Role of Hydrogeology in Professional Environmental Projects

Outline

- Introductions
- Geology, Hydrogeology, Hydrology
- Hydrogeology projects
  - Solvent Savers
  - Tucson International Airport
  - Other GW Remediation
- Conclusions
- Discussions

Disclaimer

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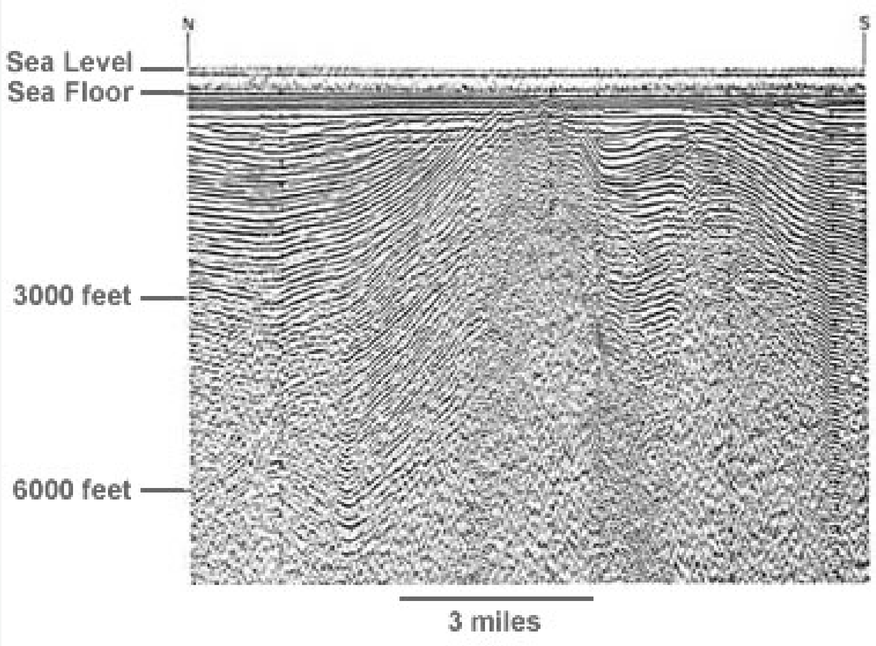
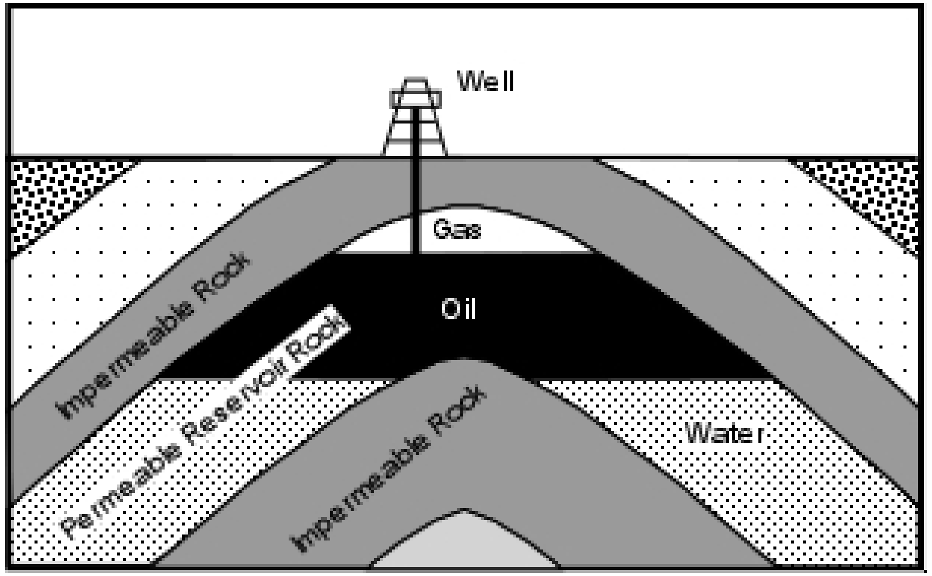
Any mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Introduction

- Michelle Simon
  - BS Chemical Engineering, University of Notre Dame
  - MS Chemical Engineering, Colorado School of Mines
  - PhD Environmental Science, Minor Chemical Engineering, University of Arizona
- Worked in Oil Industry for 10 years
- Went to US EPA in 1990 – Vadose Zone and Groundwater
- Worked on Superfund Site Cleanup until 2010
- Then worked on Stormwater Run-off
- And Surface Water - Groundwater Interaction

