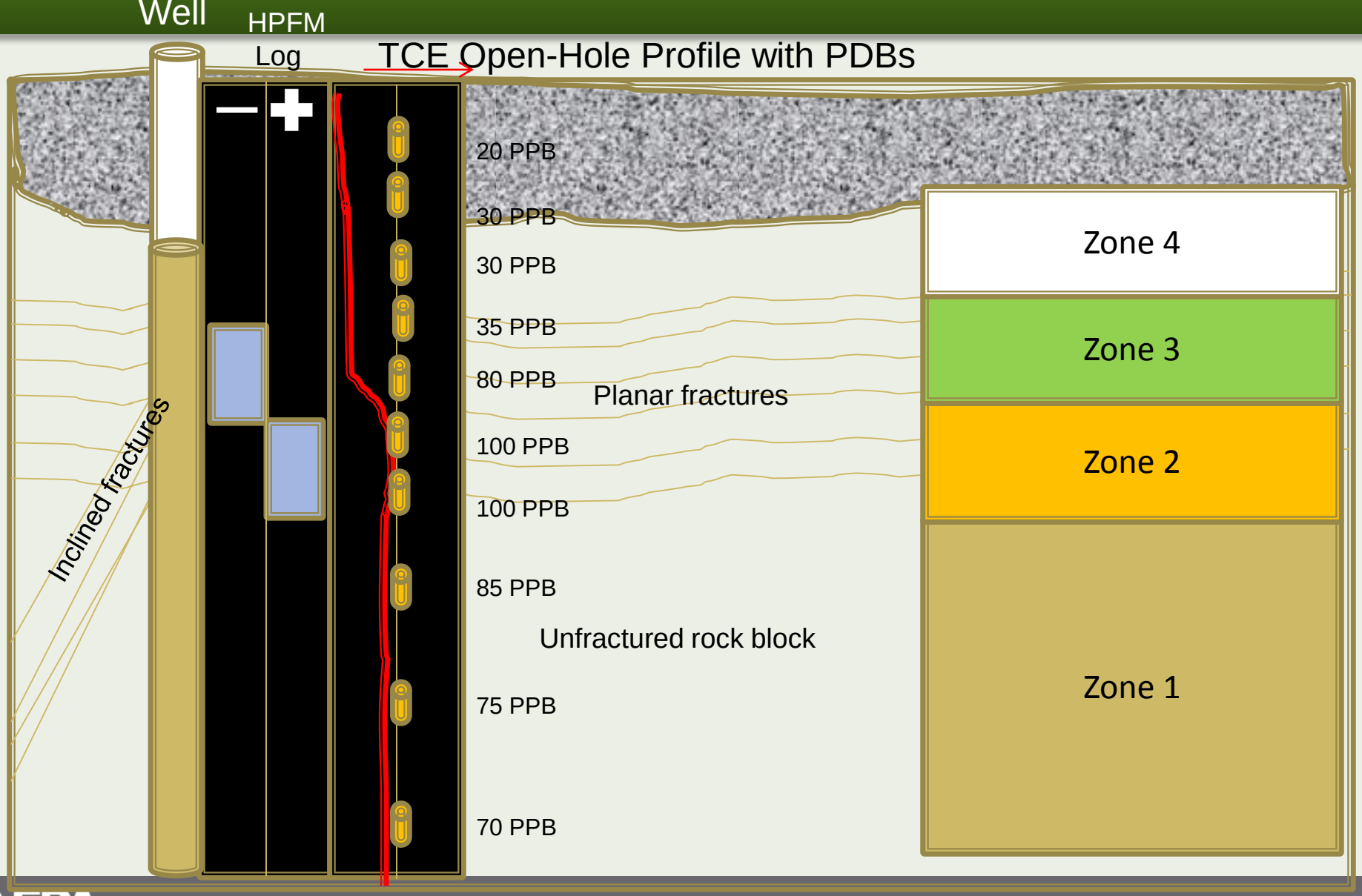
Passive sampling systems

- **Diffusion-based Passive samplers**
  - » Polyethylene Diffusion Sampler
  - » Regenerated Cellulose Diffusion Sampler
  - » Rigid Porous Pipe Sampler

