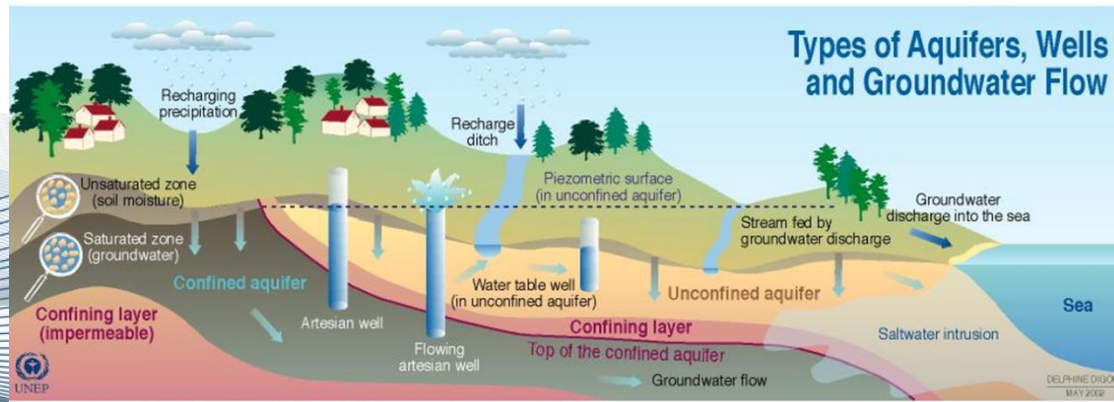


Geosyntec

consultants

HYDROGEOLOGY – BASIC PRINCIPLES TO LIVE BY



Paul Brookner, PG
Eric Tollefsrud, PG

100 Washington Avenue South
Minneapolis, MN 55401
612.253.8200

Geosyntec.com

engineers | scientists | innovators

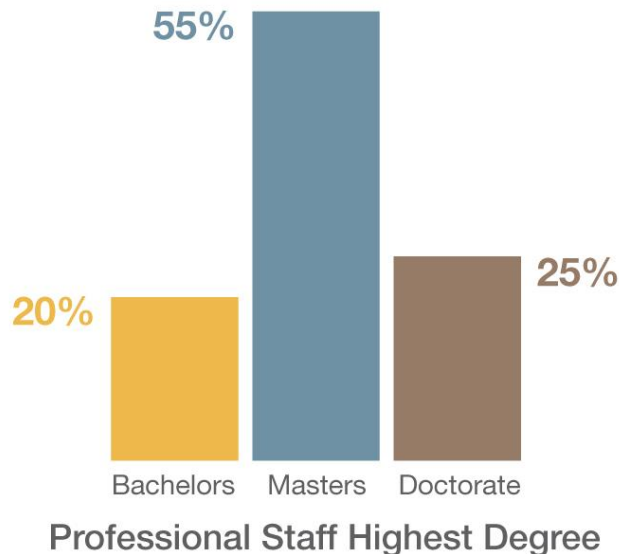
What Sets Geosyntec Apart?

Services:

- Technical support to legal counsel: CERCLA sites, vapor intrusion, due diligence
- Contaminated site assessment and cleanup
- Water resources design and engineering

Overview:

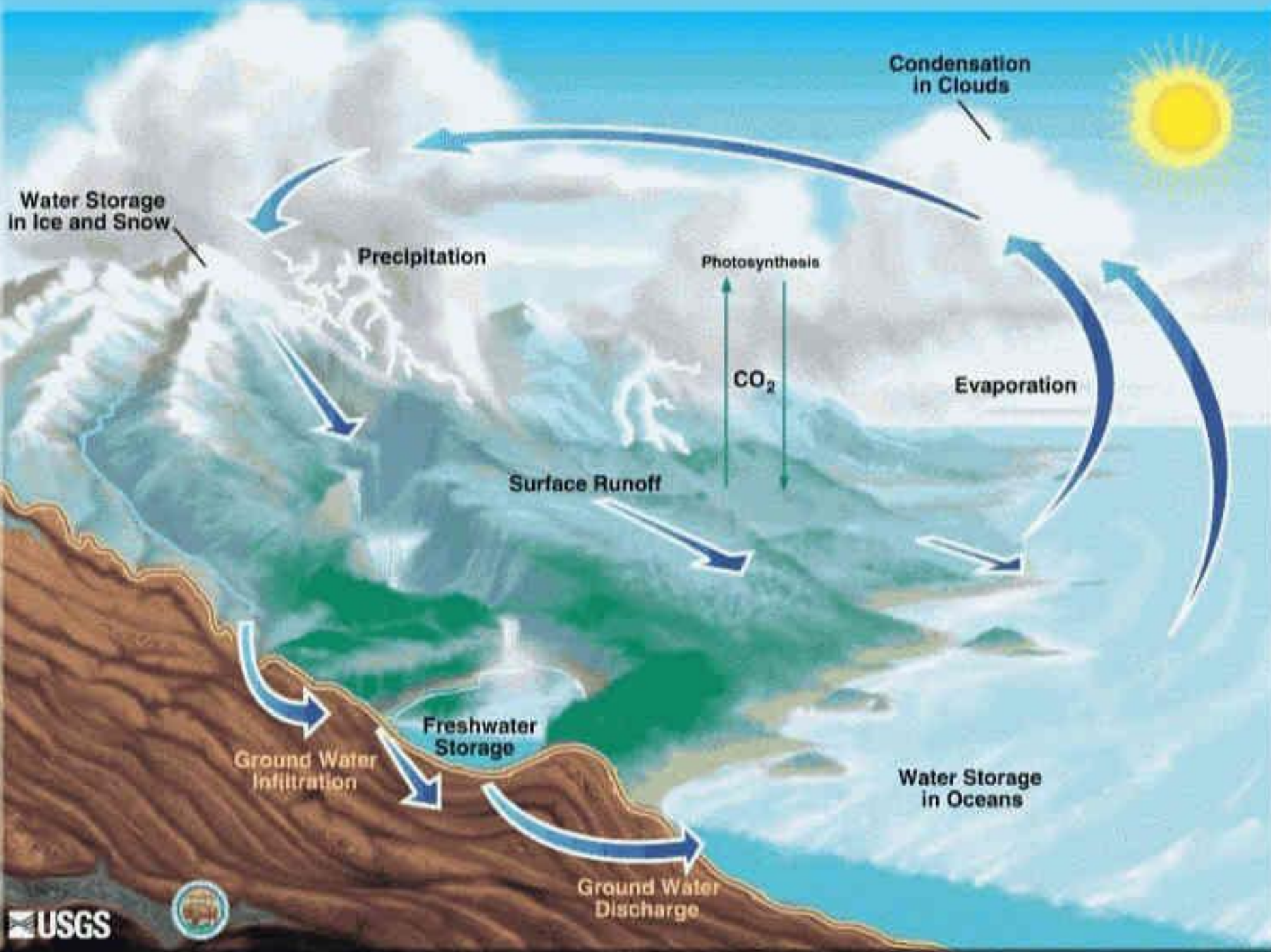
- Founded in 1983
- Strong reputation for technology innovation and solving complex problems
- Over 1000 engineers, scientists and project support personnel worldwide, offices in over 50 locations, including Minneapolis



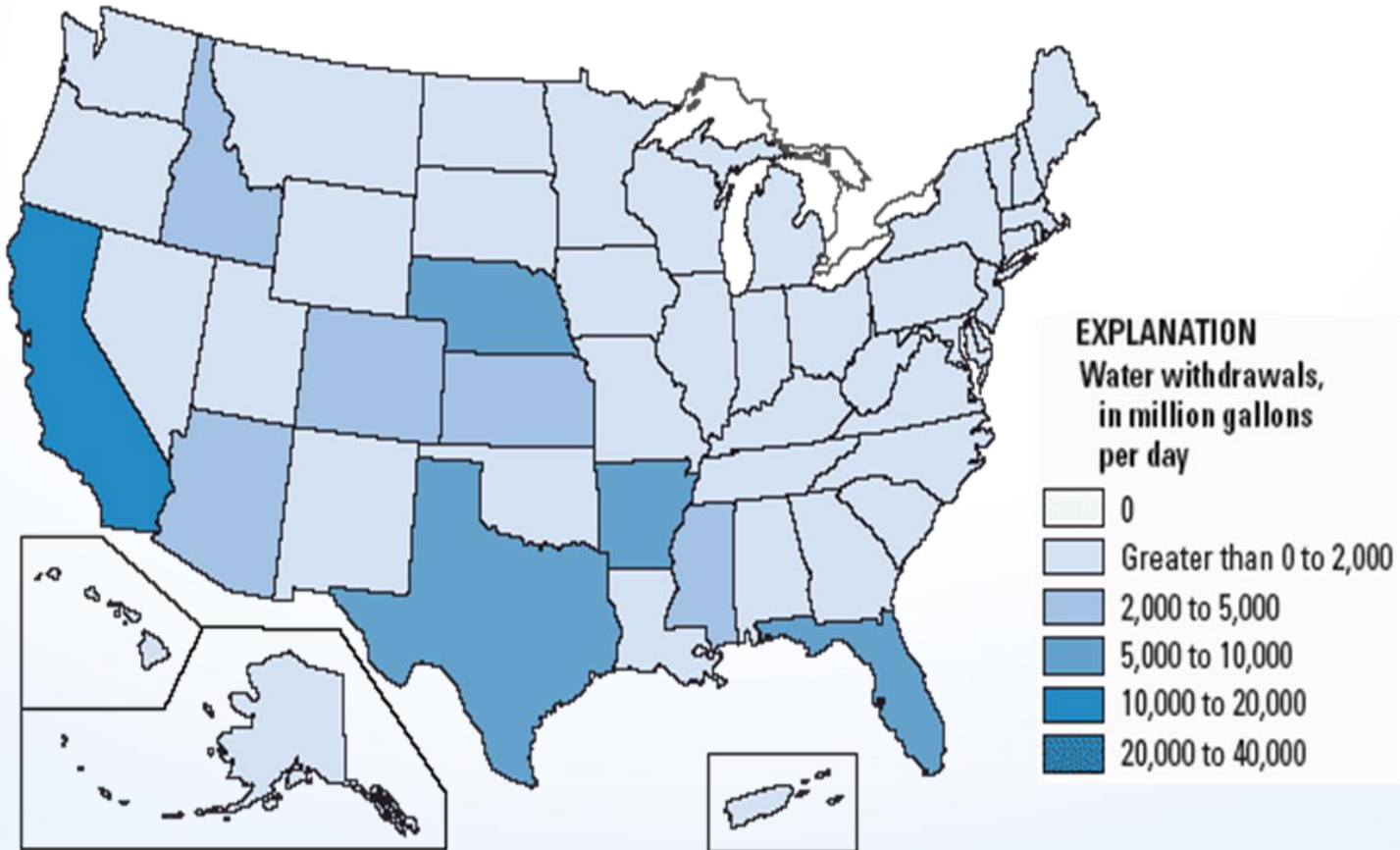
No other C&E firm better combines
technology & practice leadership with
client service & project delivery excellence
to provide **services & solutions**
that are highly valued by its clients.