Geology

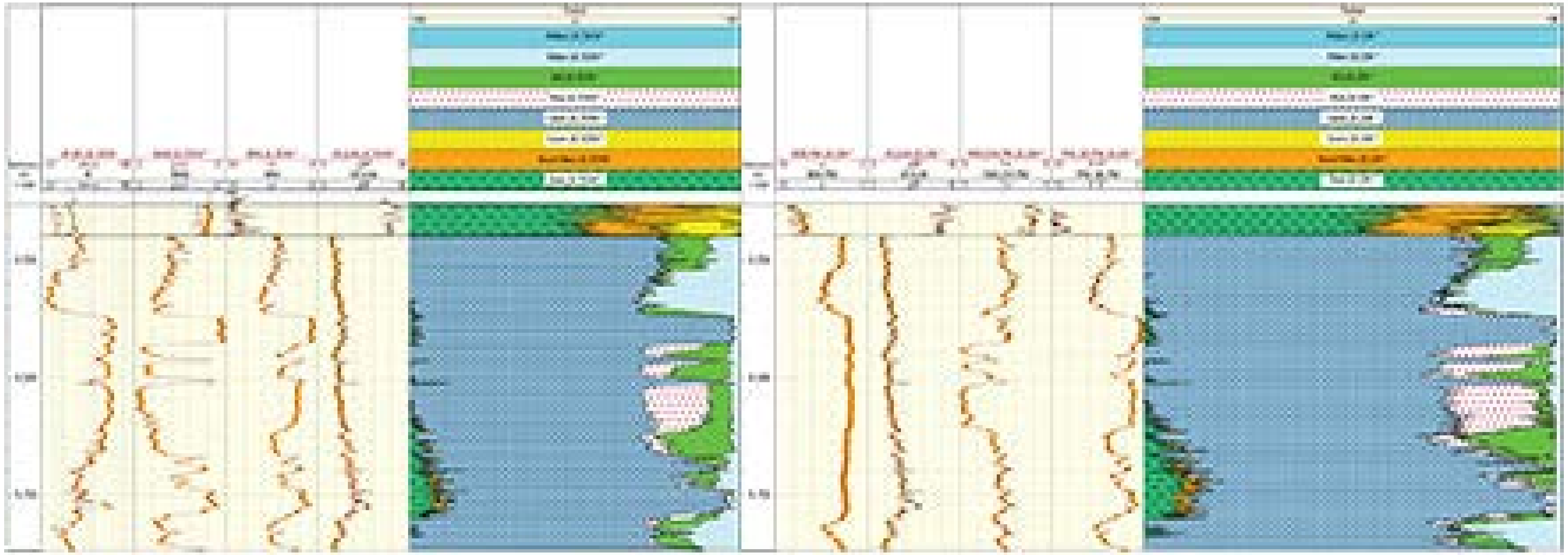




Oil companies need to use geological evaluation techniques to find oil and gas reservoirs, evaluate the transmissivity of reservoir, and calculate the amount of fluid present to determine the economics of recovery

Source: http://earthsci.org/education/teacher/basicgeol/resource/resource.html

Formation Evaluation

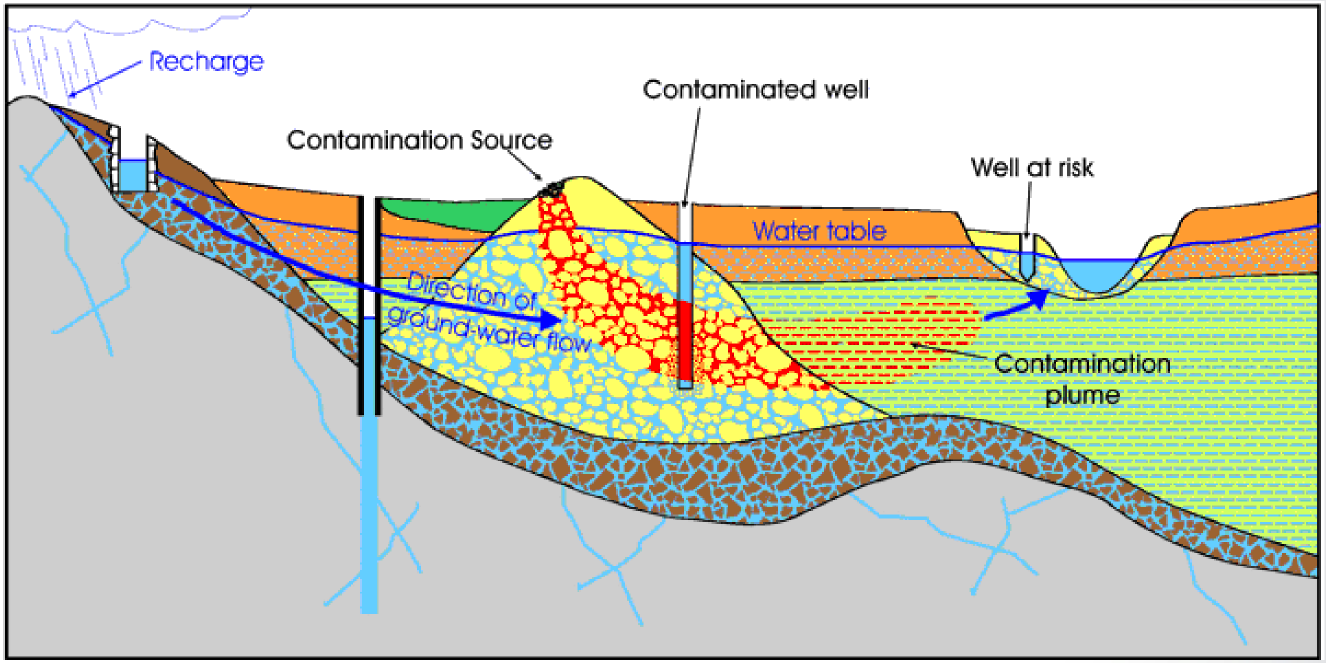


Oil companies developed seismic techniques as well as electronic formation evaluation methods to find water versus oil, oil versus gas. Hydrogeologists can use the same techniques.

Source: http://www.slb.com/resources/publications/industry_articles/evaluation/201606-ep-cased-hole-formation-evaluation.aspx

Hydrogeology

- USEPA Superfund Contaminated Site Remediation – 70 sites
- Same techniques
  - Evaluate formation
    - Transmissivity/conductivity
    - Size
    - Mass of contaminant in place
    - Recoverability
  - Decide Clean-up Goals
  - Remediation strategies



Contaminated Sites Compounds

- Specialized in Volatile Organic Contaminated Sites

- Non-chlorinated – BTEX (Benzene, Toluene, Ethyl-benzene, Xylene)
  - Fuels – gasoline, Jet Propulsion Fuel 4
  - MTBE (Methyl *tert*-butyl ether)

