Fundamentals of Site Characterization

Dr. Michael Sklash, P. Eng.

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Dragun Corporation
Environmental Consultants

Toronto, ON | Windsor, ON | Farmington Hills, MI

Fundamentals of Site Characterization

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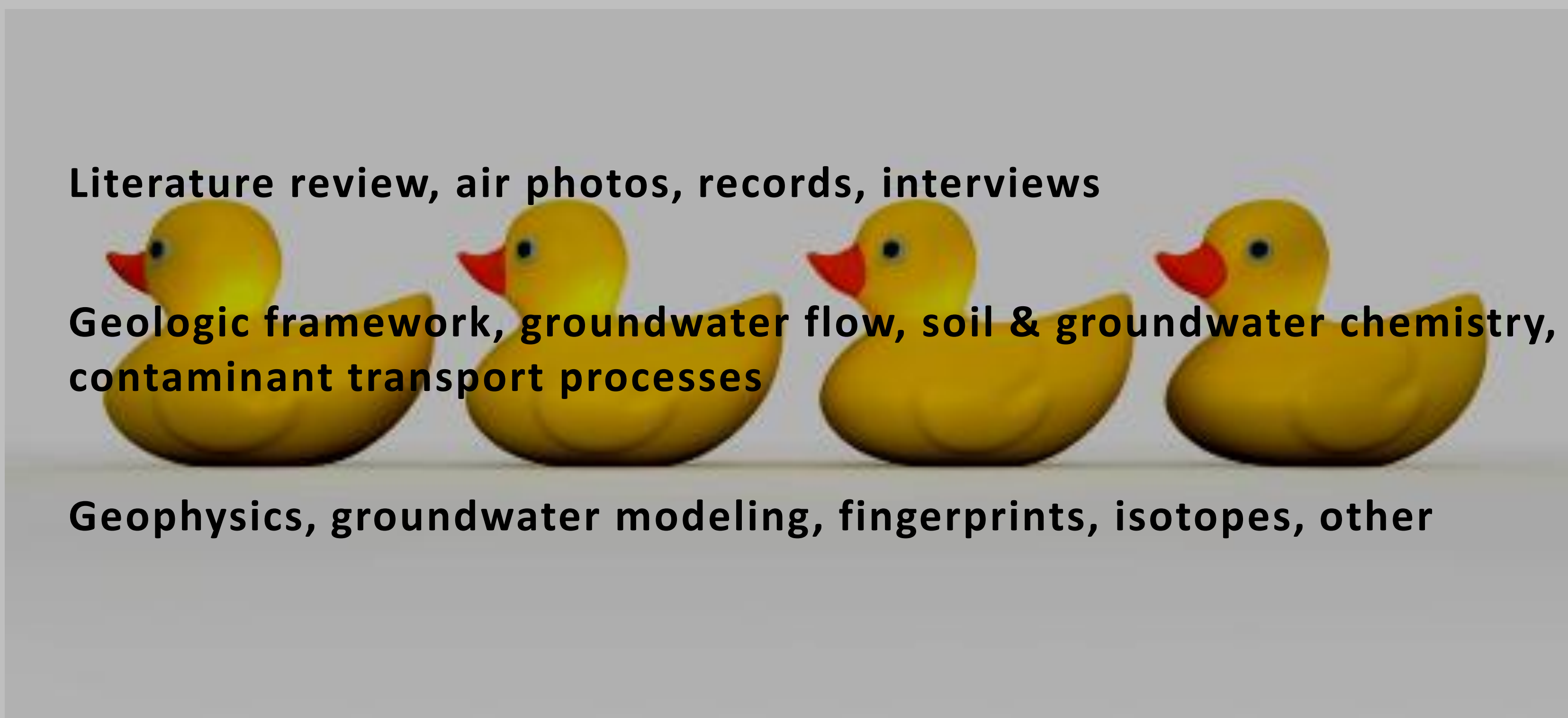
Get the Characterization Right…or



Literature review, air photos, records, interviews

Geologic framework, groundwater flow, soil & groundwater chemistry, contaminant transport processes

Geophysics, groundwater modeling, fingerprints, isotopes, other

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Your Remediation is a Shot in the Dark

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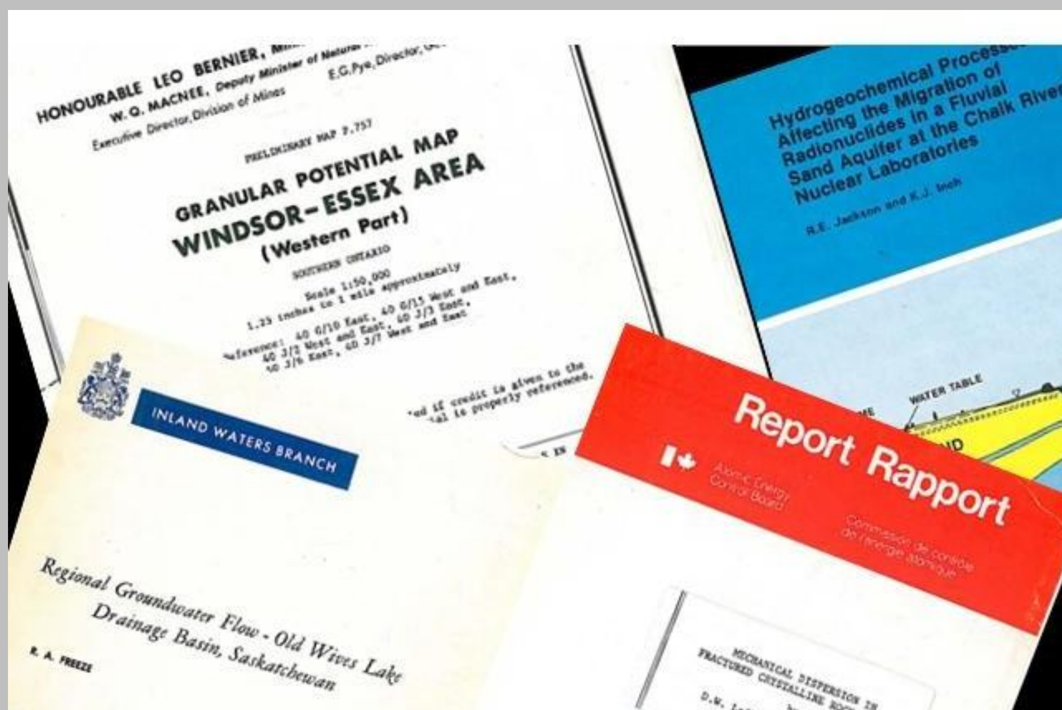
Don’t Recreate the Wheel.

Read the Literature!



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Understand Subsurface Conditions

Rock factors affecting contaminant transport:

Type of rock: igneous, sedimentary, metamorphic

Is rock structured or weathered?

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Soil factors affecting contaminant transport:

Grain size: proportions of sand, silt, and clay

How did soil form?

How thick?

Are deposits structured?

How did soil form?