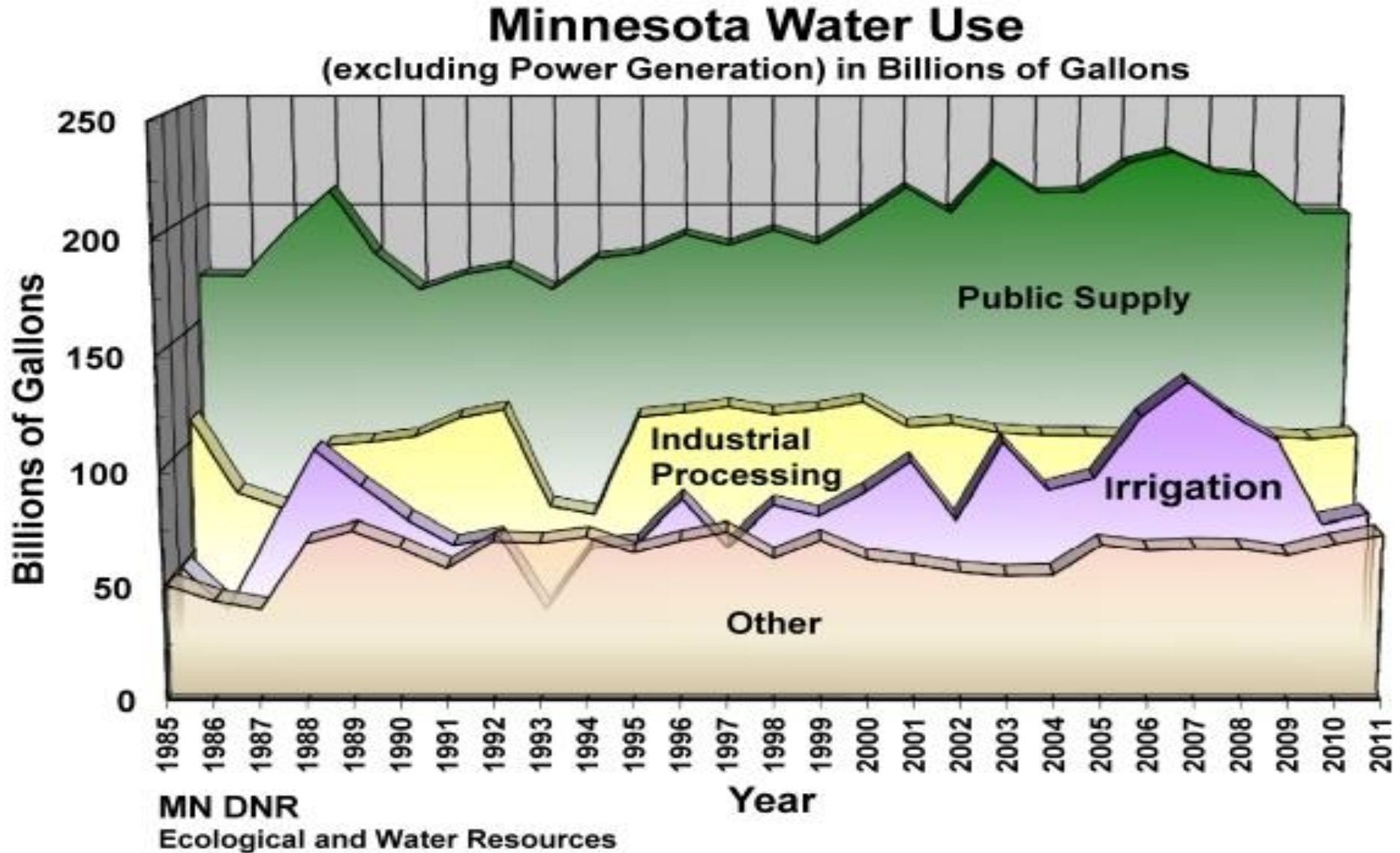
- **WHY HYDROGEOLOGY IS IMPORTANT** – Where is the groundwater and what is it doing?
- **POROSITY AND PERMEABILITY** – Are you an aquifer or an aquitard?
- **GROUNDWATER FLOW AND GRADIENTS** – What Henry Darcy would want you to know!
- **NOW FOR A TWIST: CONTAMINATION!** – So easy to get in, and so hard to get out

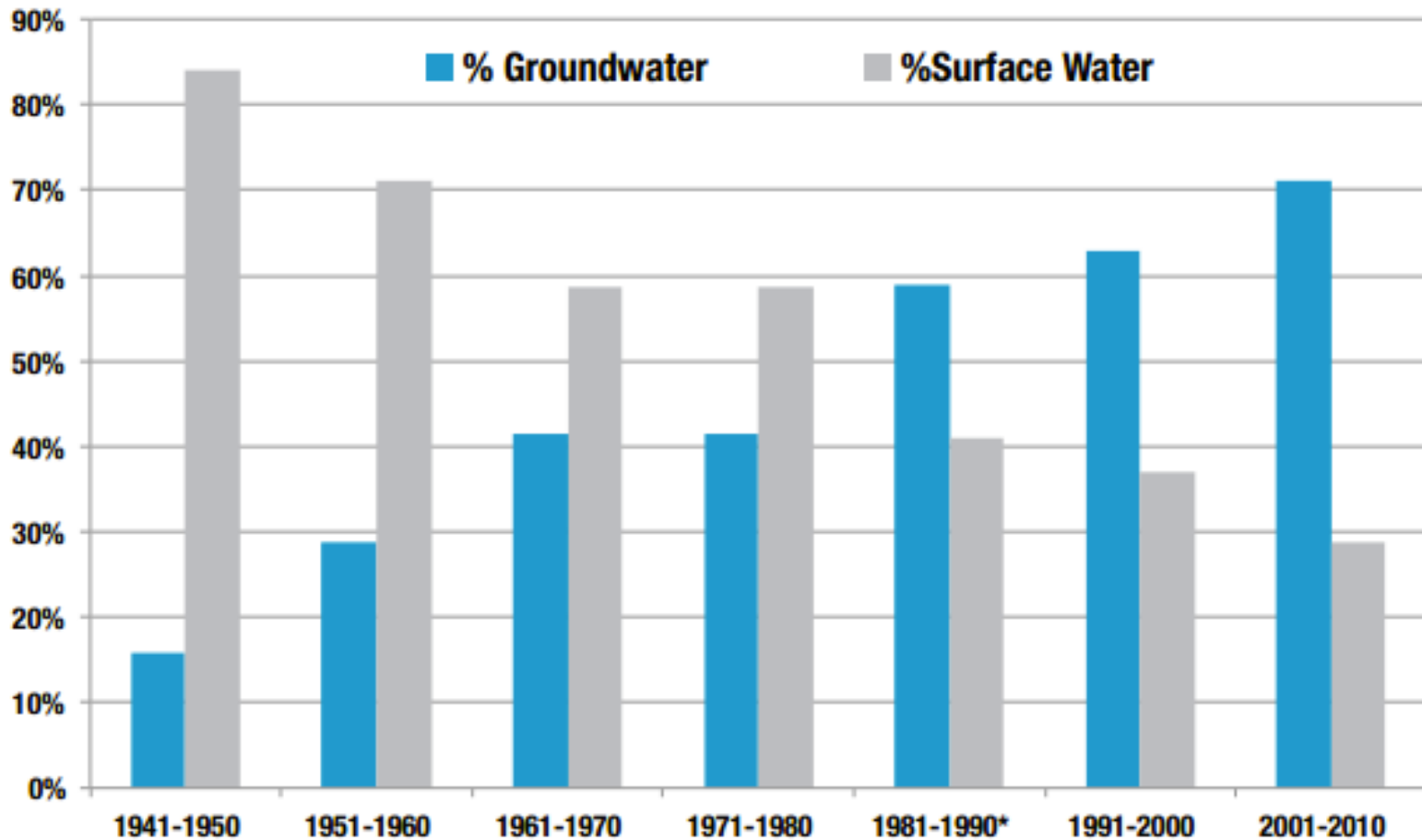
Water Use & Hydrogeology General Concepts
A Condensed Version



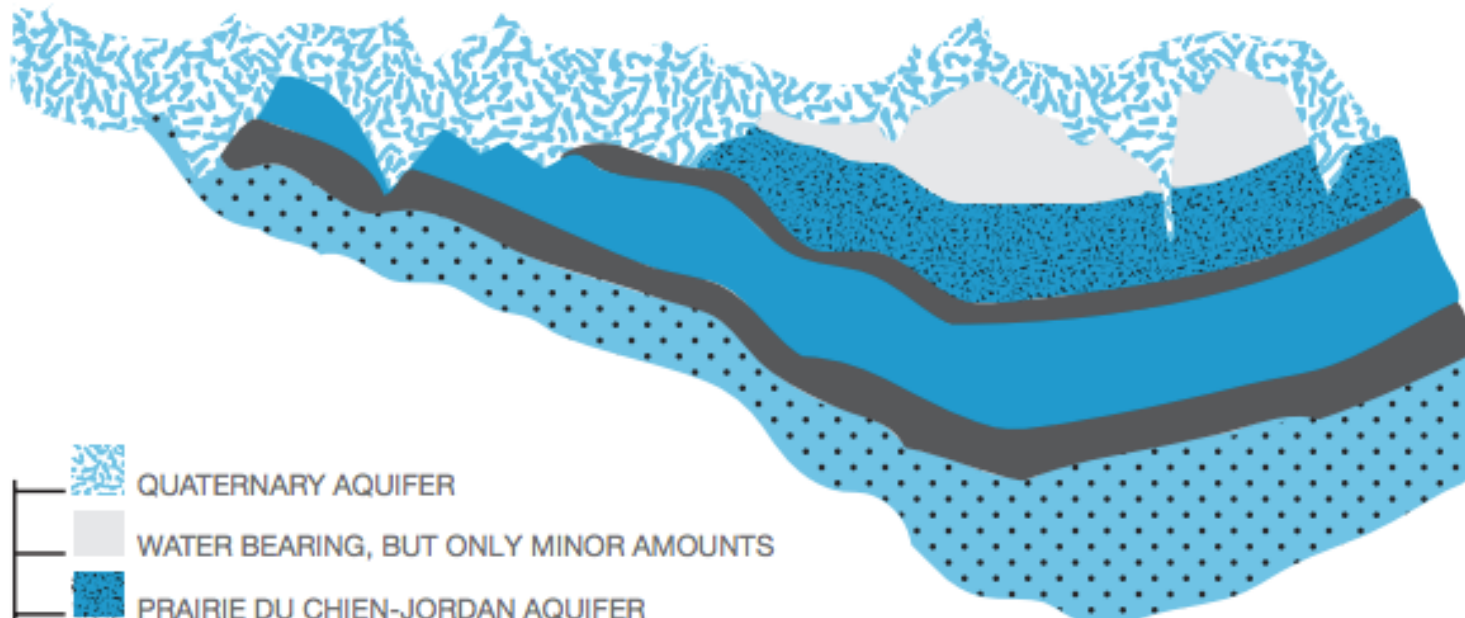
Ground-water withdrawals













WEST **ST. PAUL** **EAST**
 Wright County Hennepin County Ramsey County Washington County