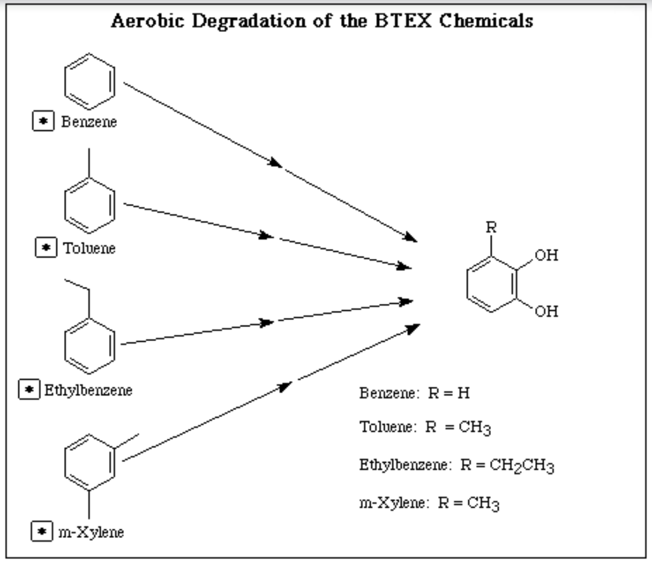
- Chlorinated – PCE, TCE, DCE, VC, ethene, ethane

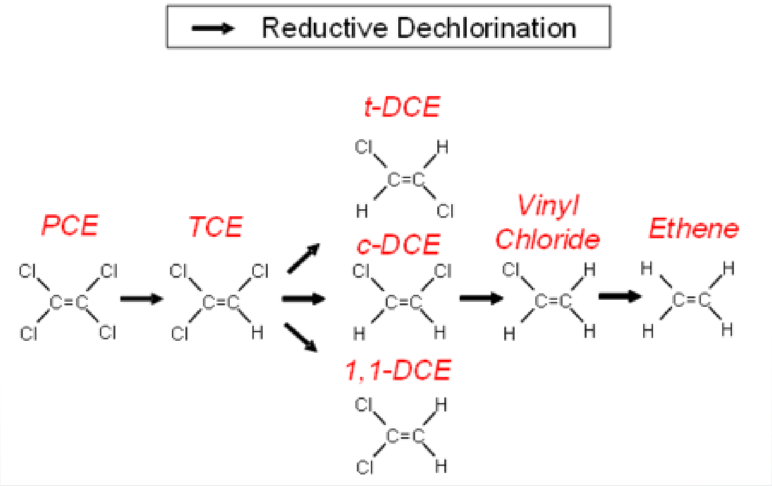
Contaminated Sites Remediation

Destruction\Removal\Containment

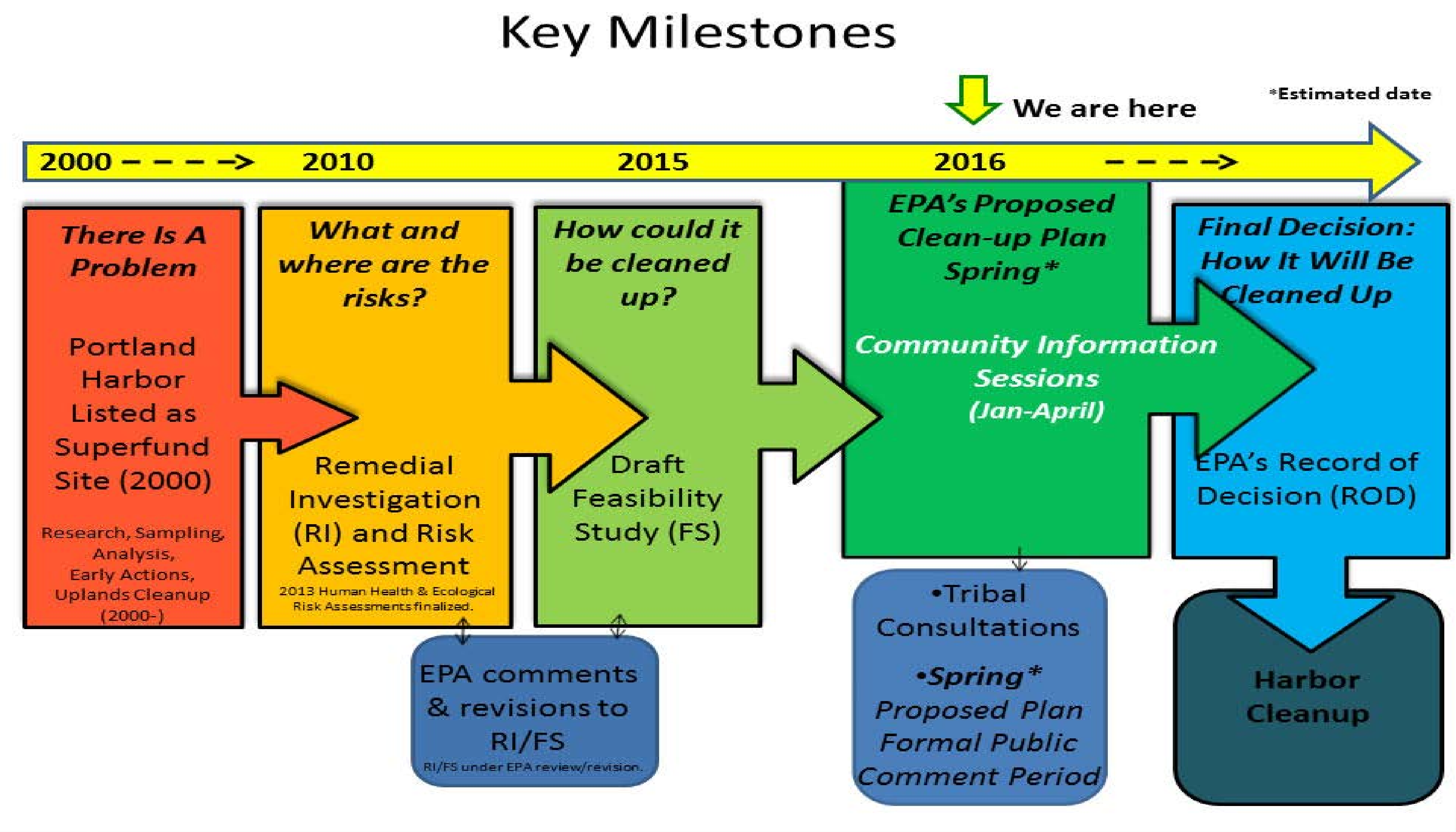
- Non-chlorinated
  - Aerobic Bioaugmentation
  - Biosparging
  - Airsparging