Glacial

Alluvial

Lacustrine

Aeolian

Marine

Residual

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Sand, Silt, and Clay

Glaciated Terrain

Alluvial Terrain

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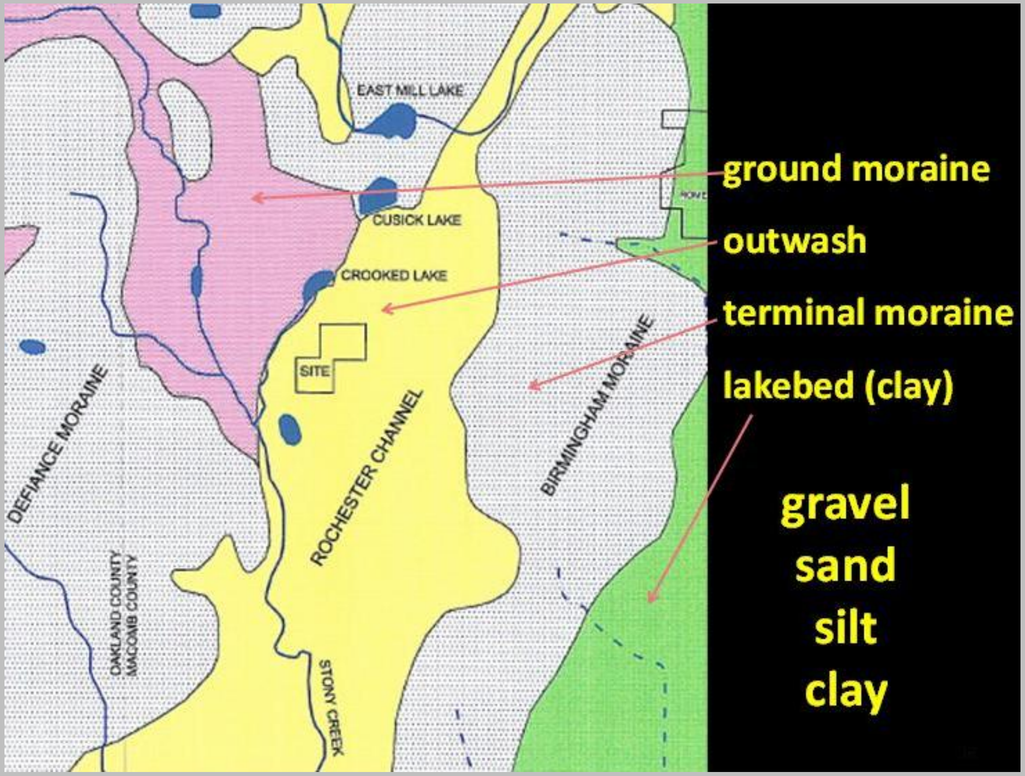
Glaciated Terrain Creates Stark Contrasts



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Alluvial Terrain - how complex can it be?

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Logging and characterization

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What is Groundwater?

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Groundwater Residence Time

Regional flow system: centuries to millennia

Local flow systems: days to years

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Darcy's Law: $v=Ki/n$

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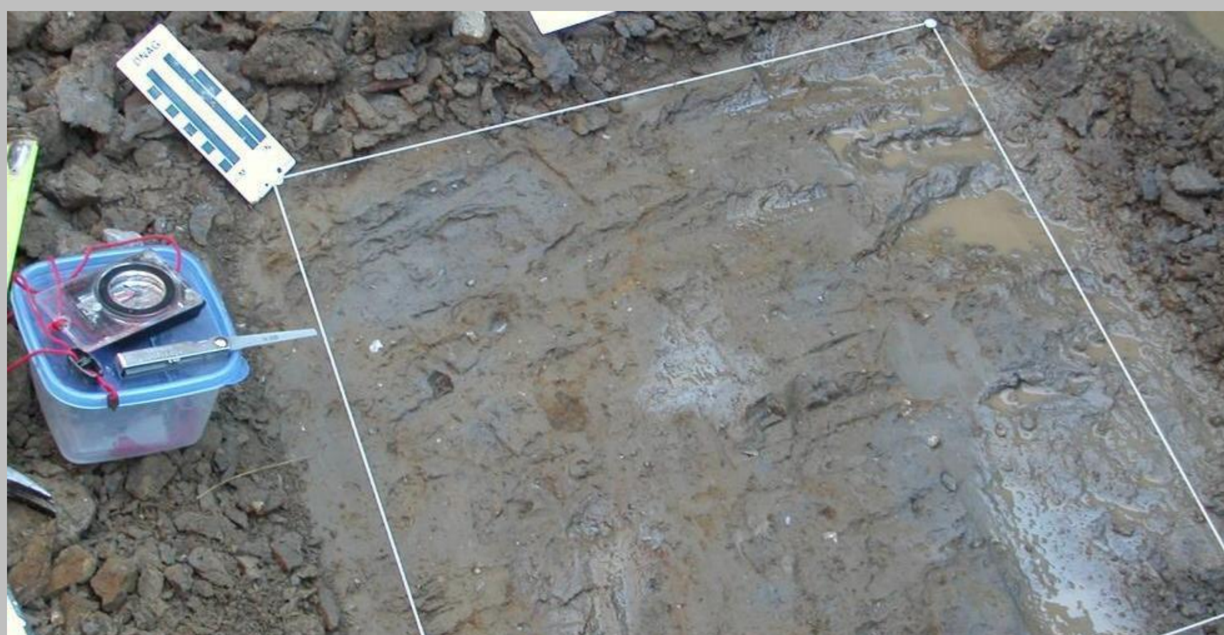
$$v=\boldsymbol{K}i/n$$

K= hydraulic conductivity

ability of a material to transmit a particular fluid



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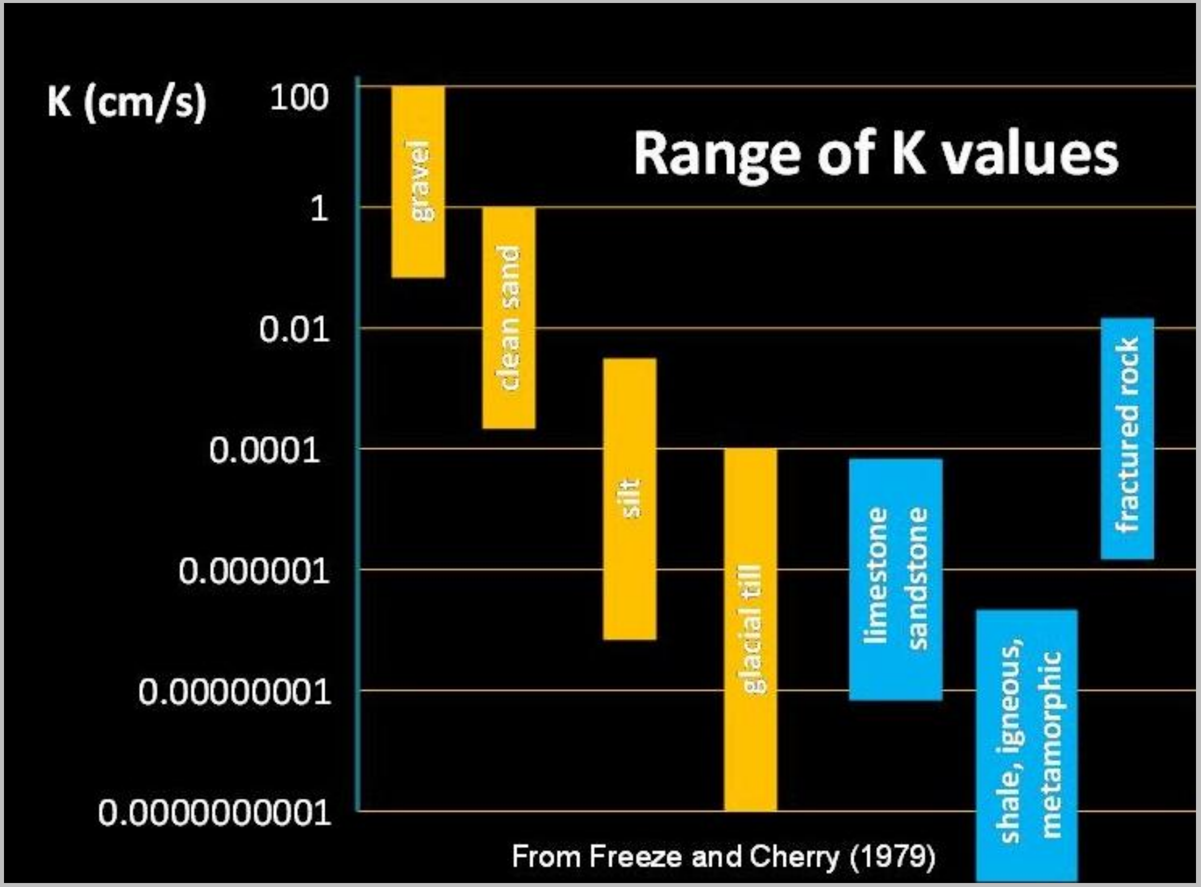
"K" varies over a great range in geologic materials