- **Grab-Type Passive Samplers**
  - » Hydrasleeve
  - » Snap Sampler

- **Sorptive Passive Samplers**
  - » Gore Module

Identification of active and inactive fracture zones



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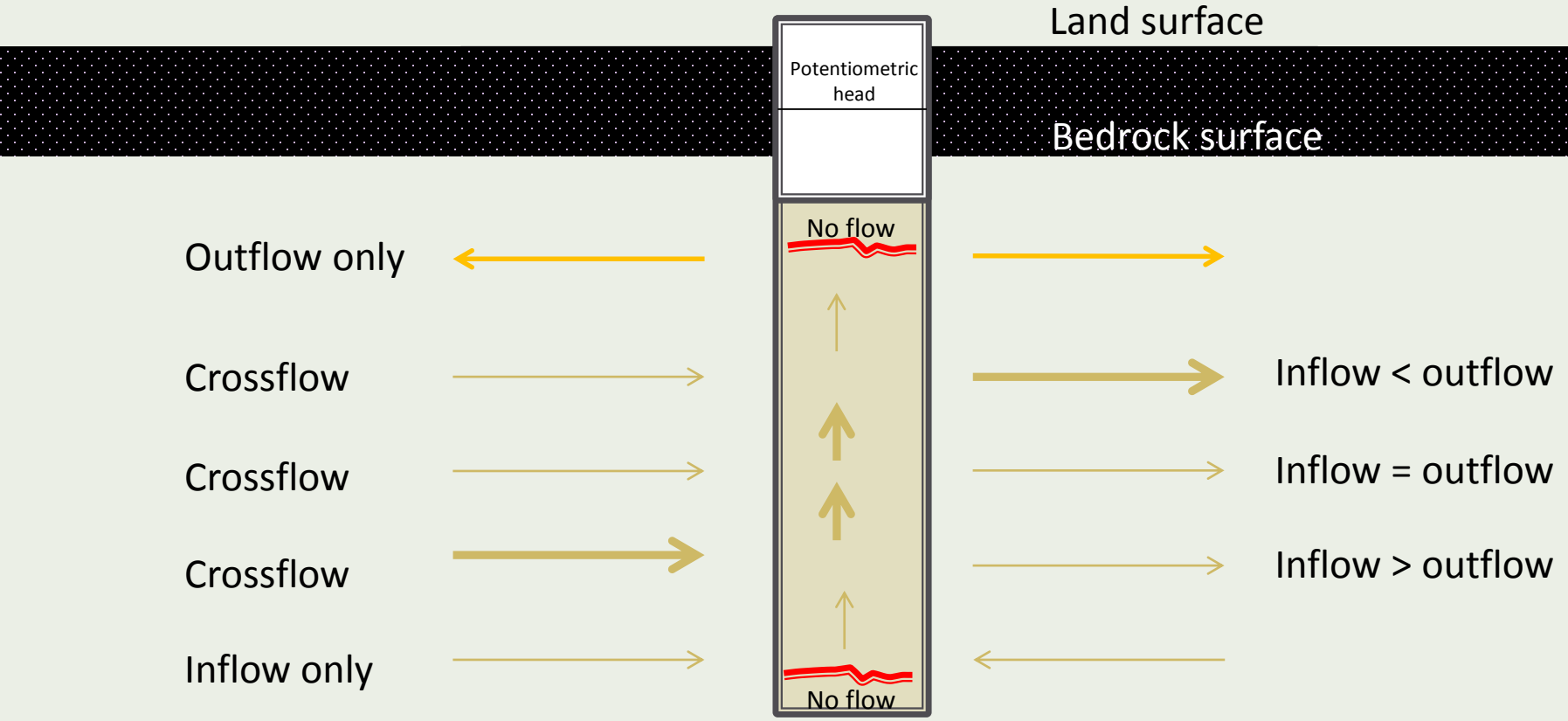
- **Discrete**
  - » Straddle packer
  - » Passive with packers
  - » Multilevel systems*

*see previous presentation on multilevel systems

Discrete Less Mixed Sampling

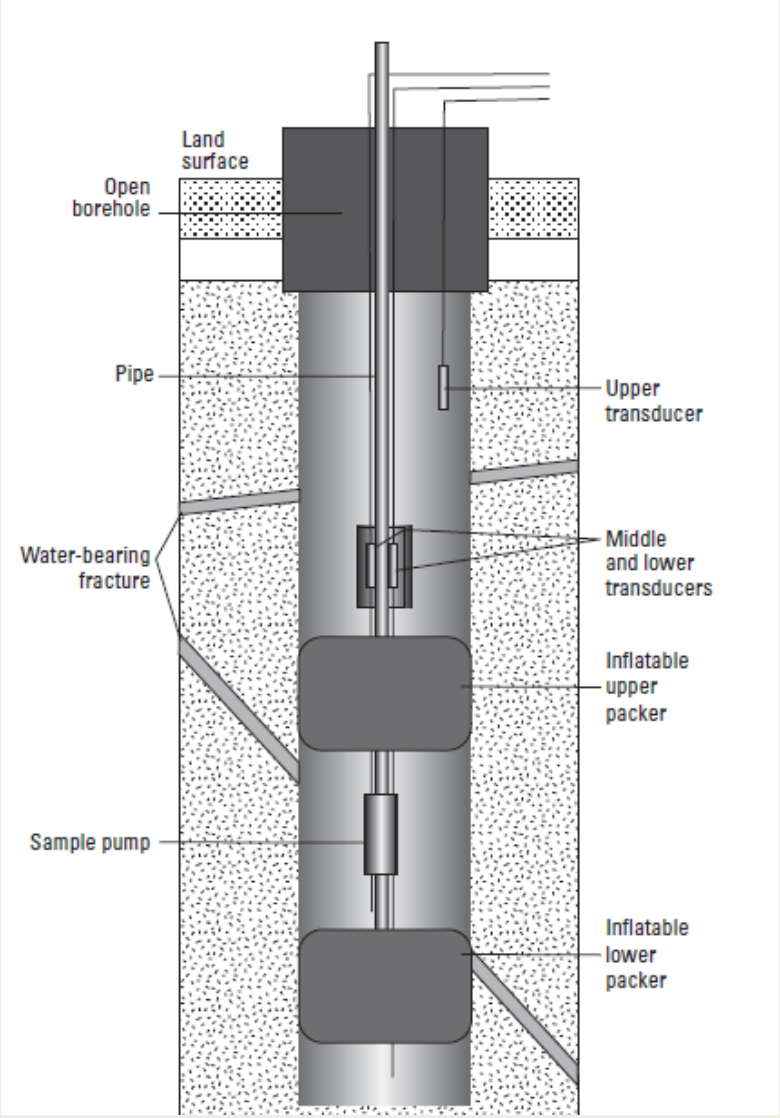
- Discrete intervals of the well are constrained either physically or hydraulically
- Different methods use different volumes of water and therefore source of water can vary
- Can still be affected by mixing if fracture was previously an outflowing fracture in an open borehole
- Multilevel systems