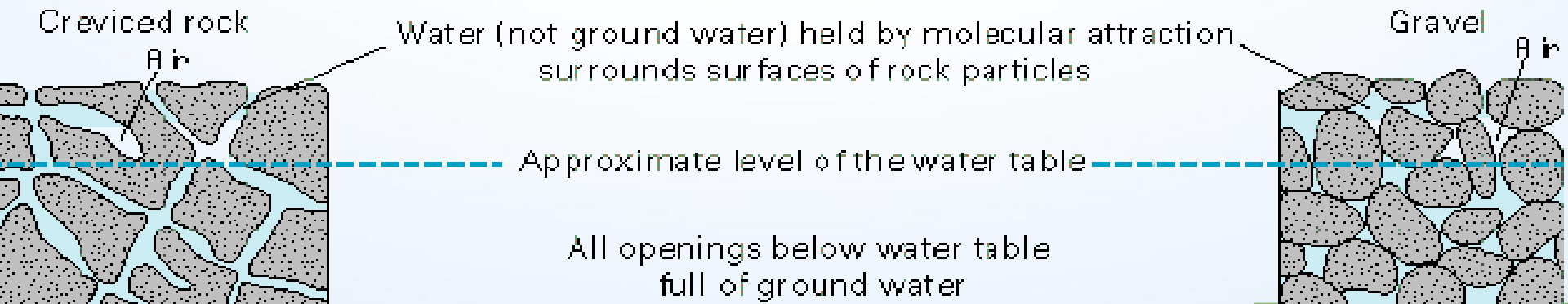
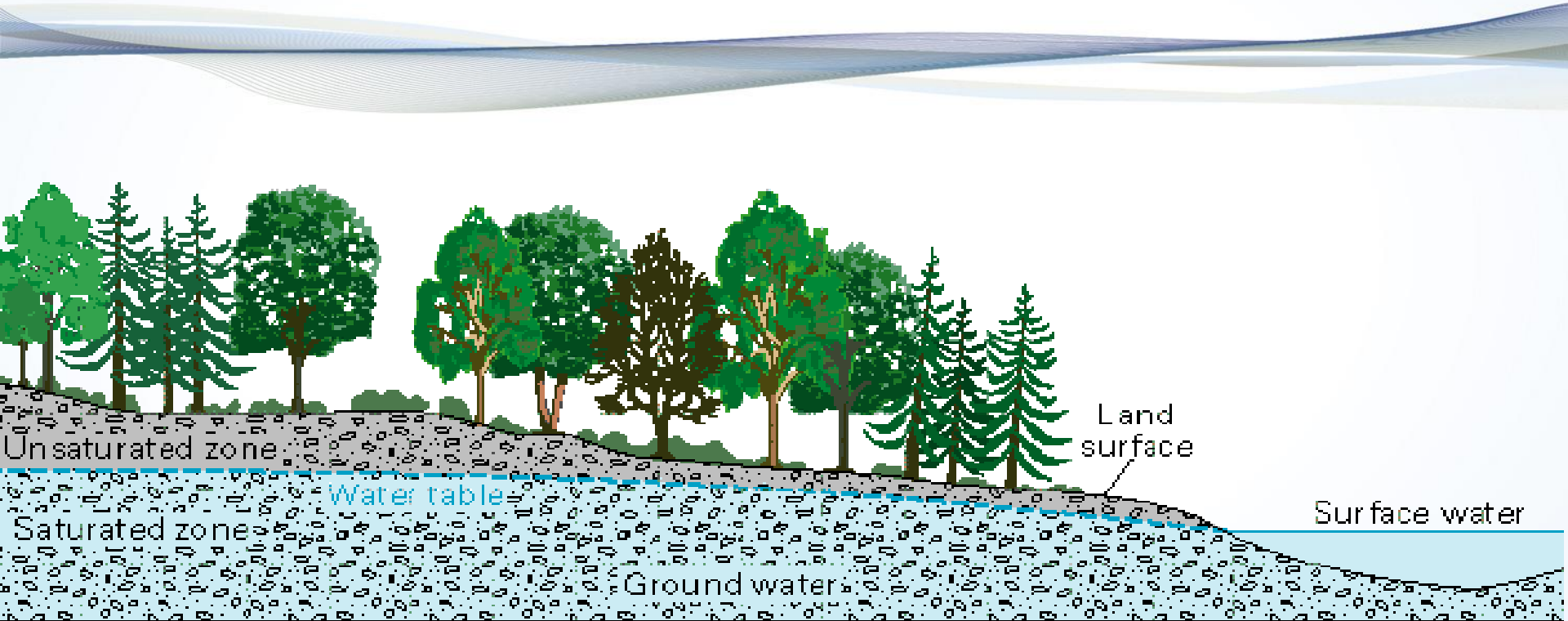


-  QUATERNARY AQUIFER
-  WATER BEARING, BUT ONLY MINOR AMOUNTS
-  PRAIRIE DU CHIEN-JORDAN AQUIFER
-  TUNNEL CITY-WONEVOC AQUIFER
-  MT. SIMON-HINCKLEY AQUIFER
-  CONFINING LAYER



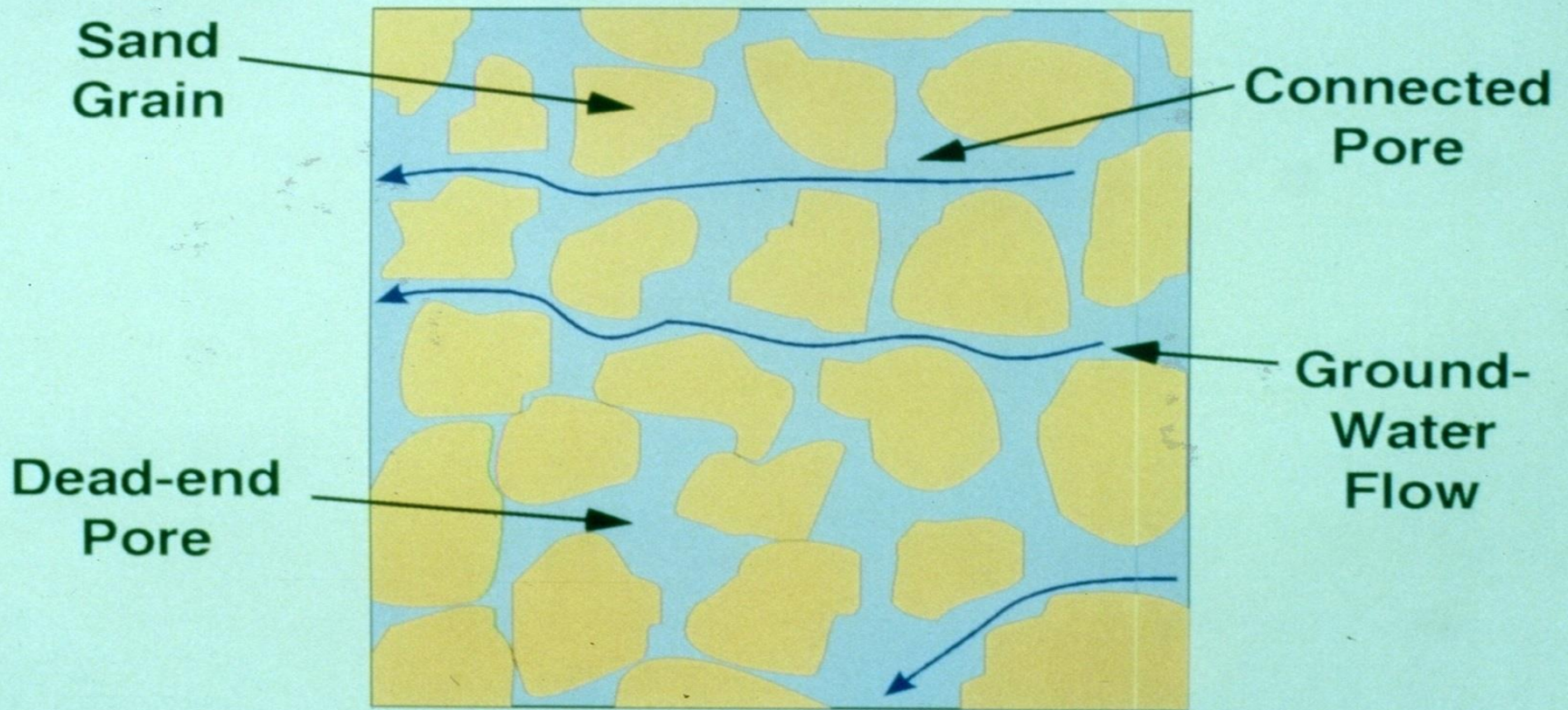
Why Geology Matters
Basic Hydrogeology

Subsurface View of an Aquifer

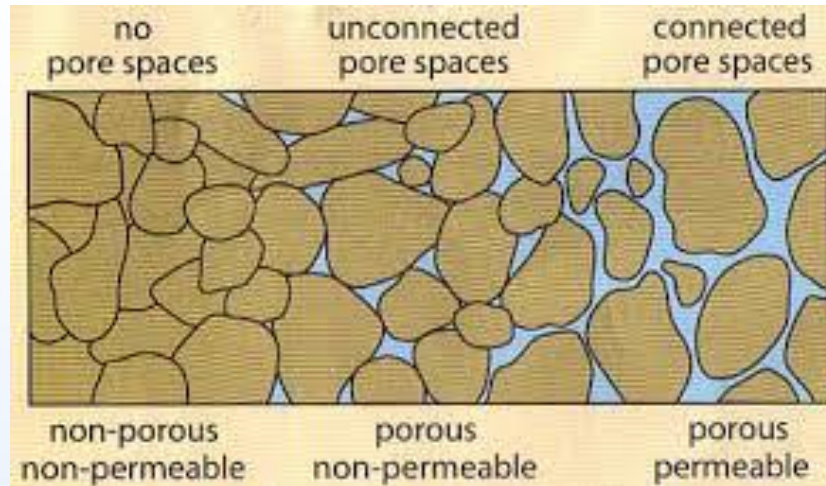


Porosity Is the Void Spaces Between the Grains in Aquifers

Porosity

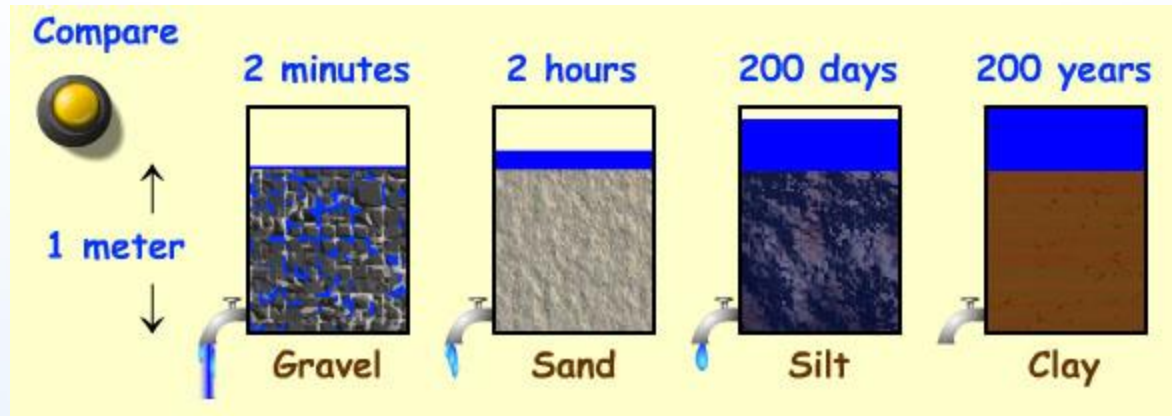


- Well-sorted sand or gravel **25-50%**
- Mixed sand and gravel 20-35%
- Silt 35-50%
- Clay **33-60%**
 - Clay is more porous than sand.....but not more permeable