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"K" can vary in space

"homogeneous": location irrelevant

"heterogeneous": location matters

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"K" can vary with direction

"anisotropic": direction matters

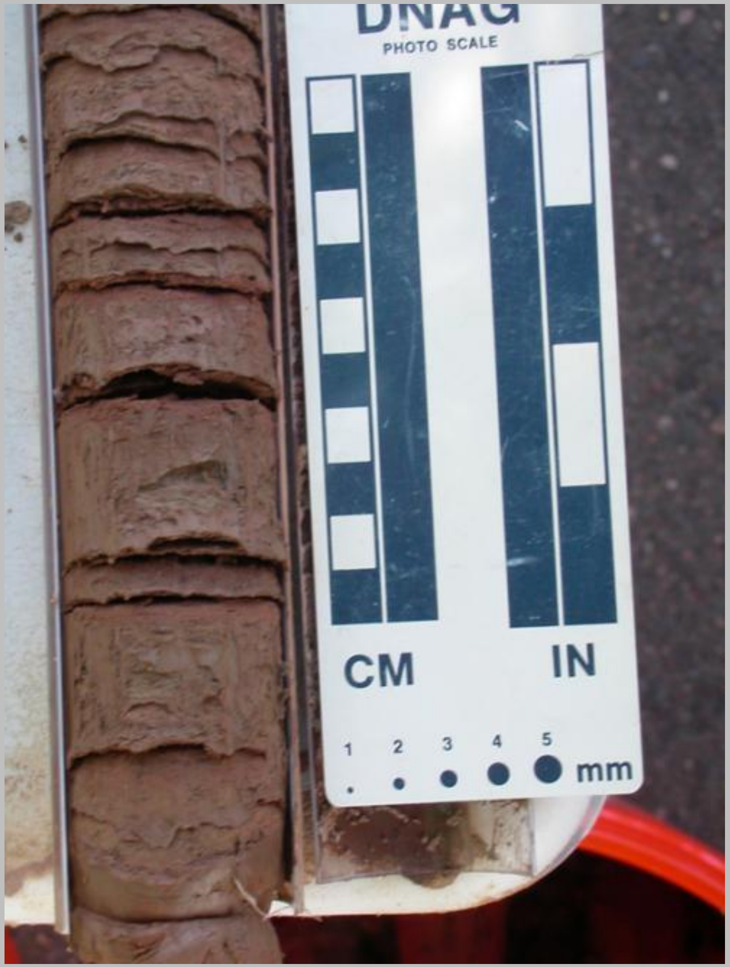
"isotropic": direction irrelevant

Kx/Kz typically at least 10/1 for soil

field tests

laboratory tests

estimates



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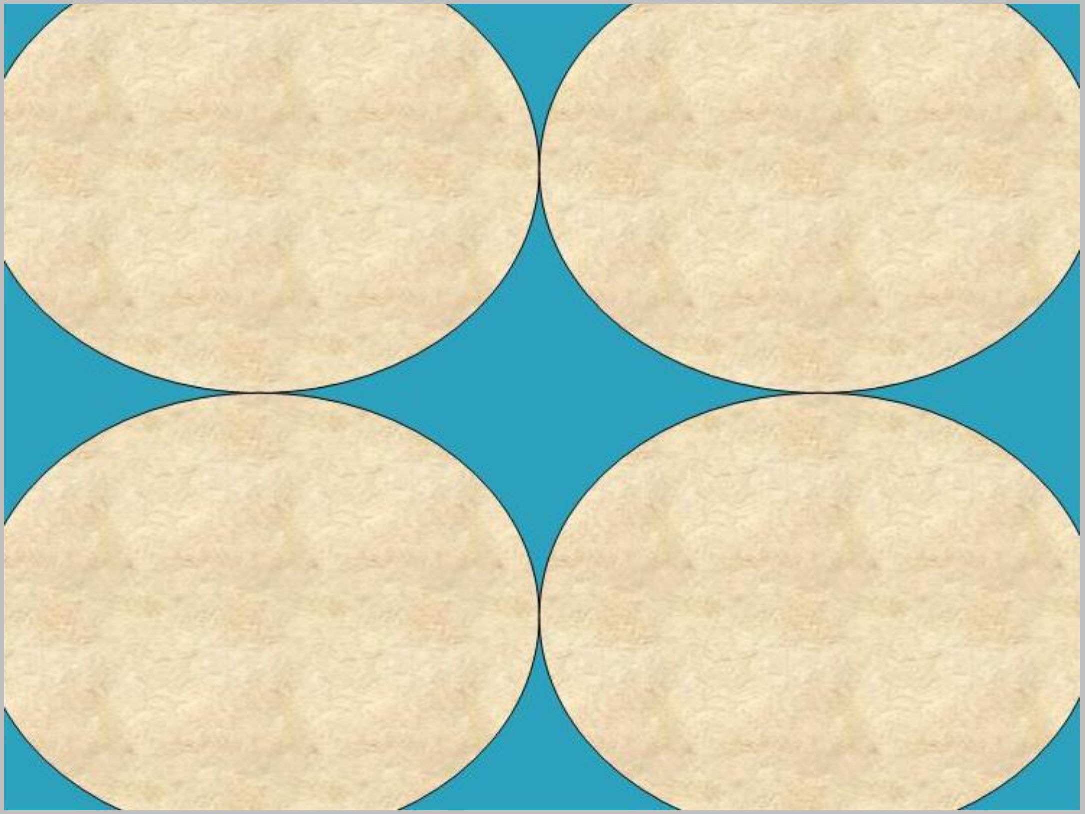
$v = Ki/\boldsymbol{n}$

"n"= porosity

"n" = $\frac{\text{(volume of voids)}}{\text{(total volume)}}$



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<u>Primary porosity</u> forms when soil or rock forms

<u>Secondary porosity</u> forms after soil or rock formed:

- fractures
- solution

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Soil porosity is typically "assumed"

Soil porosity for sand is 25-35%

Rock porosity depends on rock type, fracturing, and weathering.

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Rock porosity typically < soil porosity.

Implications?