- Chlorinated
  - Anaerobic Bioaugmentation
  - Soil Vapor Extraction
  - In Situ Oxidation



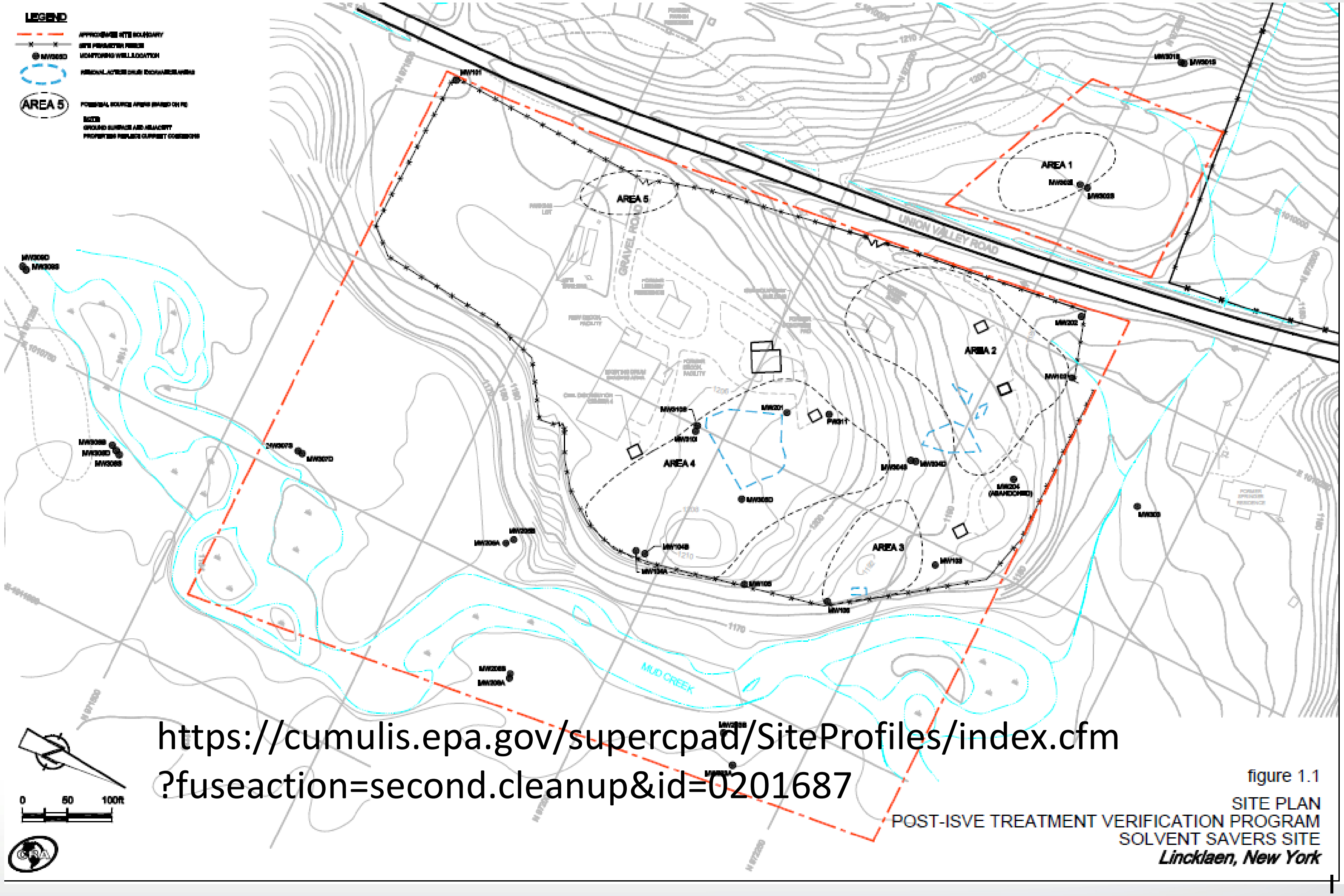


Superfund Process



Site Investigation

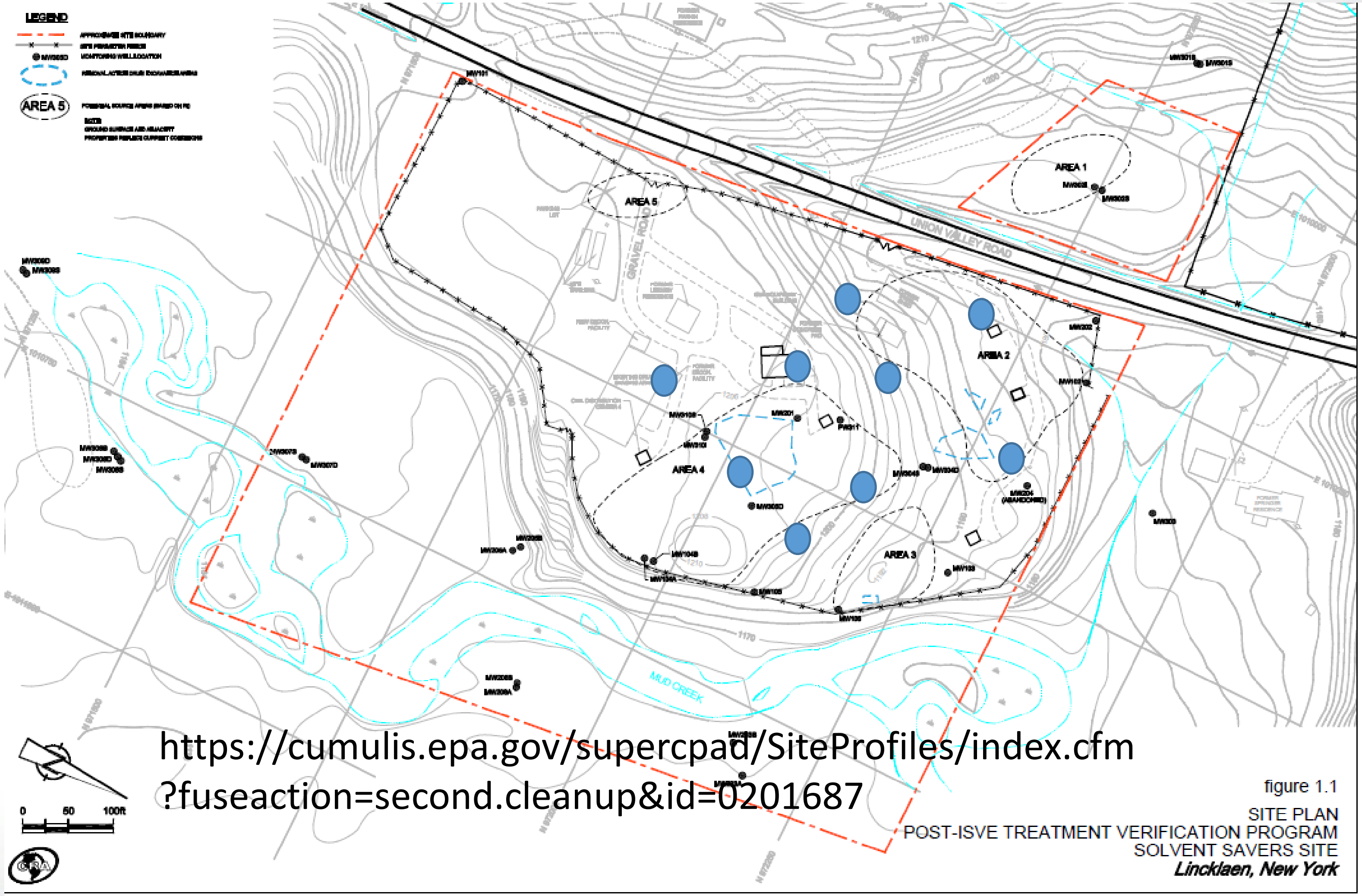
New York State
Solvent Recycling Facility