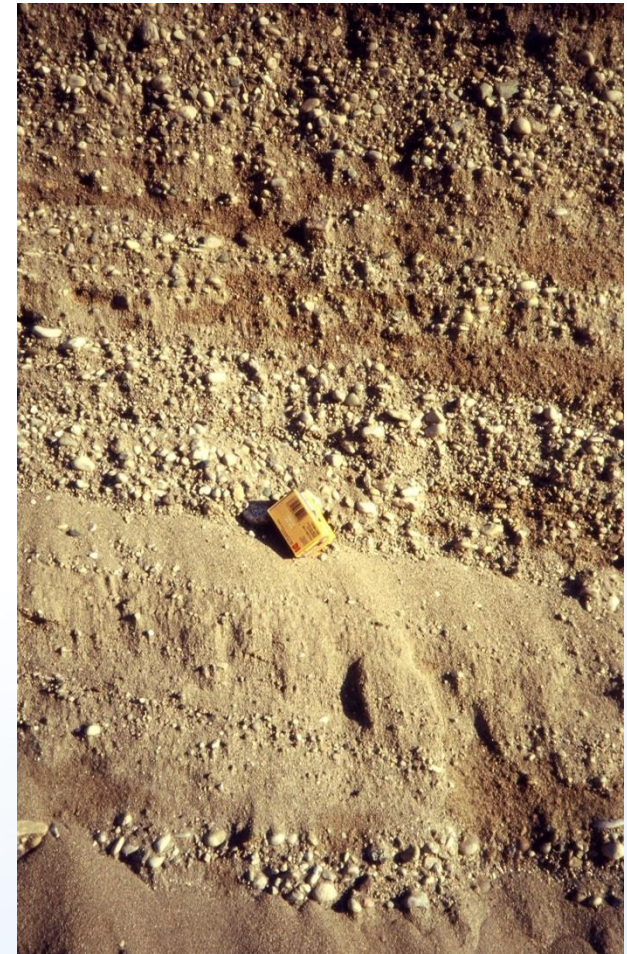
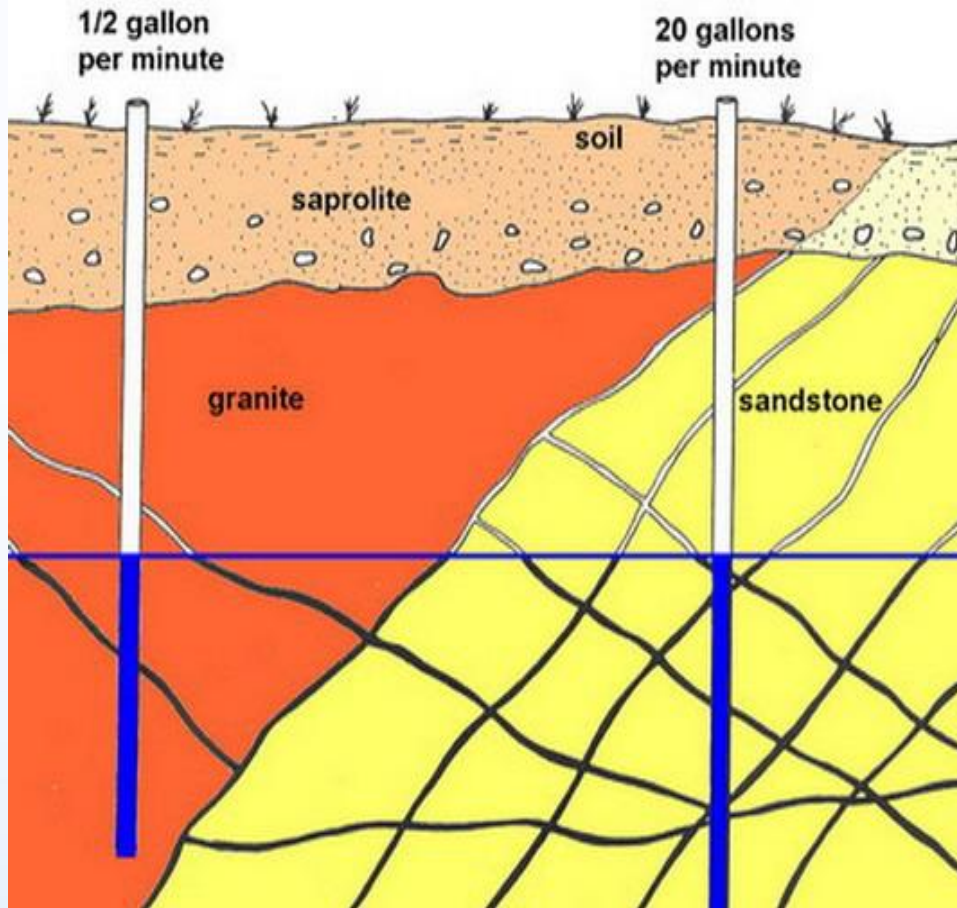


Hydraulic Conductivity, “Permeability”

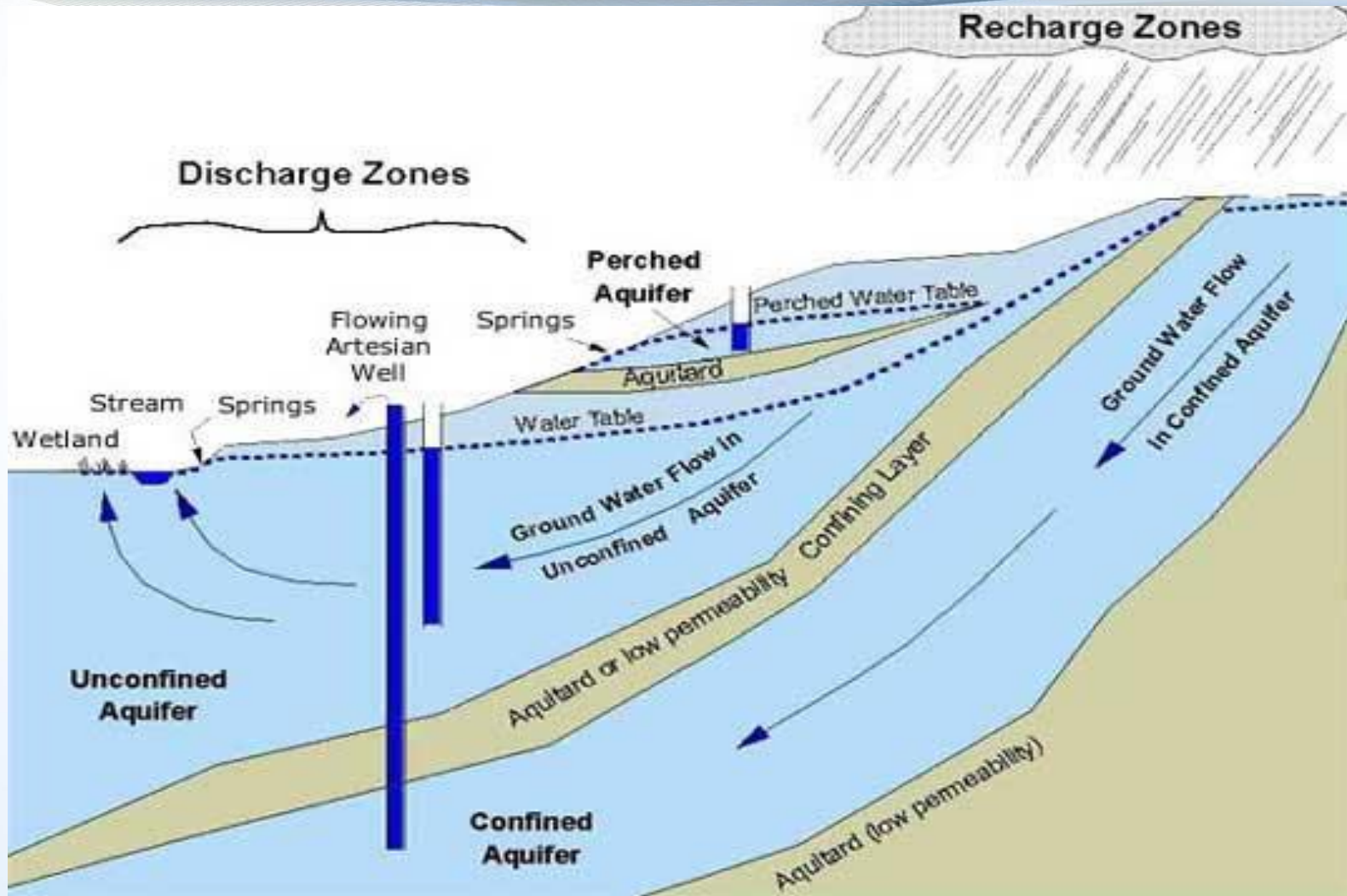
- Good ability to transmit water
 - Sand
 - Gravel
 - Fractured rock
- Poor ability to transmit water
 - Clay
 - Shale
 - Un-fractured rock

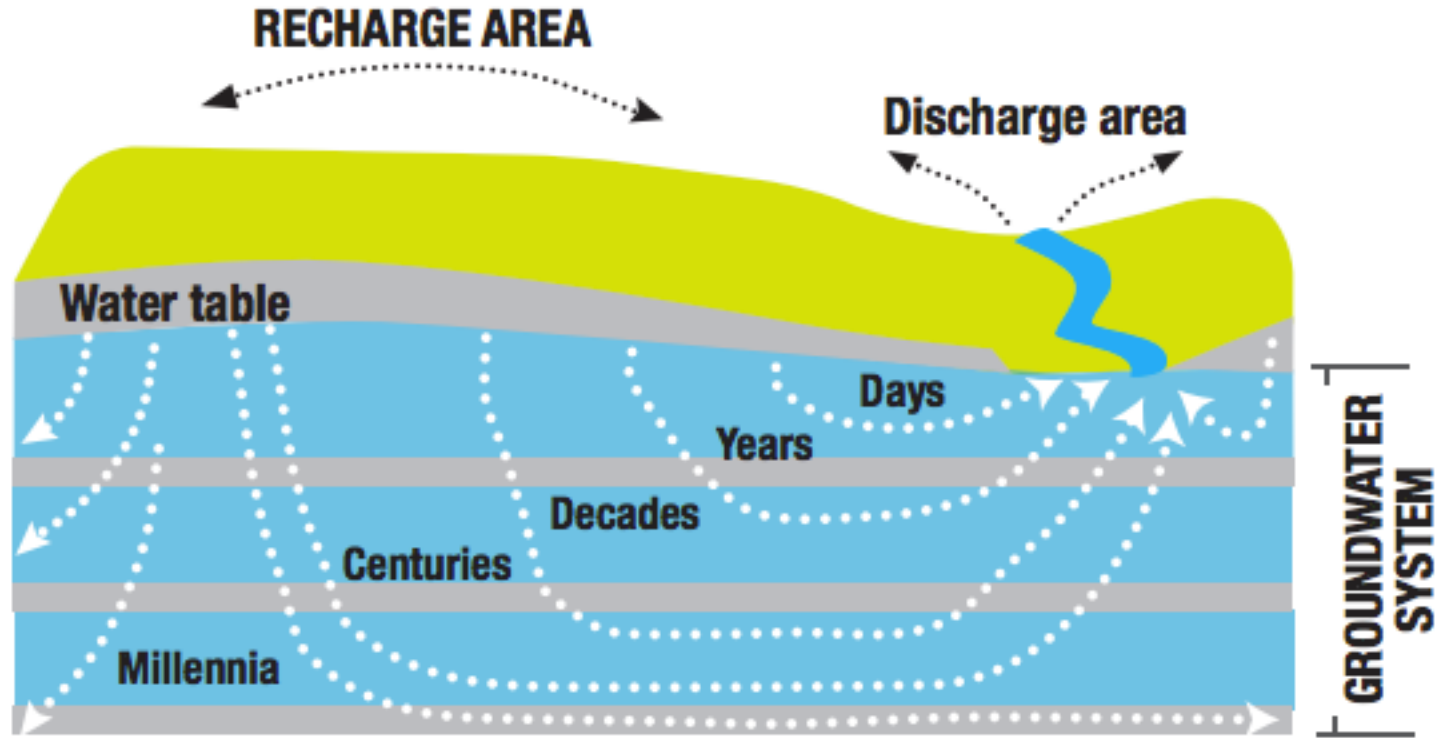


Geology Makes a Difference!