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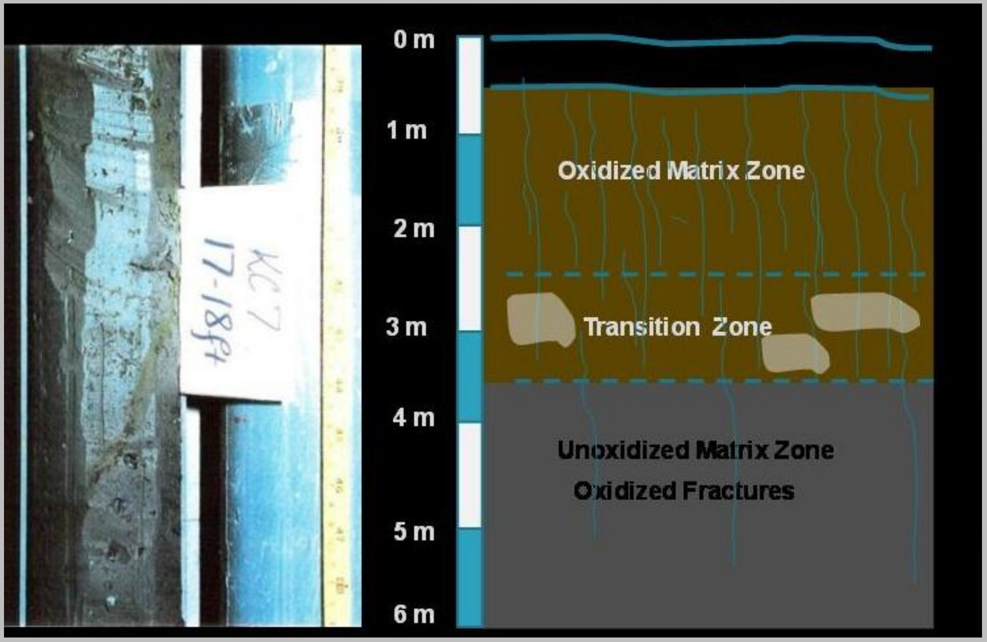
Fractured clays

Frequency and **aperture** of fractures decrease with depth



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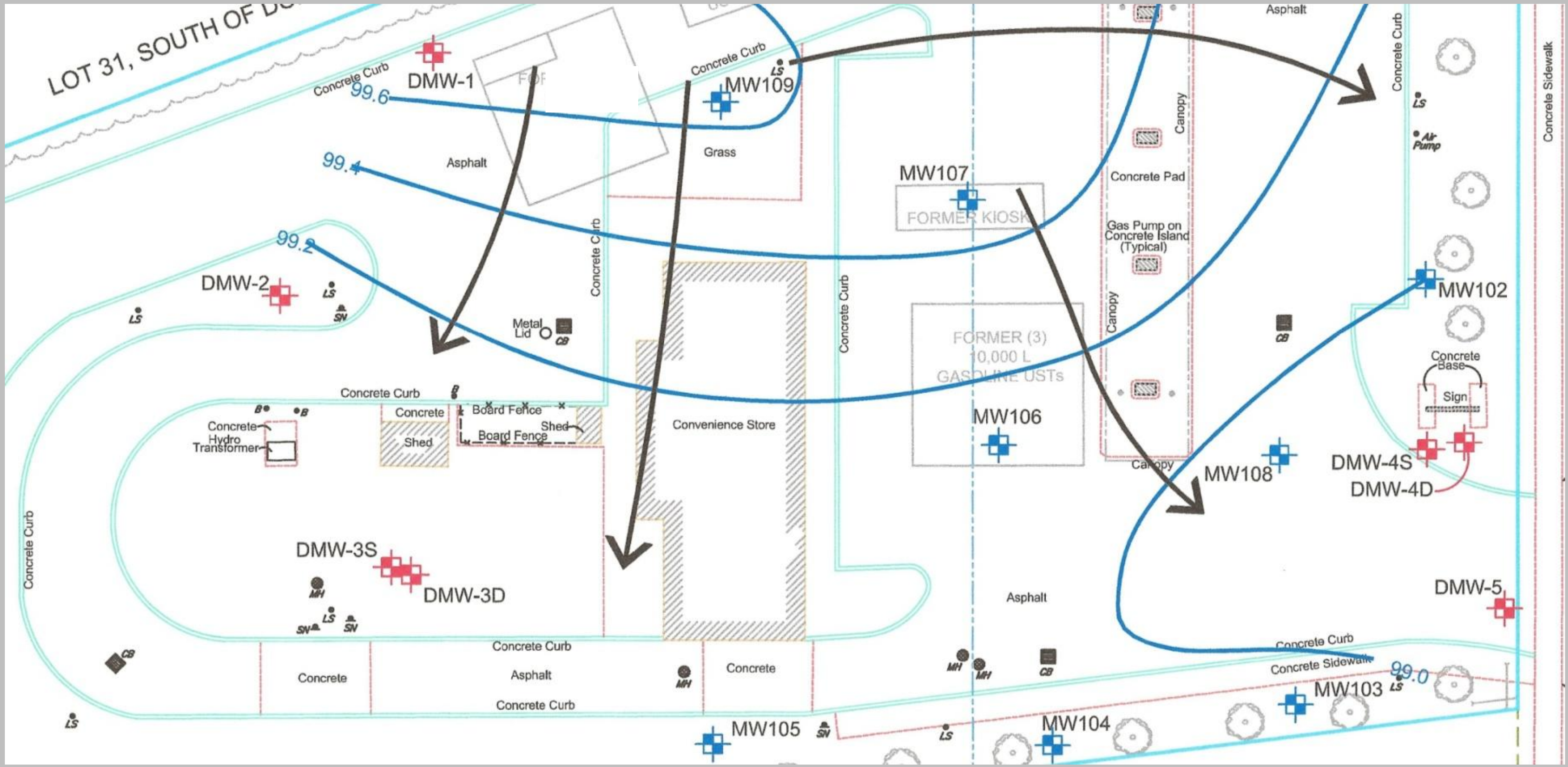
$v = K\boldsymbol{i}/n$

"i" = hydraulic gradient



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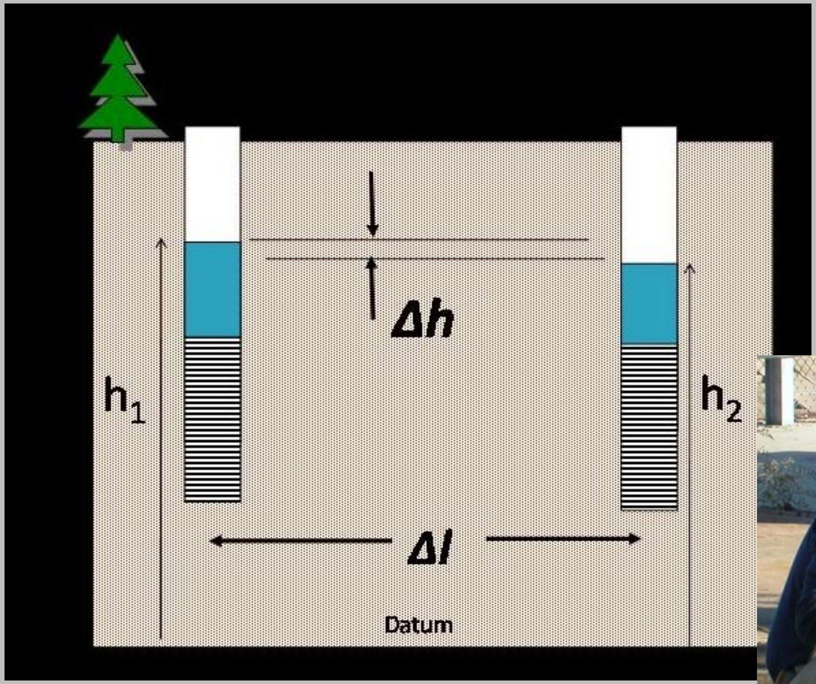
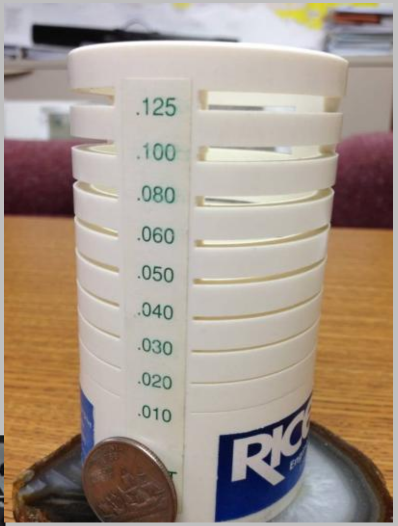
Groundwater flows due to hydraulic gradient