Schematic of borehole flow patterns with vertical upflow



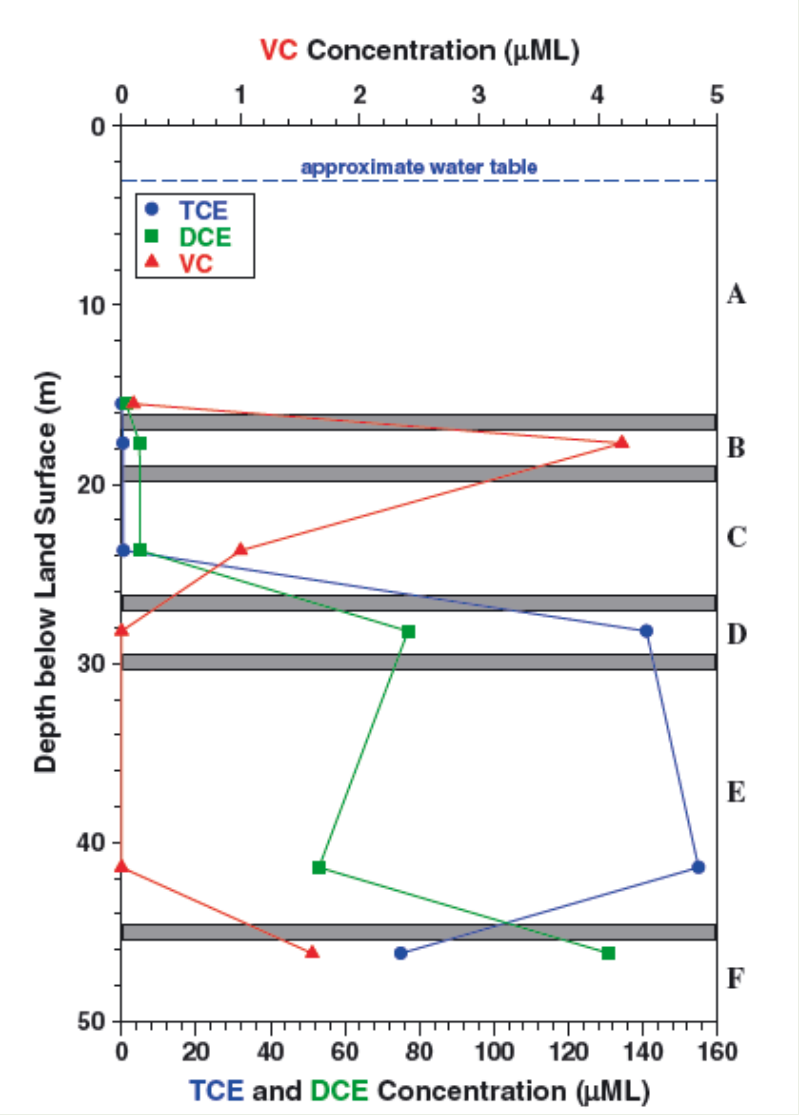
Straddle Packer

- Borehole physically sealed
- Sealed zone pumped
- Leakage verified using head and tracer measurements



Packers and Diffusion samplers

- One-year deployment
- Set within packers
- Triassic shales



Summary

- Think of monitoring well sampling as a continuum of different magnitudes of mixing
- Low volume purge can capture primarily borehole water
- High volume purge captures mixed sample
- Discrete samples also can be affected by mixing for outflow fractures
- Many options for hybrid or partially mixed samples and for discrete samples

Questions?

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