Where's the water going?
Groundwater Movement

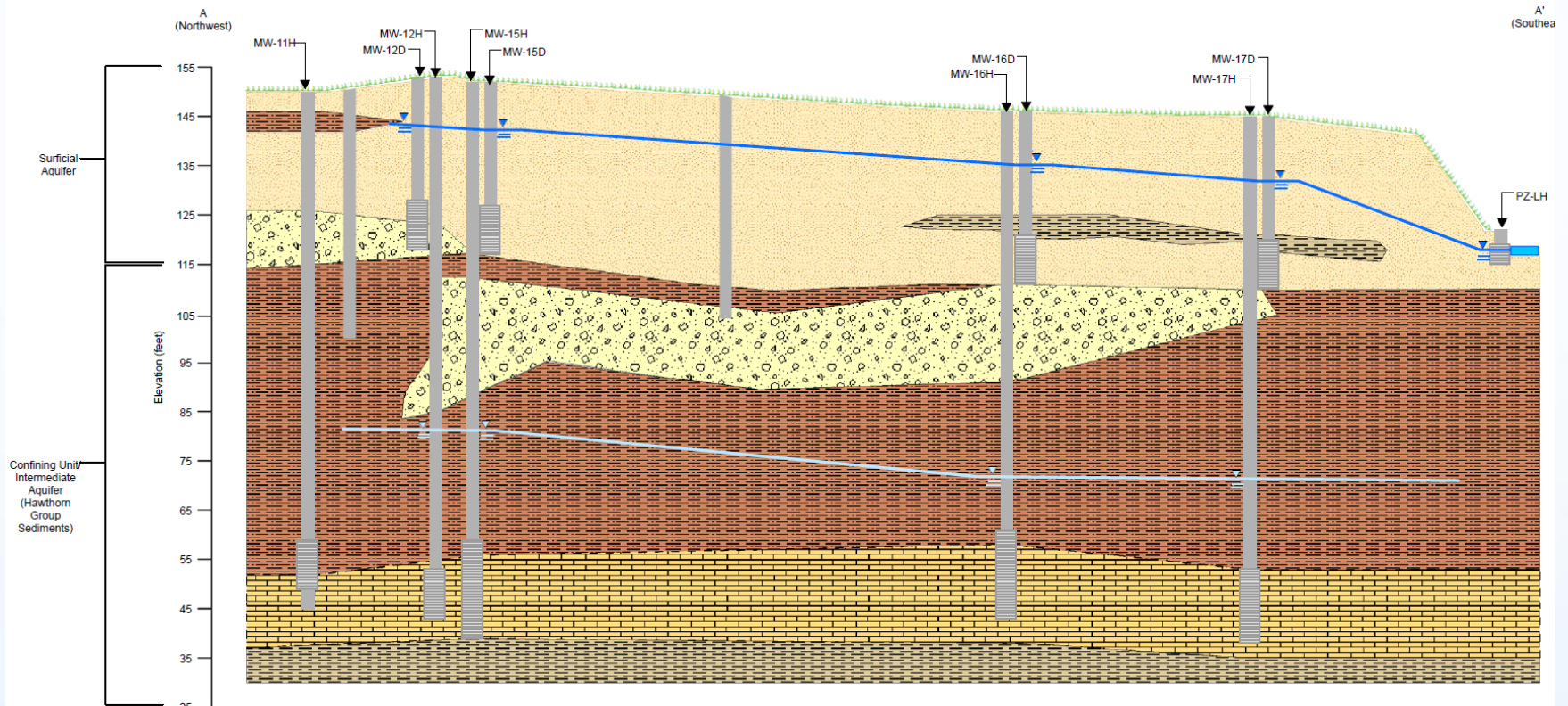




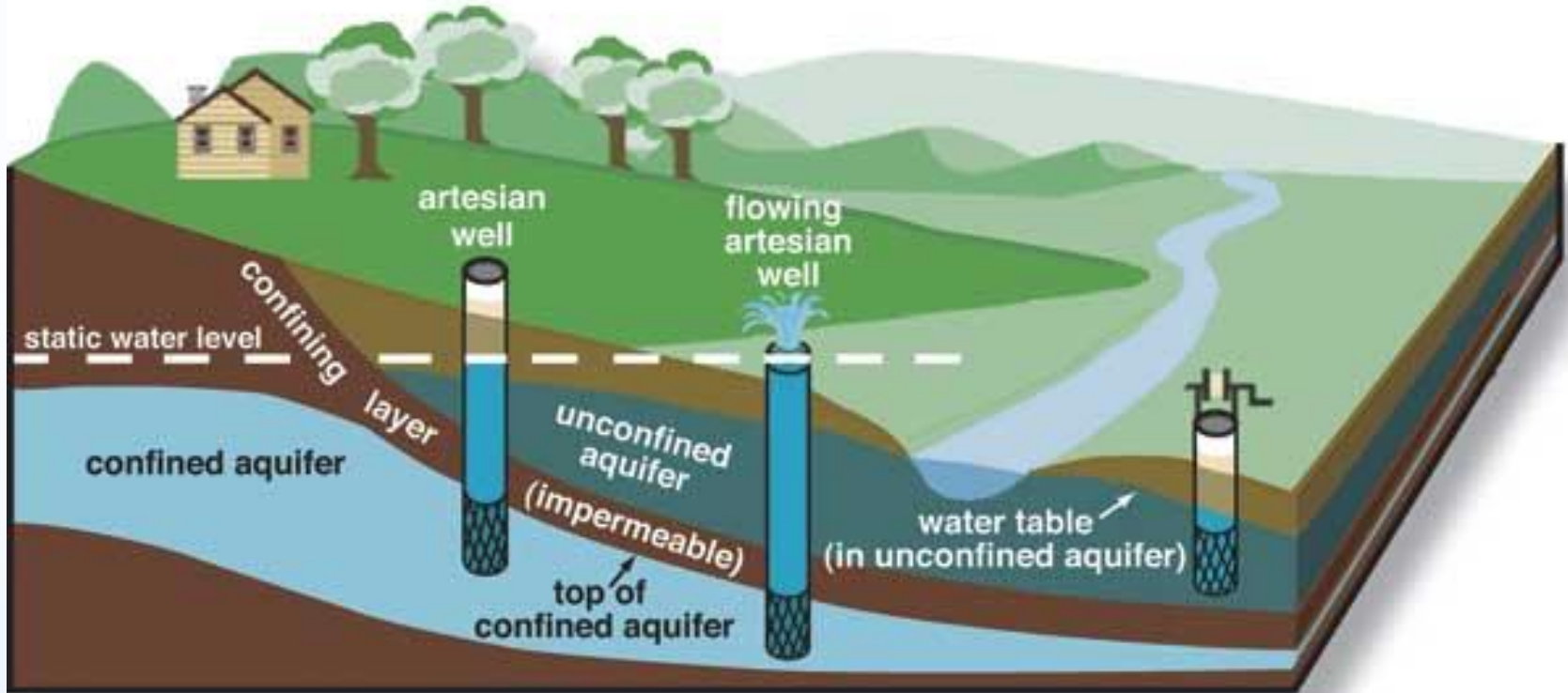
How are these concepts used?

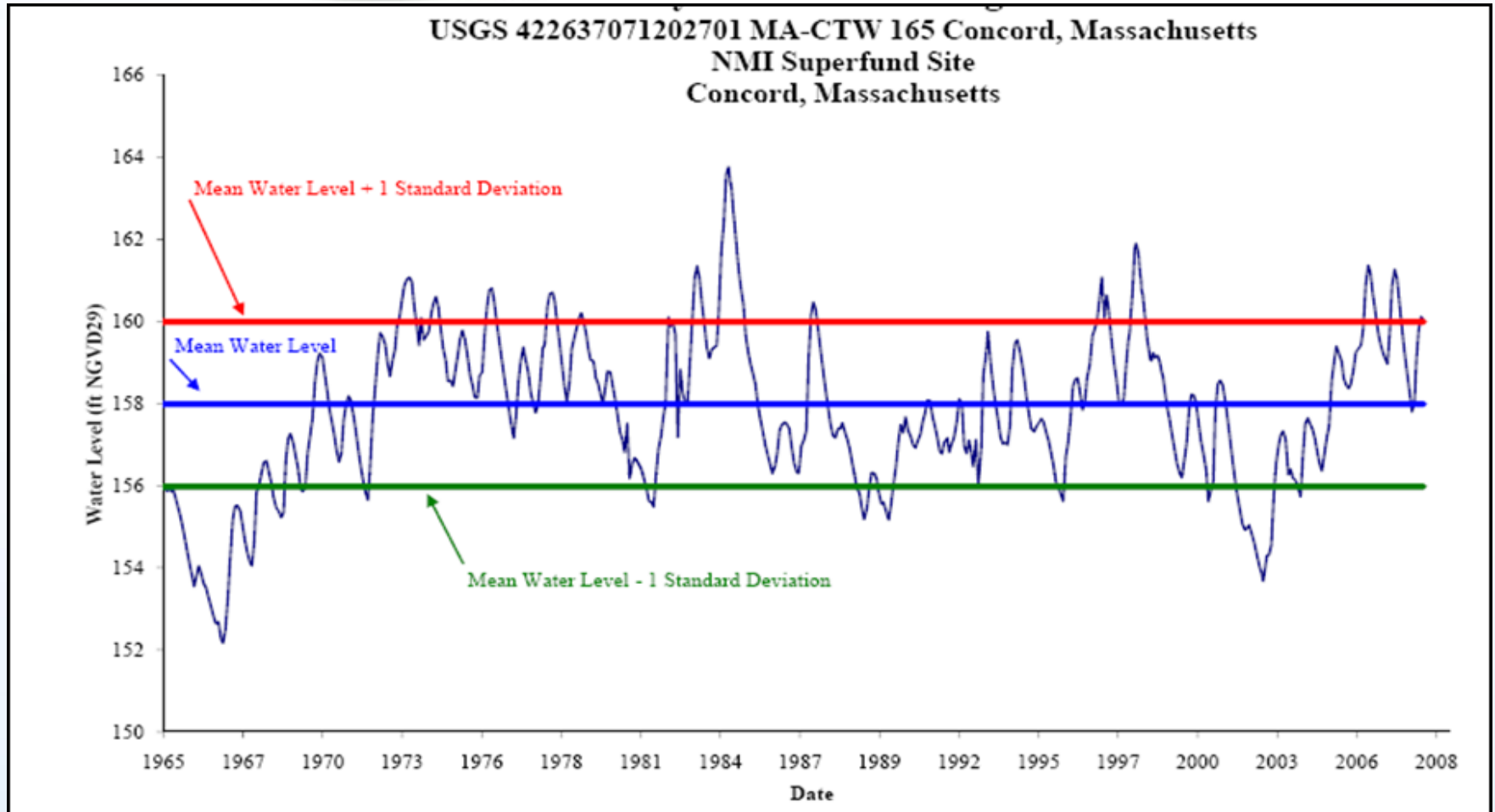
Evaluating and Making Use of the Data

Data Collection & Analysis: Hydrogeological Cross-Section

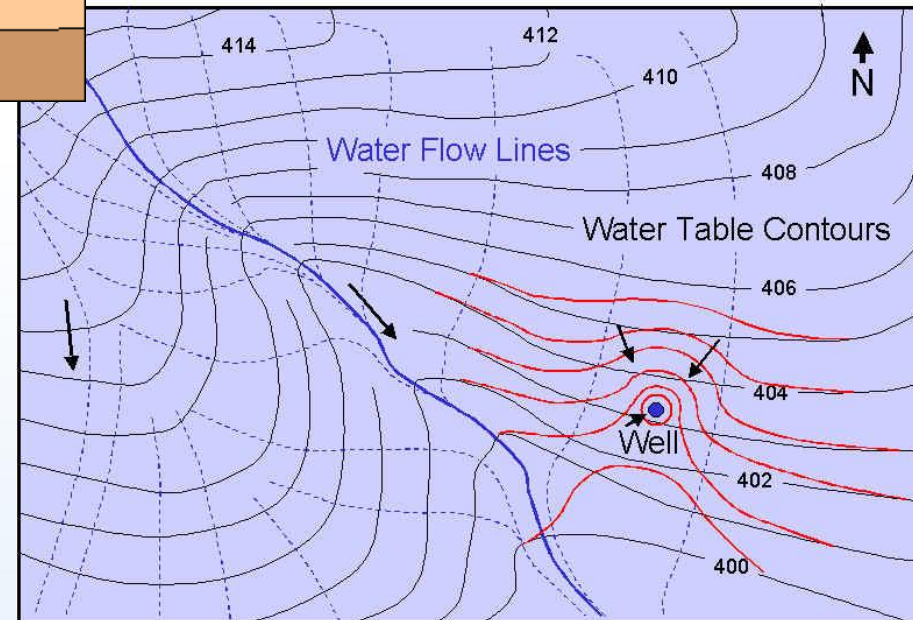
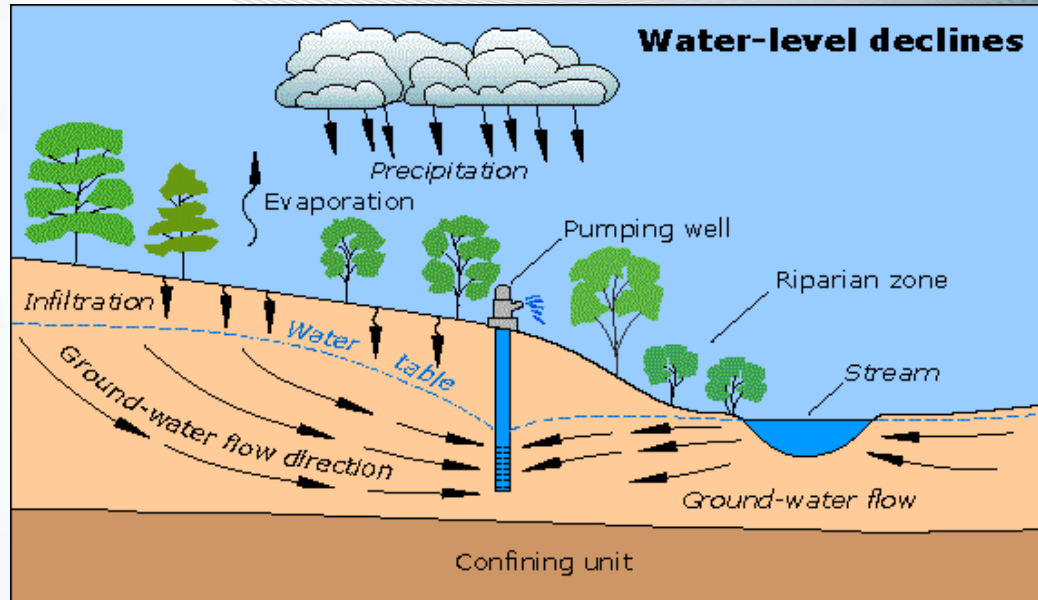