hydraulic gradient (i) = Δh/Δl





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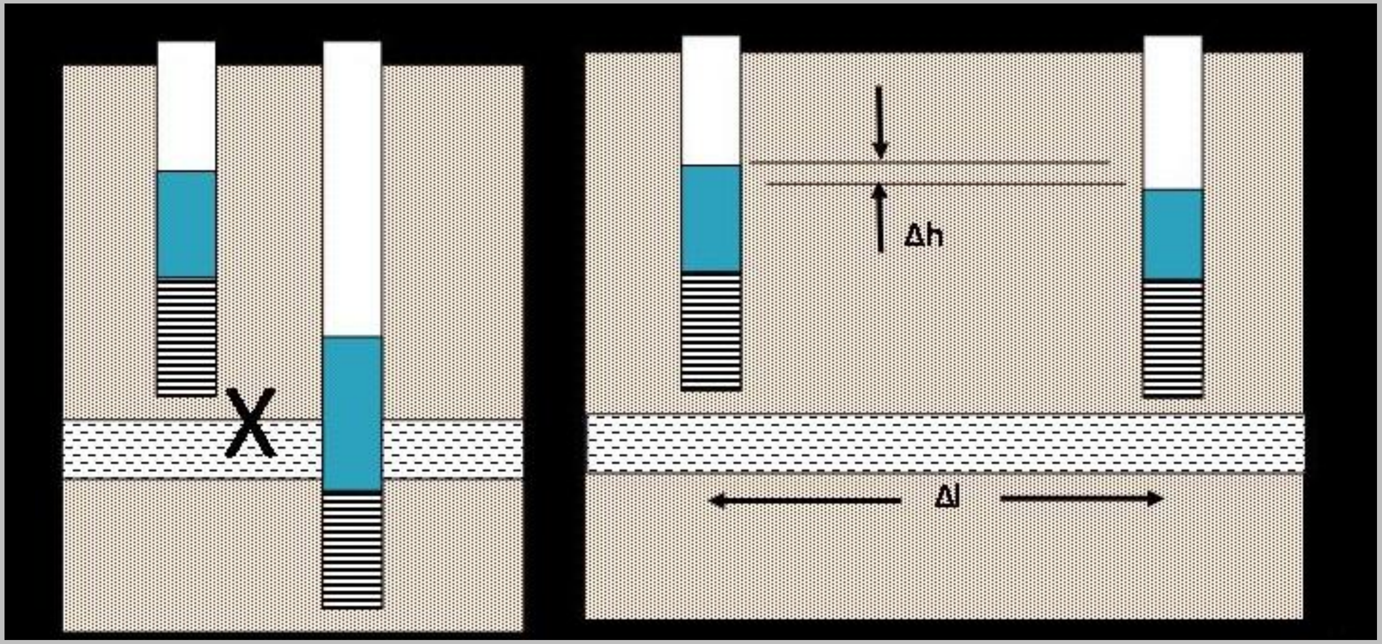
For horizontal hydraulic gradient (i_h) …
need a minimum 3 monitoring wells,
screened at <u>same</u> depth or in <u>same</u> formation



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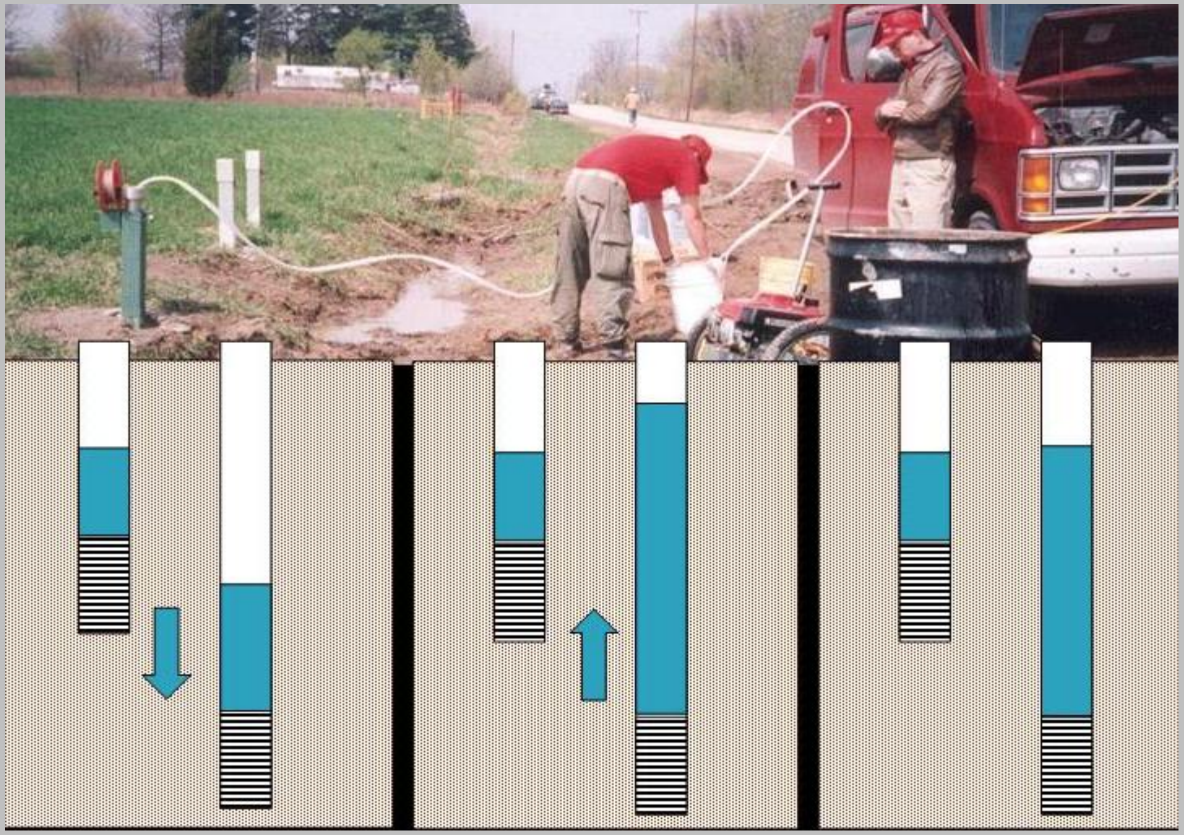
Determining vertical groundwater flow direction