https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.cleanup&id=0201687

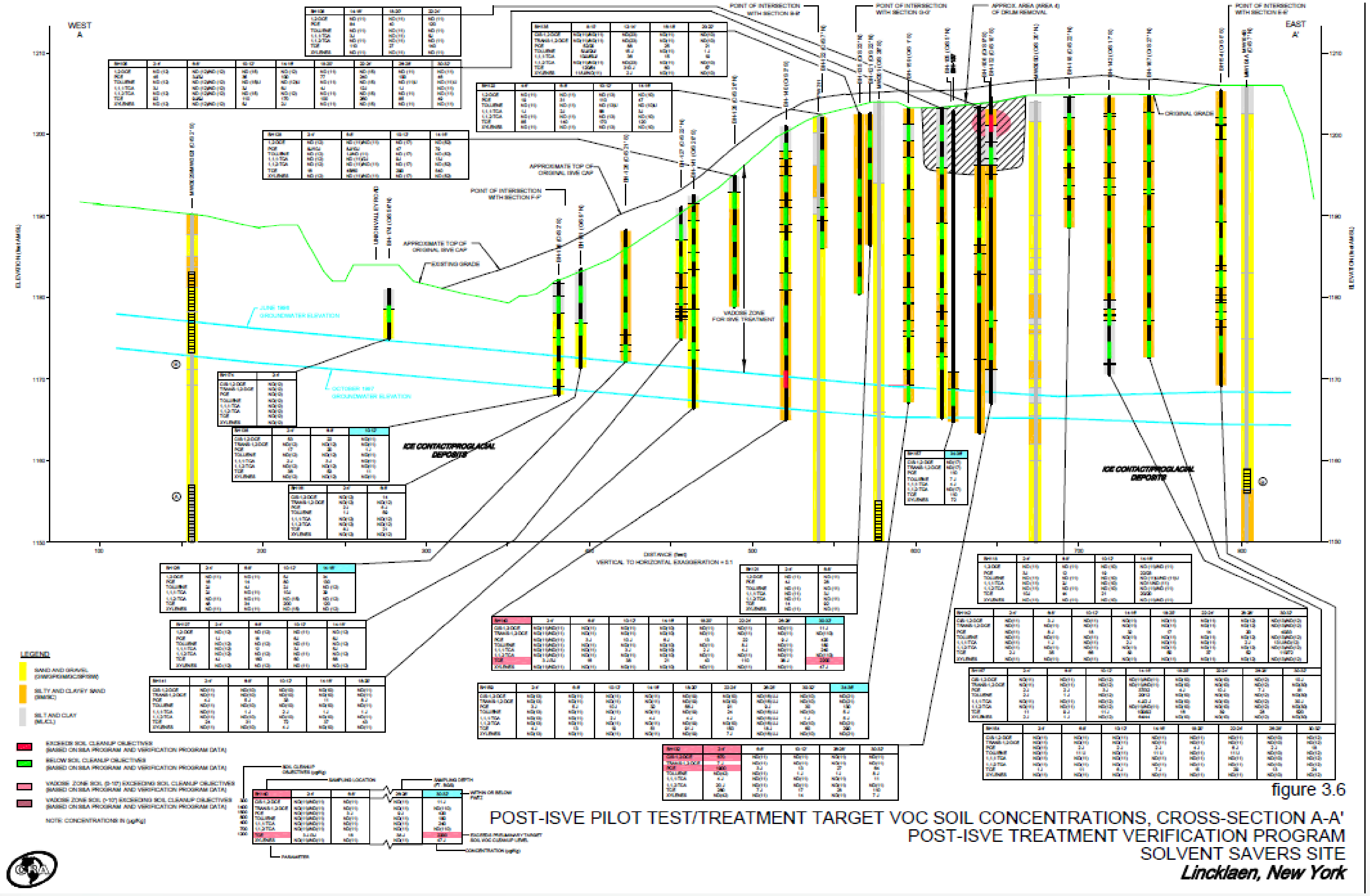
Install Wells

New York State
Solvent Recycling Facility

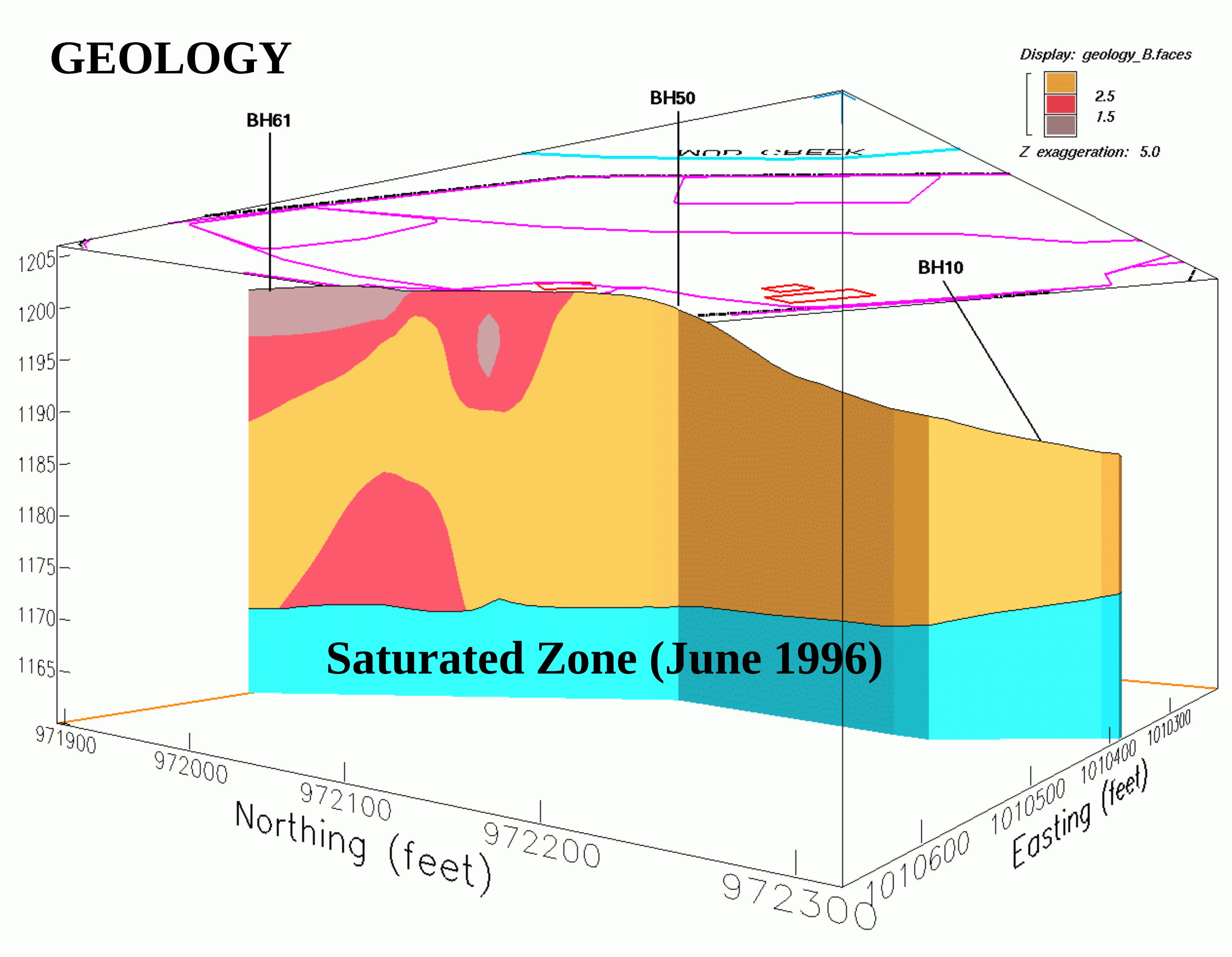