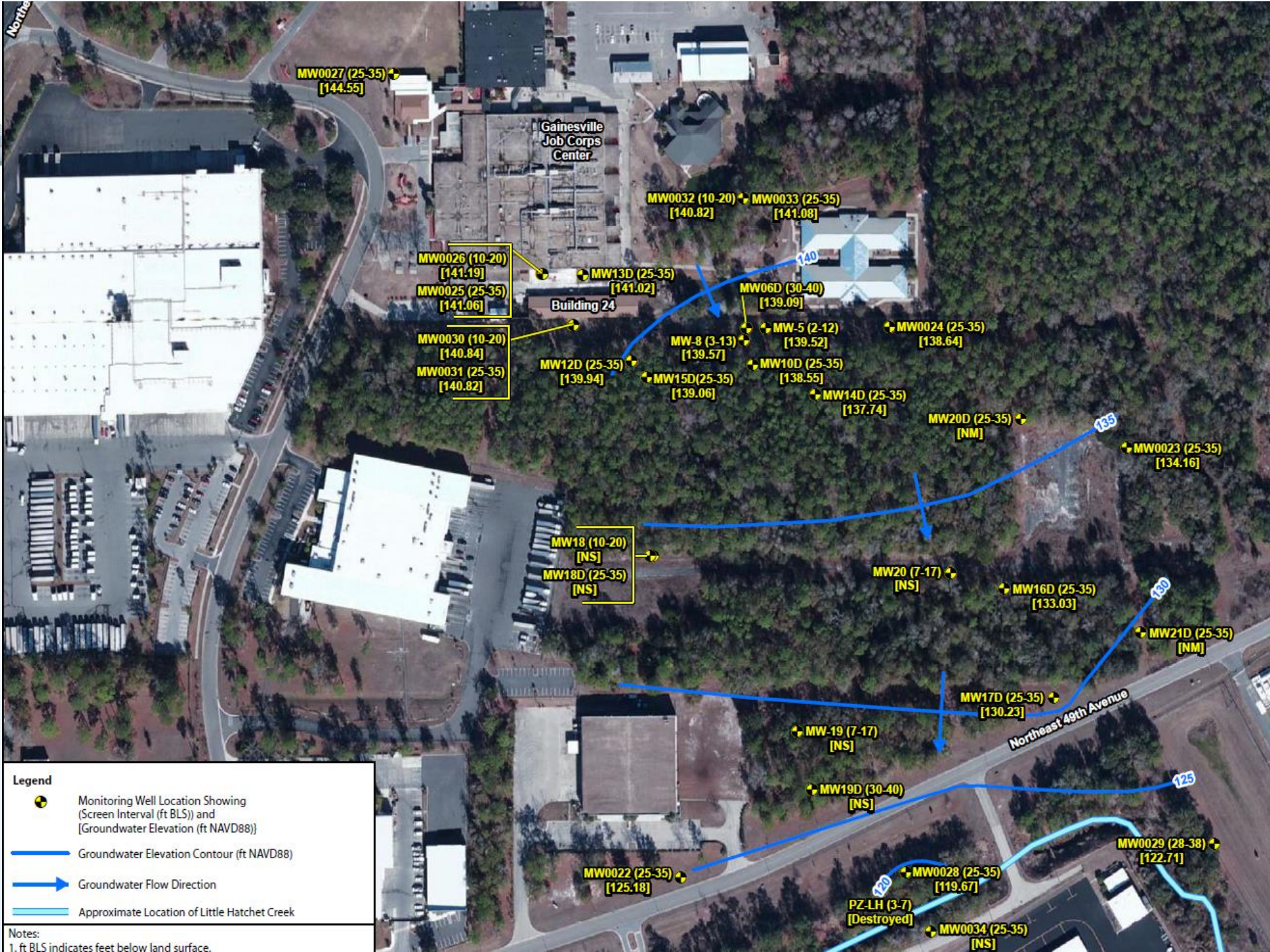
Data Collection & Analysis: Measuring Water Level in Wells





Data Collection & Analysis: Where's the Water Going?





MW0027 (25-35)
[144.55]

Gainesville
Job Corps
Center

MW0032 (10-20)
[140.82]

MW0033 (25-35)
[141.08]

MW0026 (10-20)
[141.19]

MW0025 (25-35)
[141.06]

MW13D (25-35)
[141.02]

Building 24

MW06D (30-40)
[139.09]

MW0030 (10-20)
[140.84]

MW0031 (25-35)
[140.82]

MW12D (25-35)
[139.94]

MW-8 (3-13)
[139.57]

MW-5 (2-12)
[139.52]

MW0024 (25-35)
[138.64]

MW15D (25-35)
[139.06]

MW10D (25-35)
[138.55]

MW14D (25-35)
[137.74]

MW20D (25-35)
[NM]

MW0023 (25-35)
[134.16]

MW18 (10-20)
[NS]

MW18D (25-35)
[NS]

MW20 (7-17)
[NS]

MW16D (25-35)
[133.03]

MW21D (25-35)
[NM]

MW17D (25-35)
[130.23]

MW-19 (7-17)
[NS]

MW19D (30-40)
[NS]

Northeast 49th Avenue

MW0022 (25-35)
[125.18]





PZ-LH (3-7)
[Destroyed]

MW0028 (25-35)
[119.67]

MW0034 (25-35)
[NS]

MW0029 (28-38)
[122.71]

Legend

-  Monitoring Well Location Showing (Screen Interval (ft BLS)) and (Groundwater Elevation (ft NAVD88))
-  Groundwater Elevation Contour (ft NAVD88)
-  Groundwater Flow Direction
-  Approximate Location of Little Hatchet Creek

Notes:
1. ft BLS indicates feet below land surface.

How Does a Hydrogeologist Use All of This Information?

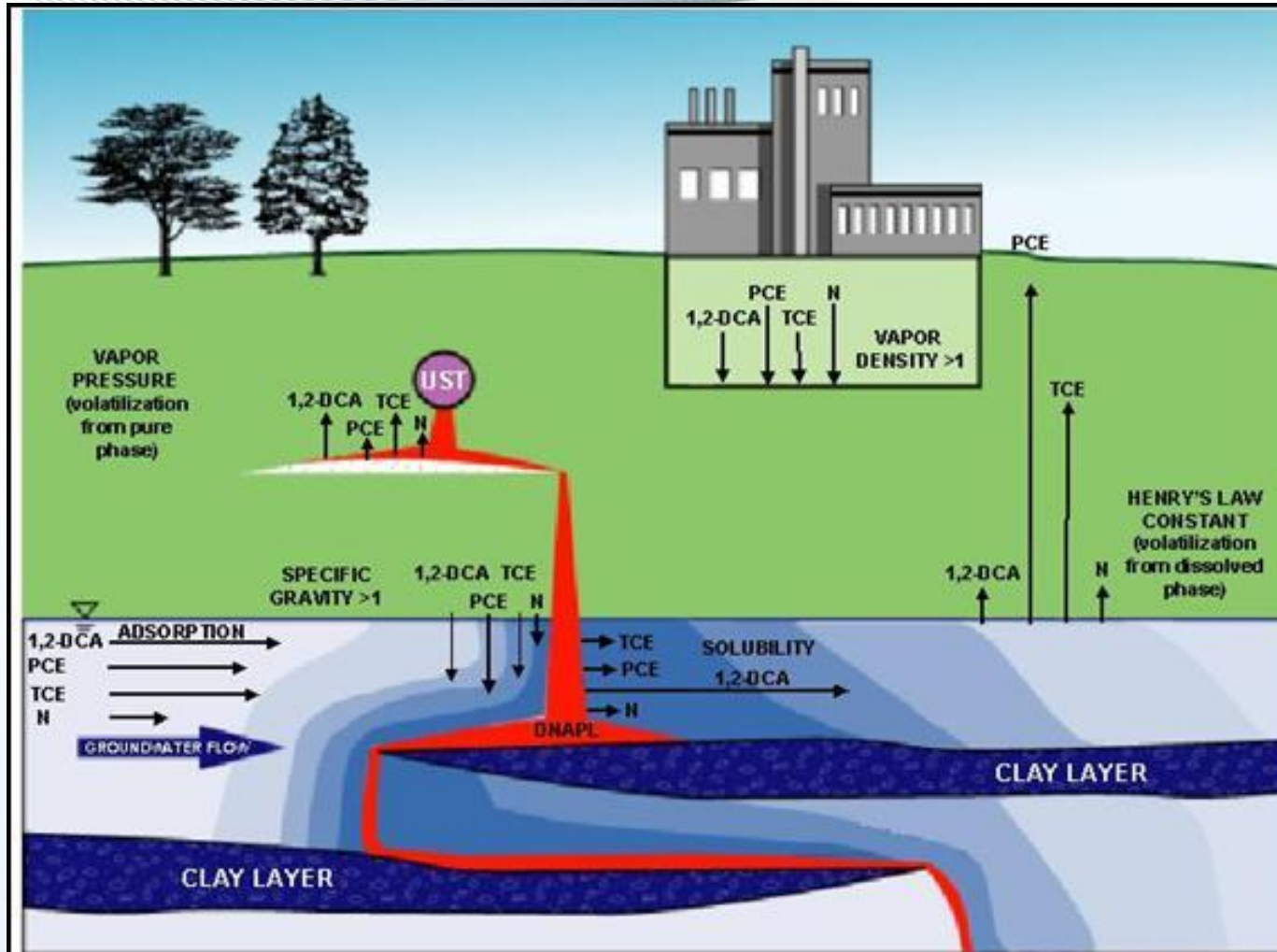
- ❑ Speed and direction of groundwater flow
- ❑ Capture zones of pumping wells
- ❑ Volume of contaminated water migrating across a site boundary
- ❑ Rate of movement of a contaminant plume
- ❑ Expected drawdown and area of influence from proposed pumping wells

Also:

- ❑ 2D analytical modeling and 3D numerical modeling of a wide range of hydrogeologic situations