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Chemical Behaviour

Miscible
Conservative
Stable

Immiscible
Retarded/Reacts
Degrades

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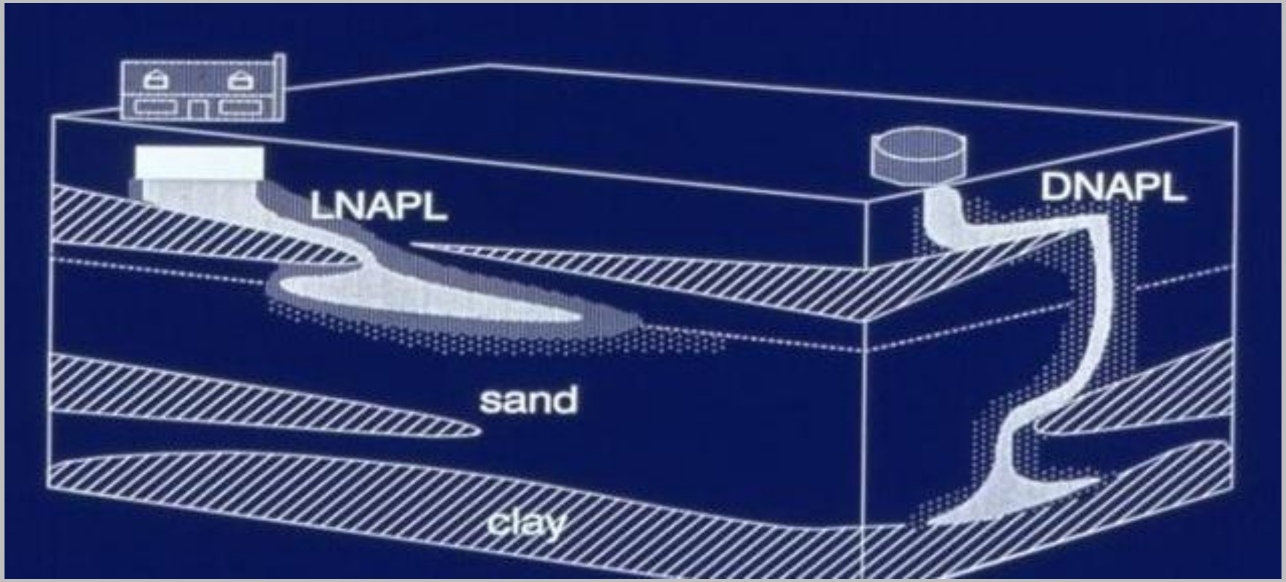
LNAPL =light non-aqueous phase liquids
float on groundwater*
e.g. gasoline, diesel, fuel oil, jet fuel



DNAPL= dense non-aqueous phase liquids
sink in groundwater*
e.g. TCE, PCE

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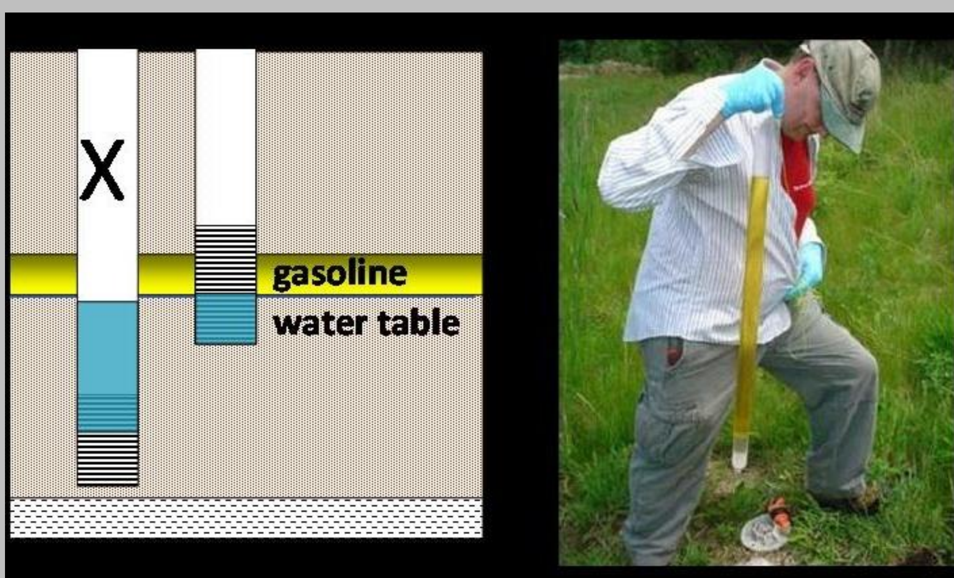
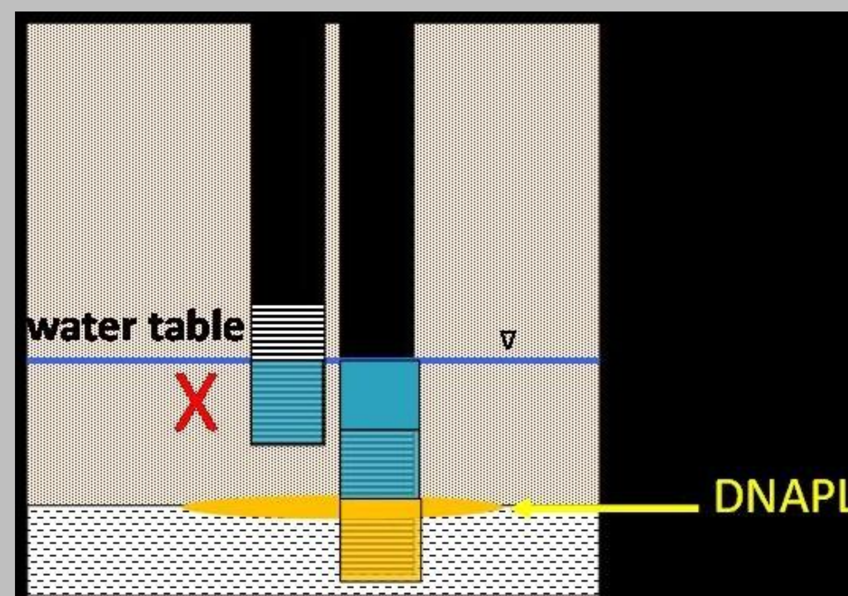
Monitoring wells for "LNAPL" sites screen across top of saturated zone

Monitoring wells for "DNAPL" sites screen at base of permeable zone





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Low Flow Sampling

peristaltic pump
electrical conductivity
temperature
pH and Eh
dissolved oxygen meter
turbidity meter
water level meter
interface probe

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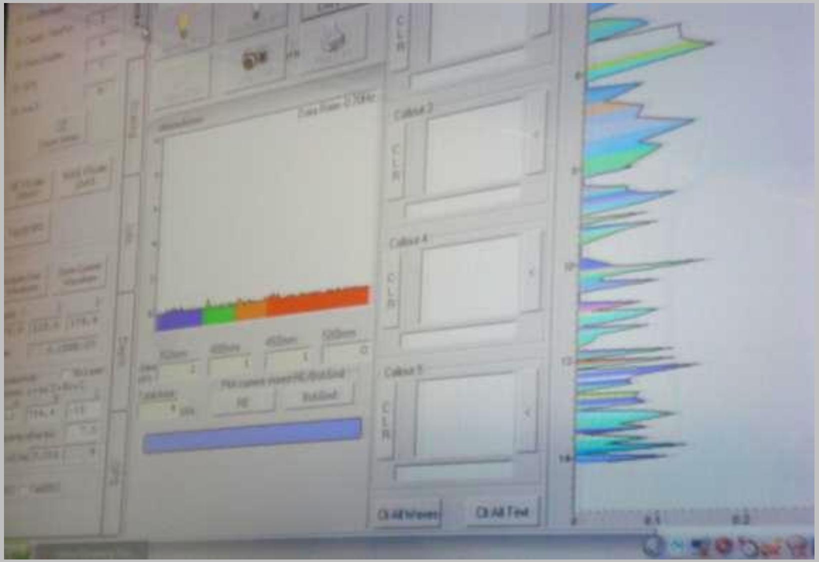
Membrane Interface Probe (MIP)