https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.cleanup&id=0201687

Characterize Geology



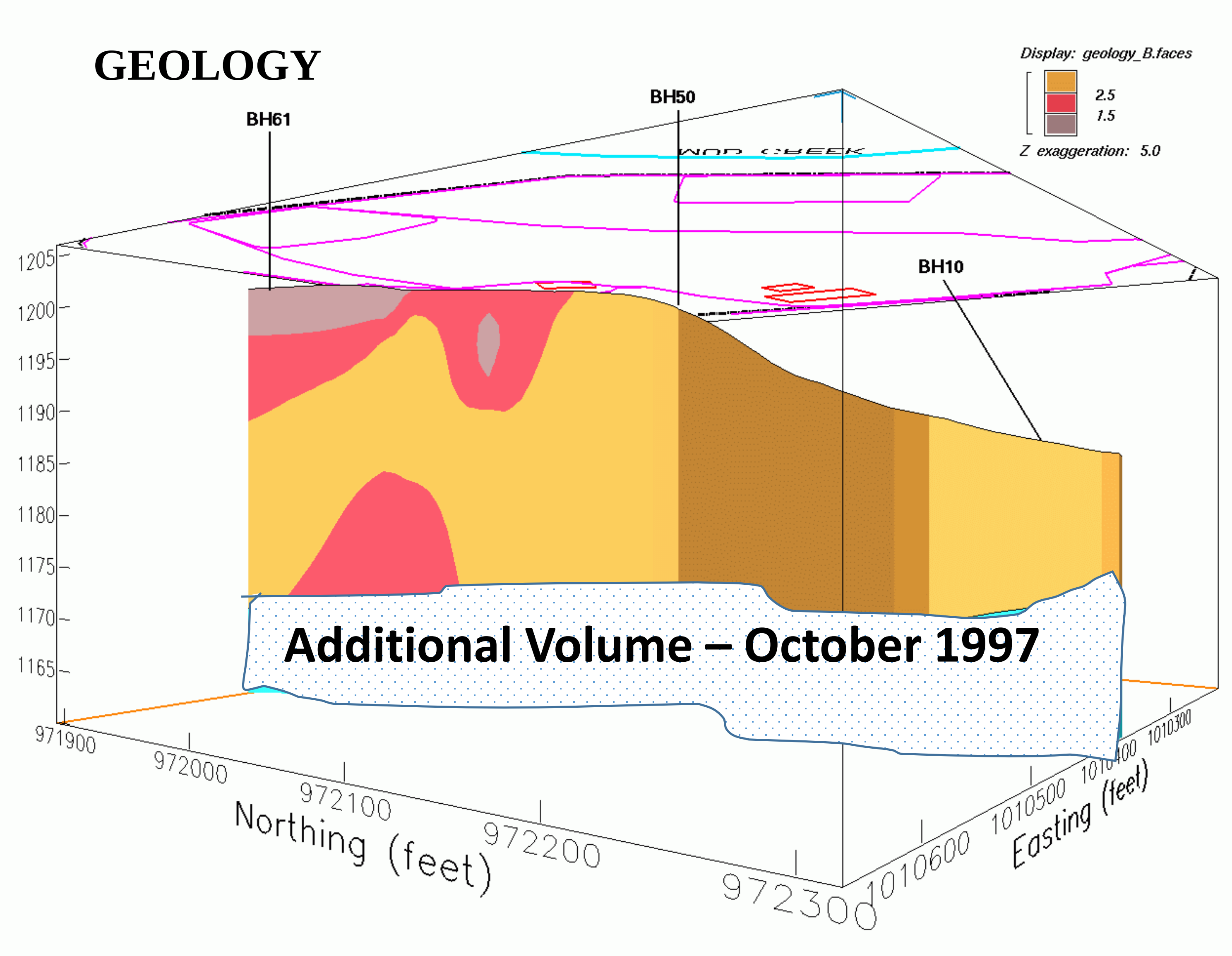
Calculate Vadose Zone Characteristics



Calculate Vadose Zone Volume