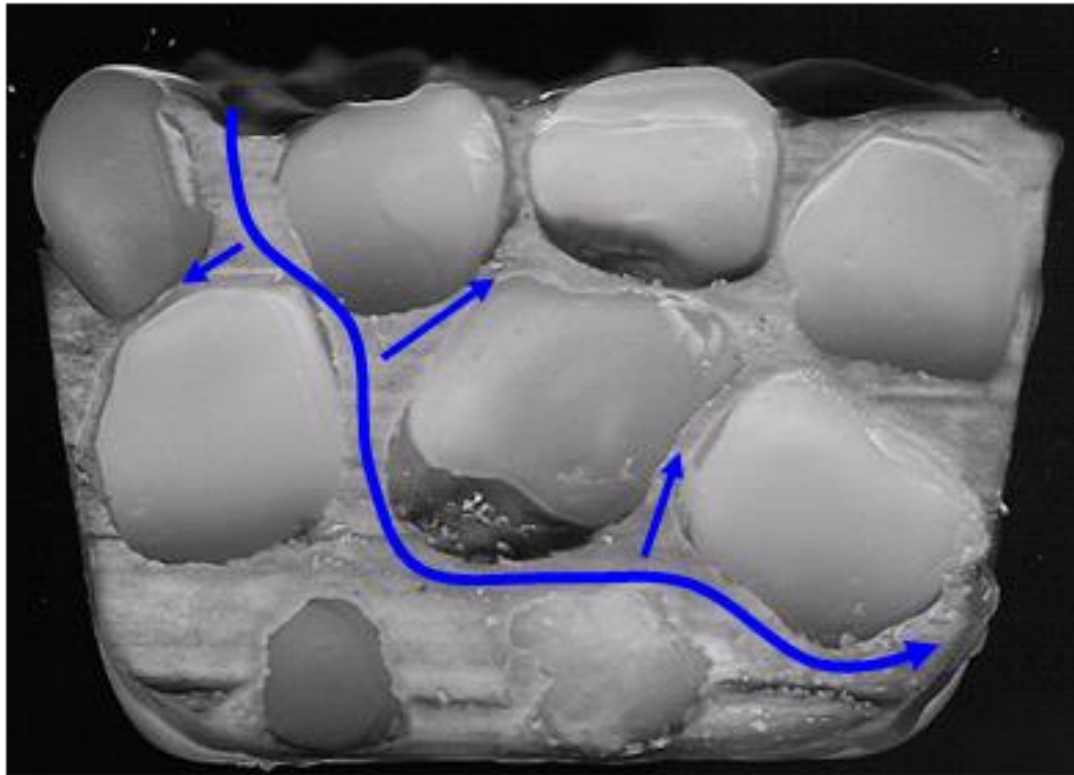
Contaminants and Groundwater

Contaminants: Easy to get into the ground and hard to get out



Getting out is a bit more difficult (remember porosity/permeability?)

Porosity at the Project Scale



Back Diffusion

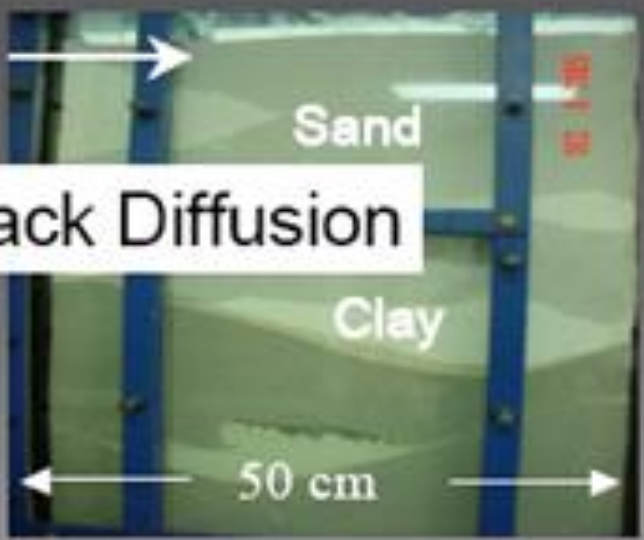


Figure 1.1: Setup - Sand and Clay

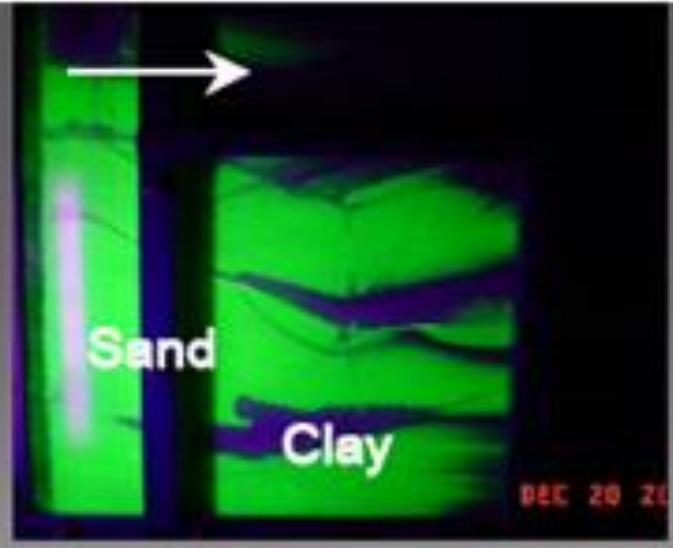


Figure 1.2: Fluorescein Inflow (Matrix Storage)

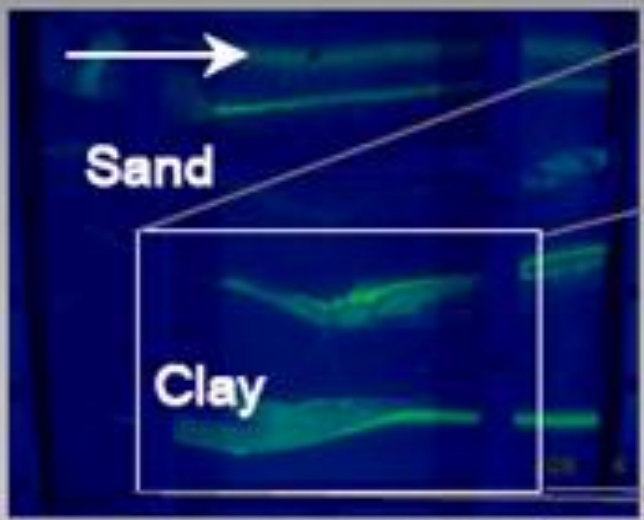


Figure 1.3: Source Off – Back Diffusion

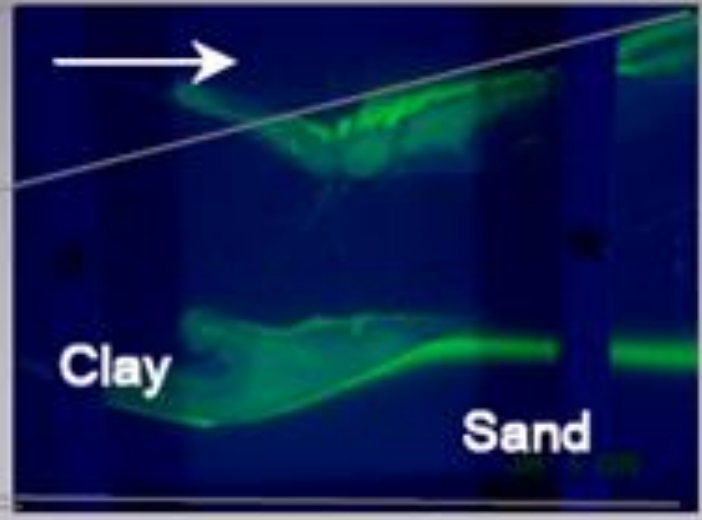
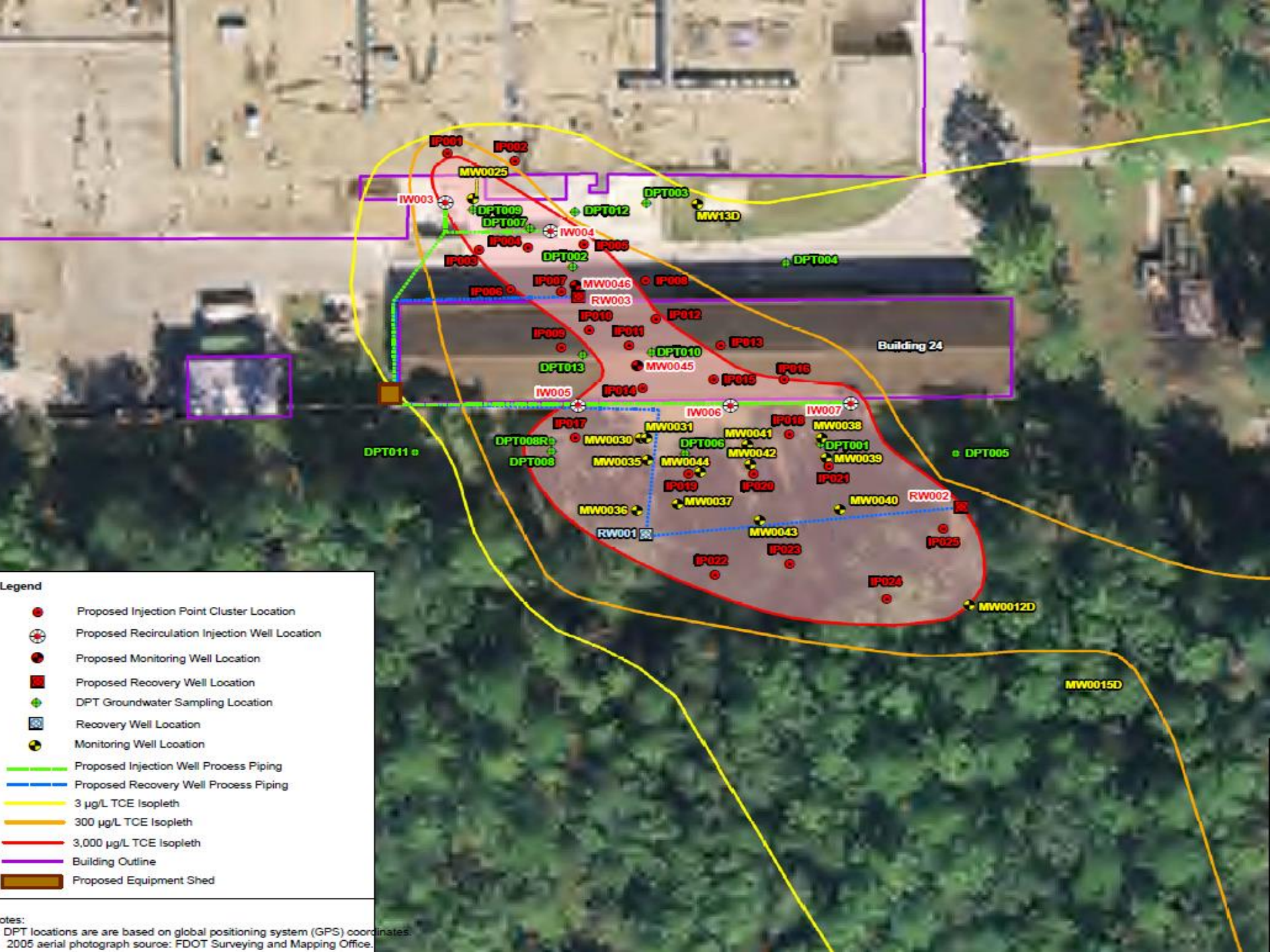


Figure 1.4: Close-up of Back Diffusion

What Does a Groundwater Plume Look Like?