Halogen Specific Detector (XSD)

Laser Induced Fluorescence (LIF)



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Fate and Transport of Releases

<u>Common types of releases</u>

Petroleum-related chemicals
(e.g. BTEX, MTBE)

Chlorinated chemicals
(e.g. TCE, PCE)

Inorganics
(e.g. metals, fertilizers, brine, leachate)

<u>Other types of releases</u>

Lagoons, radionuclides, microbial

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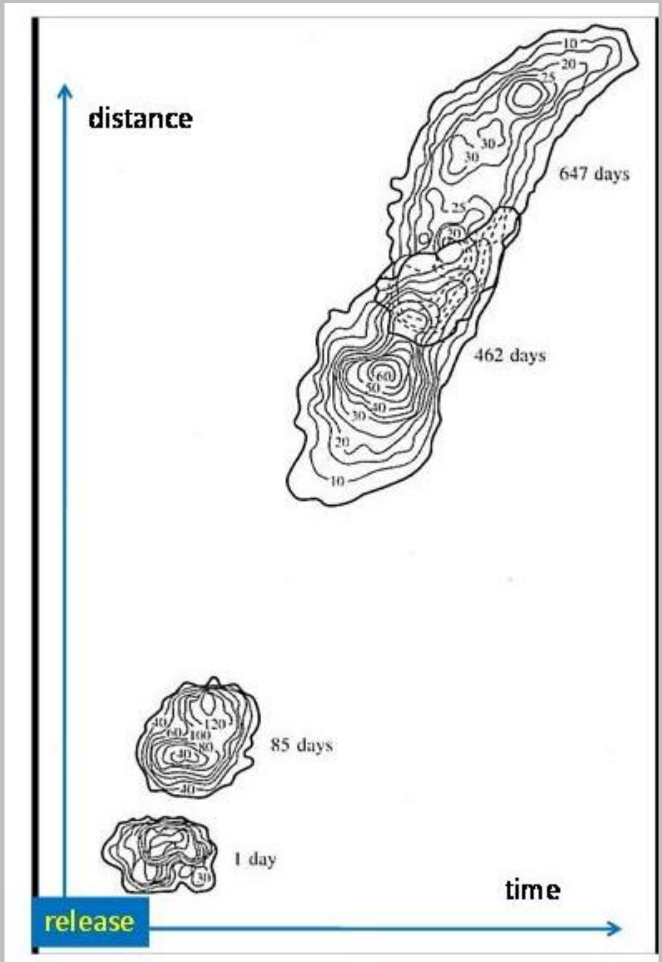
How do releases become plumes?



Source: Barker, et.al. (1987)

Dispersion and Diffusion

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Mechanical dispersion:
mixing within pores,
between pores, “tortuosity”

Diffusion:
transfer of chemical from
higher to lower
concentrations

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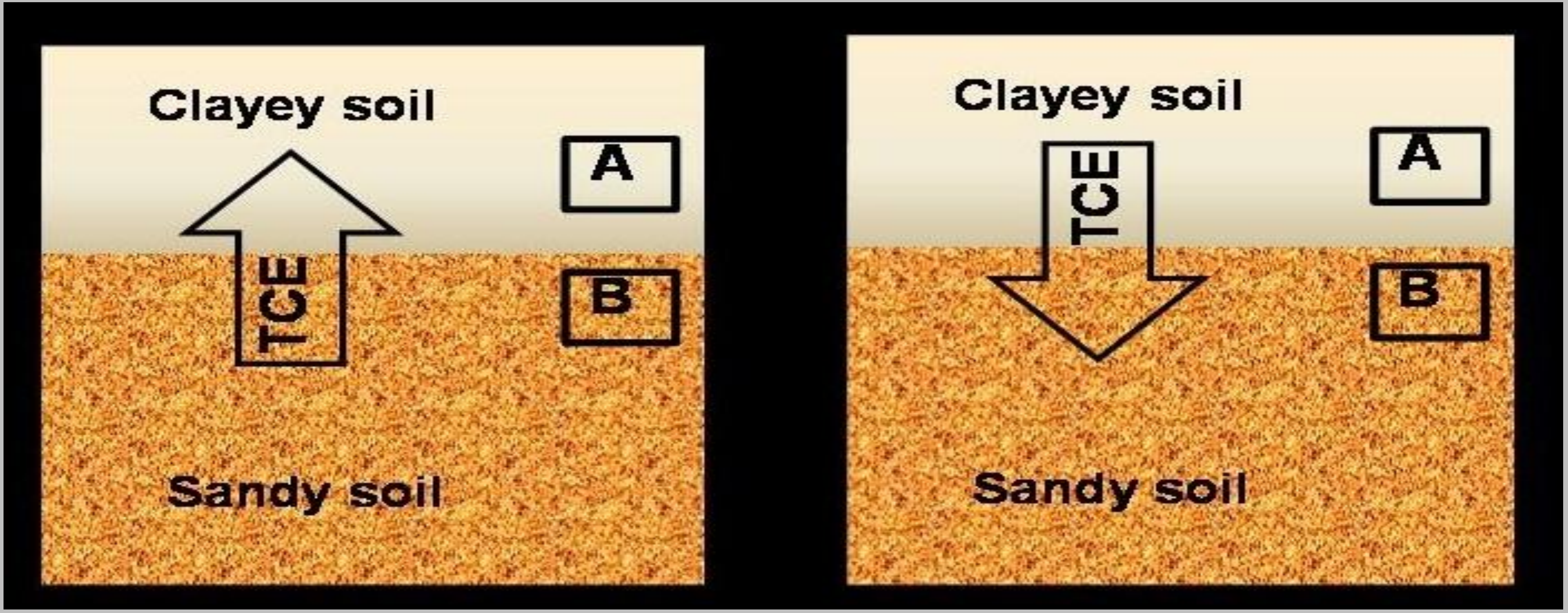
Diffusion process is slow … implications?