- Conductivity
- Extent
- Porosity
- Depth to Water

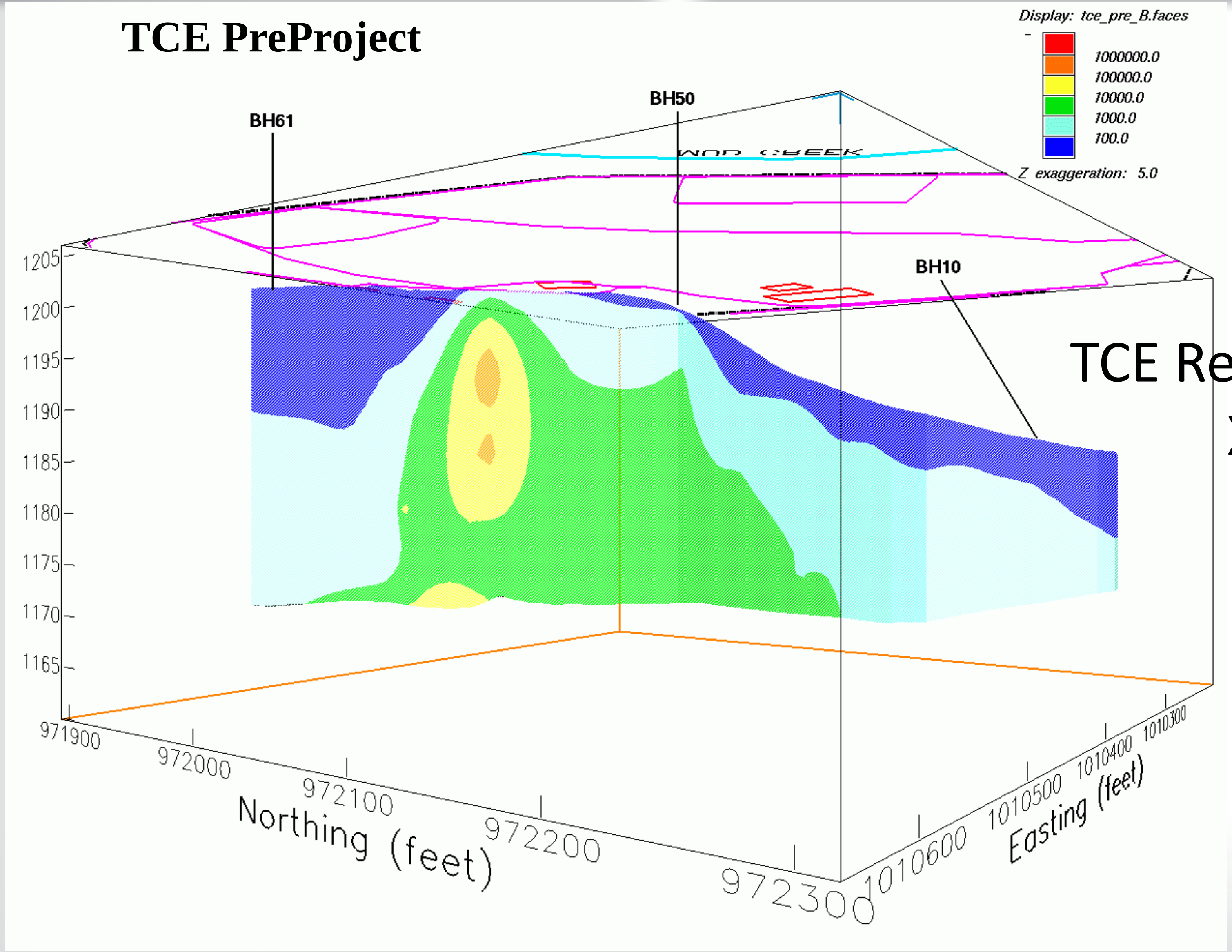
Calculate Vadose Zone Characteristics



Which can change with time

- Water Level dropped

Calculated Contaminant Mass in Place