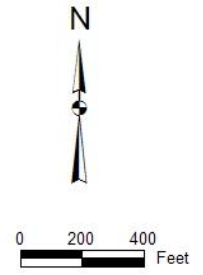
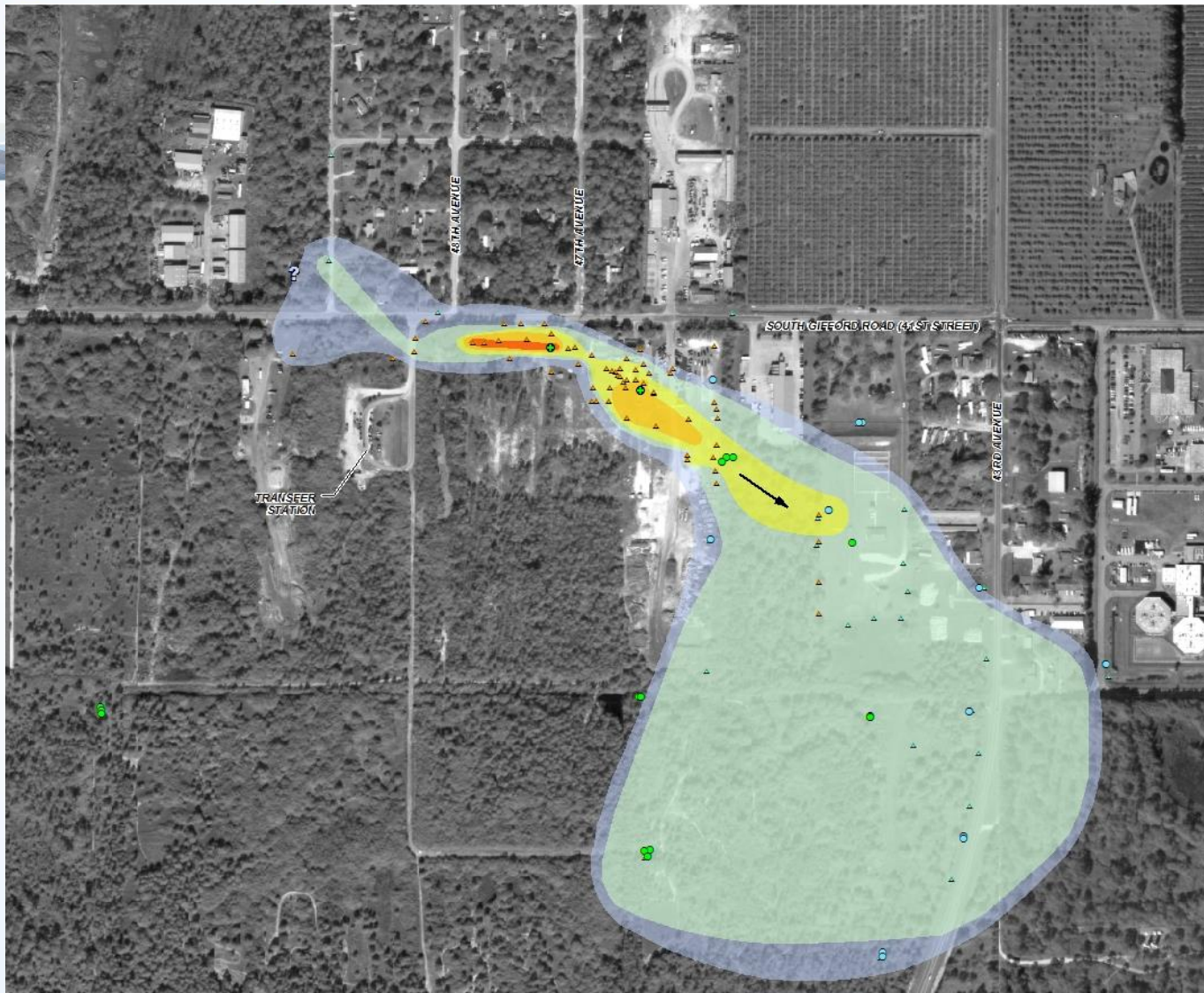
Typical Groundwater Contamination Issues



Legend

- Proposed Injection Point Cluster Location
- ⊕ Proposed Recirculation Injection Well Location
- Proposed Monitoring Well Location
- Proposed Recovery Well Location
- + DPT Groundwater Sampling Location
- Recovery Well Location
- Monitoring Well Location
- Proposed Injection Well Process Piping
- Proposed Recovery Well Process Piping
- 3 µg/L TCE Isopleth
- 300 µg/L TCE Isopleth
- 3,000 µg/L TCE Isopleth
- Building Outline
- Proposed Equipment Shed

Notes:
 DPT locations are based on global positioning system (GPS) coordinates.
 2005 aerial photograph source: FDOT Surveying and Mapping Office.



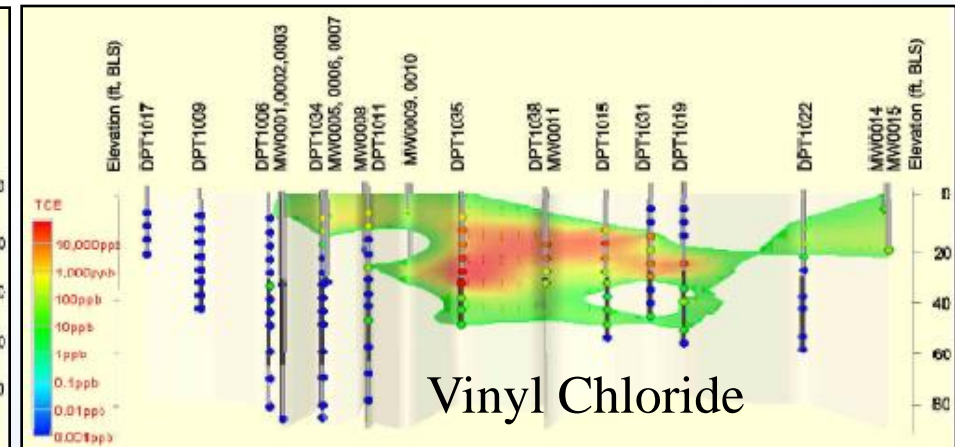
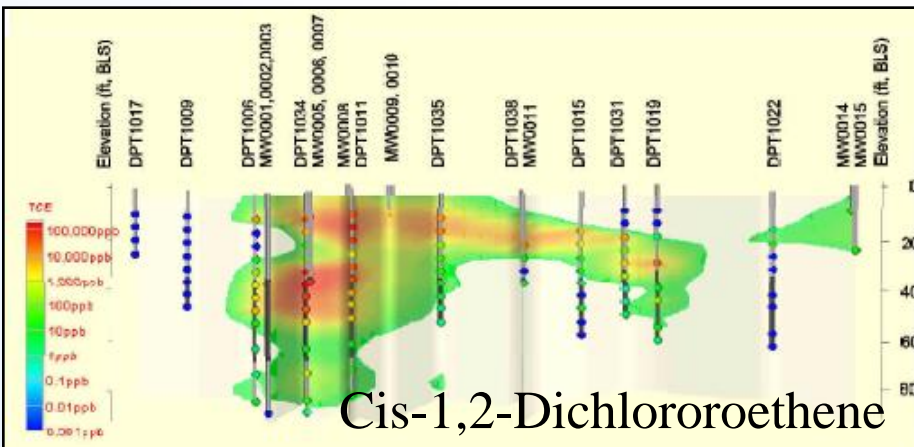
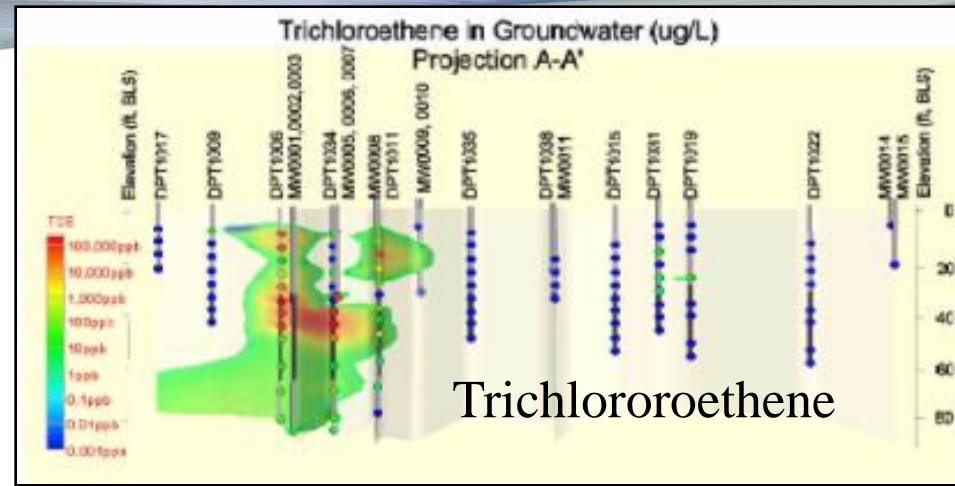
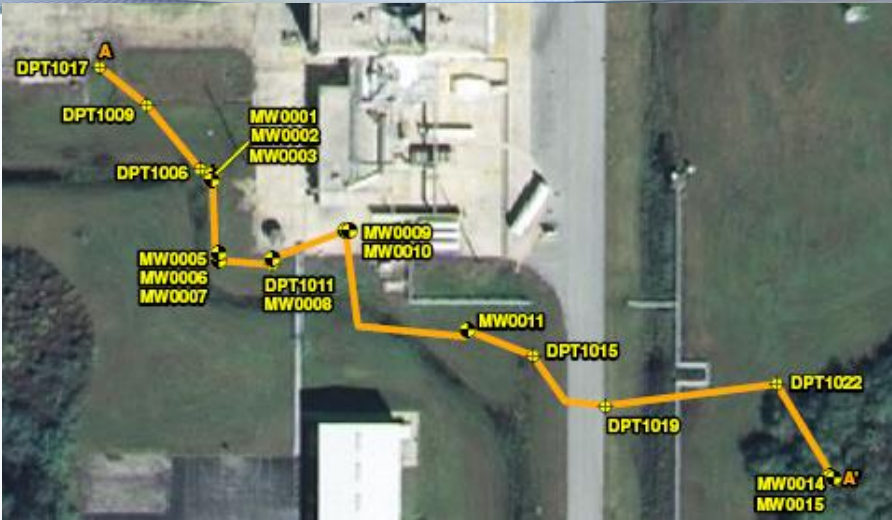
LEGEND

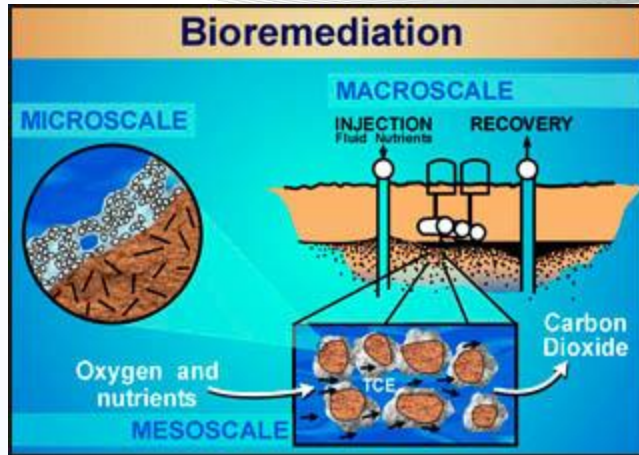
- ▲ DPT Groundwater Sampling Location
 - ▲ Off-Site Assessment DPT Groundwater Sampling Locations
 - WPIS Well
 - Plume Monitoring Well
 - On-Site Recovery Well
- VC Isoconcentration**
- > 5,000 µg/L
 - > 1,000 µg/L
 - > 100 µg/L (Natural Attenuation Default for VC)
 - > 10 µg/L
 - > 1 µg/L (GCTL for VC)
- ➔ Approximate groundwater flow direction

- Notes:
1. µg/L: Micrograms per liter.
 2. GCTL: Groundwater Cleanup Target Level.
 3. Downgradient monitoring well network (sampled in October through December 2002) was used to refine downgradient VC isoconcentration areas.
 4. Maximum concentration measured in depth-specific monitoring well clusters used in the preparation of isoconcentration map.
 5. Monitoring well installation and sampling activities are currently being completed (May and June 2003) north and west of South Gifford Road to further define DPT groundwater data.

Estimated Lateral Extent of VC Impacts in Groundwater South Gifford Road Landfill

Different Contaminants = Different Plumes





What about that hard to get out part?

See us next time!