Before remediation of sand After remediation of sand

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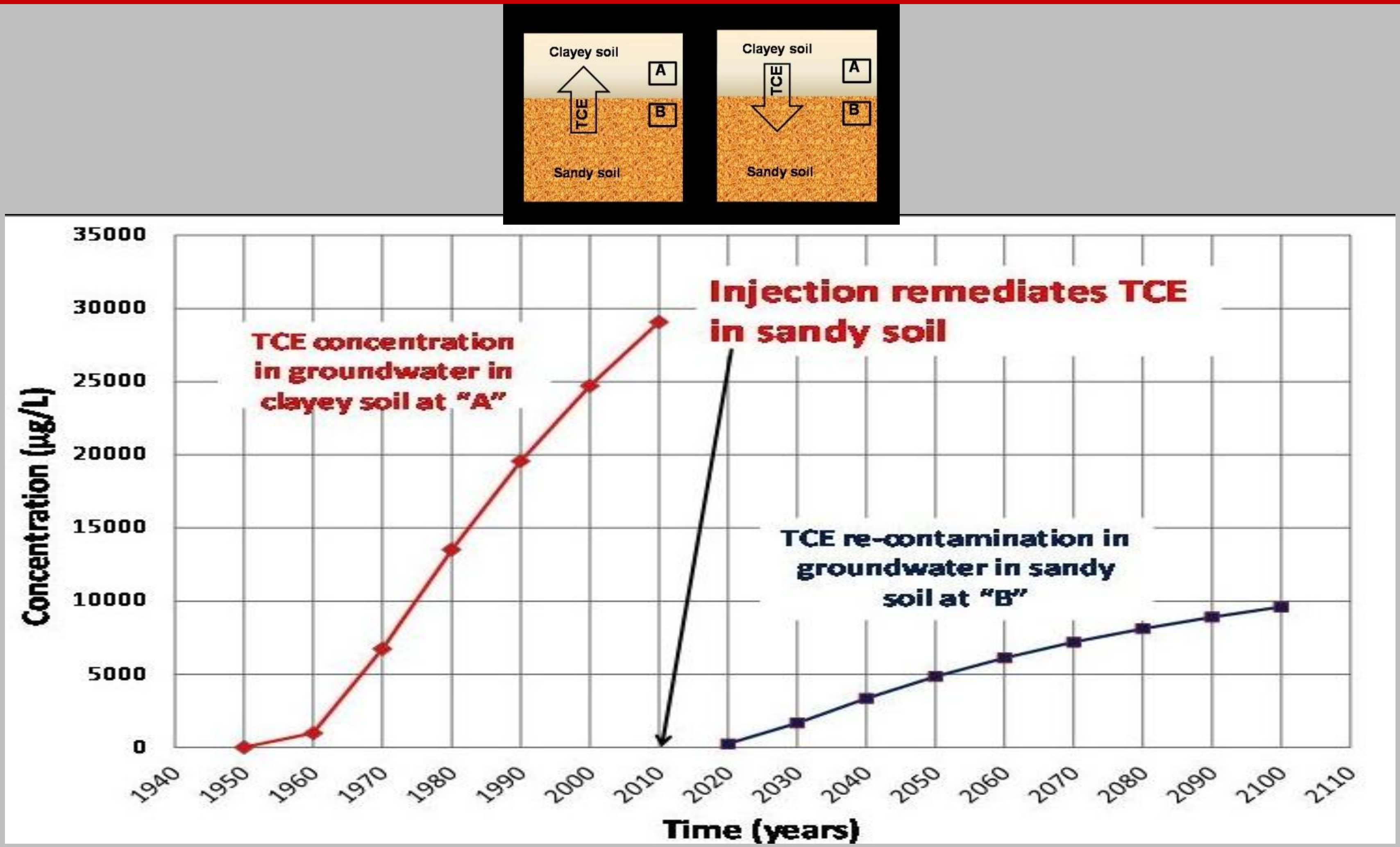

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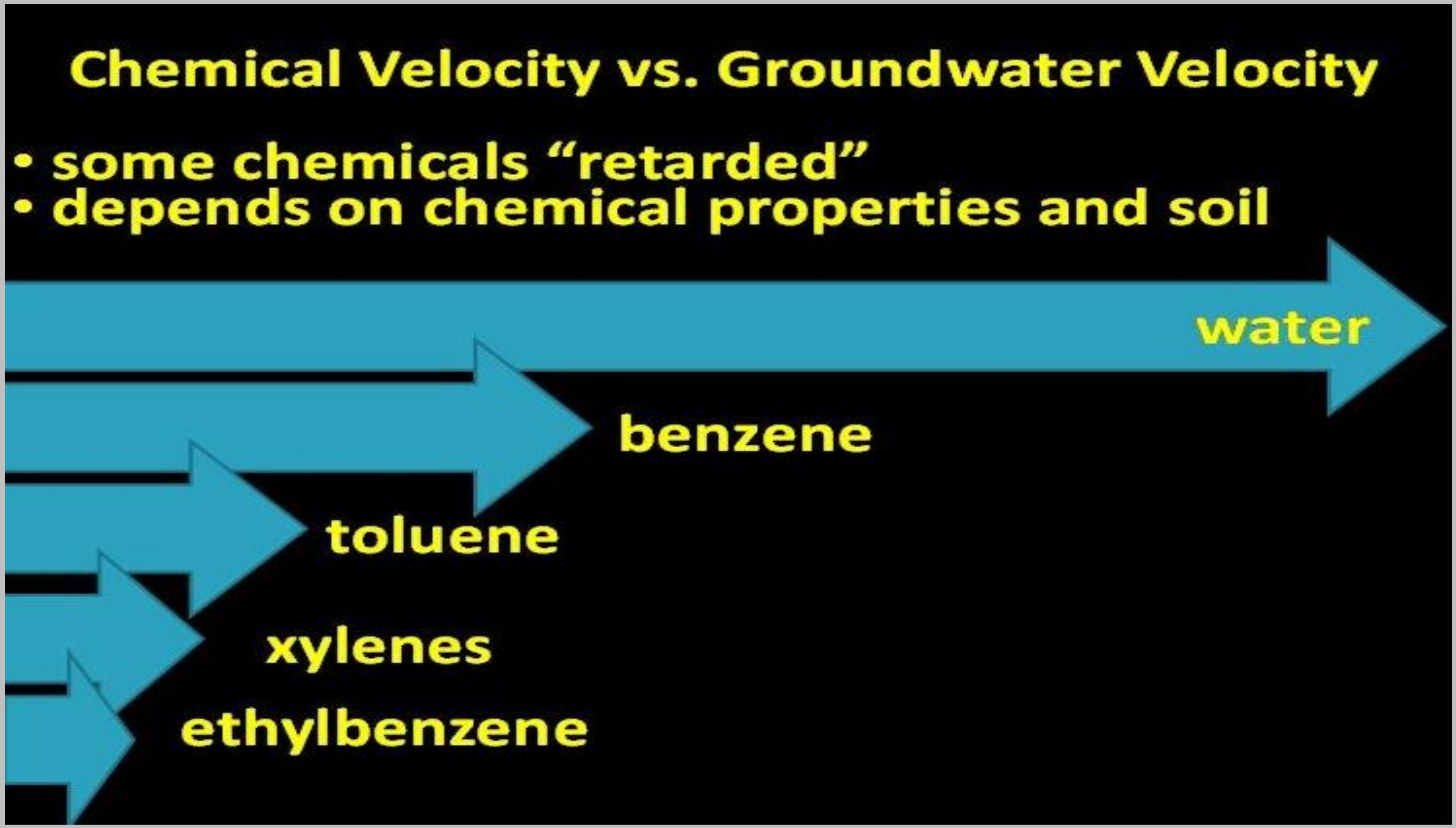
"Retardation" of organic chemicals



Mini Case Study

Re-characterization and transport modeling, minimal monitoring, limited soil remediation, and … closure

… from …

Proposed pump and treat remediation for TCE - forever and potential litigation

Concluding Thoughts

Thorough Site Characterization Is Essential For Remediation Success!

1. Understand the hydrogeology
2. Understand the distribution of chemicals
3. Understand the chemical fate and transport
4. Understand the other constraints…*and then…*
5. Select the best remedial option to meet goals

Questions?