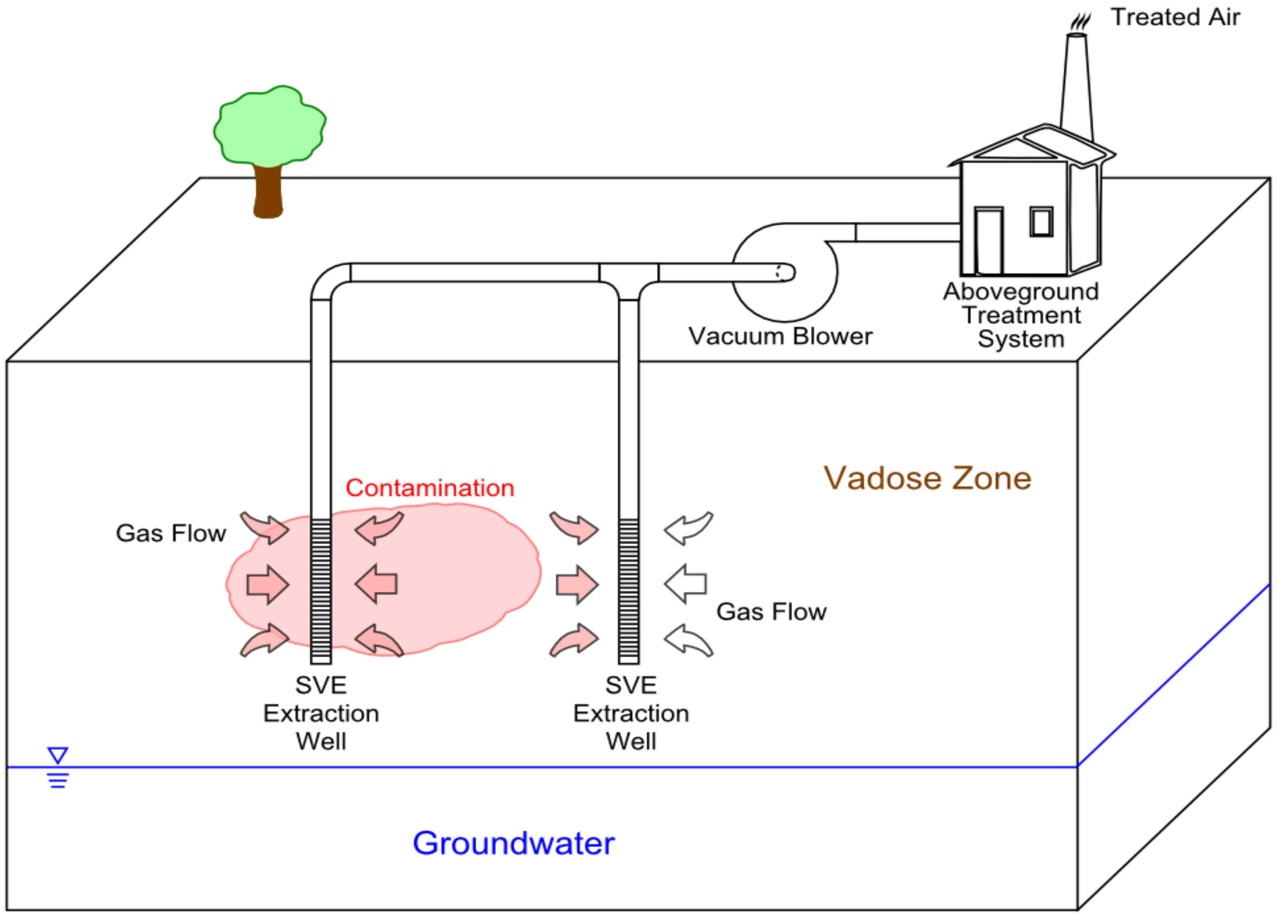


TCE Representative Concentrations

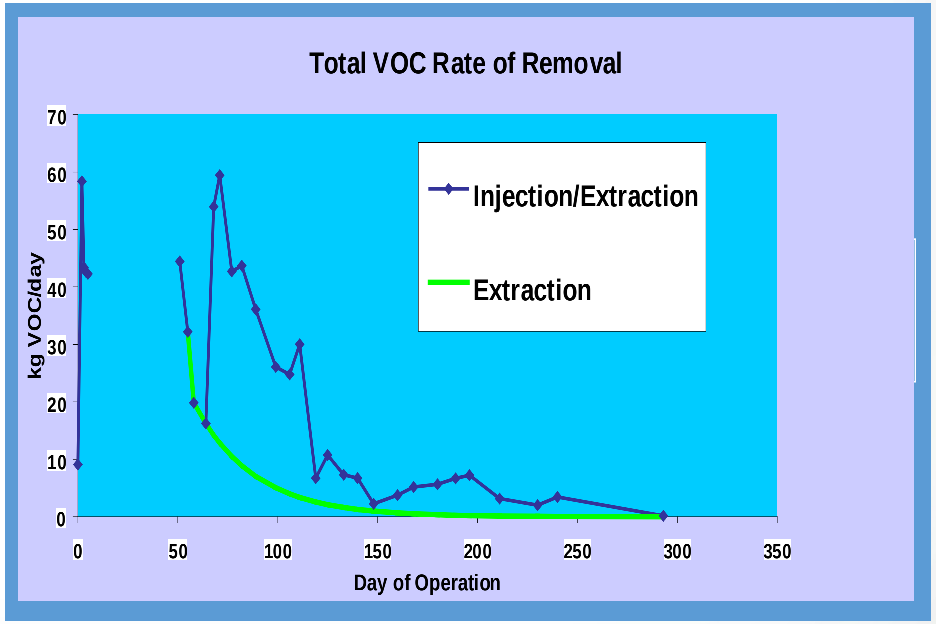
X Subvolumes

= TCE Initial Mass in Place

VOC Remediation Soil Vapor Extraction

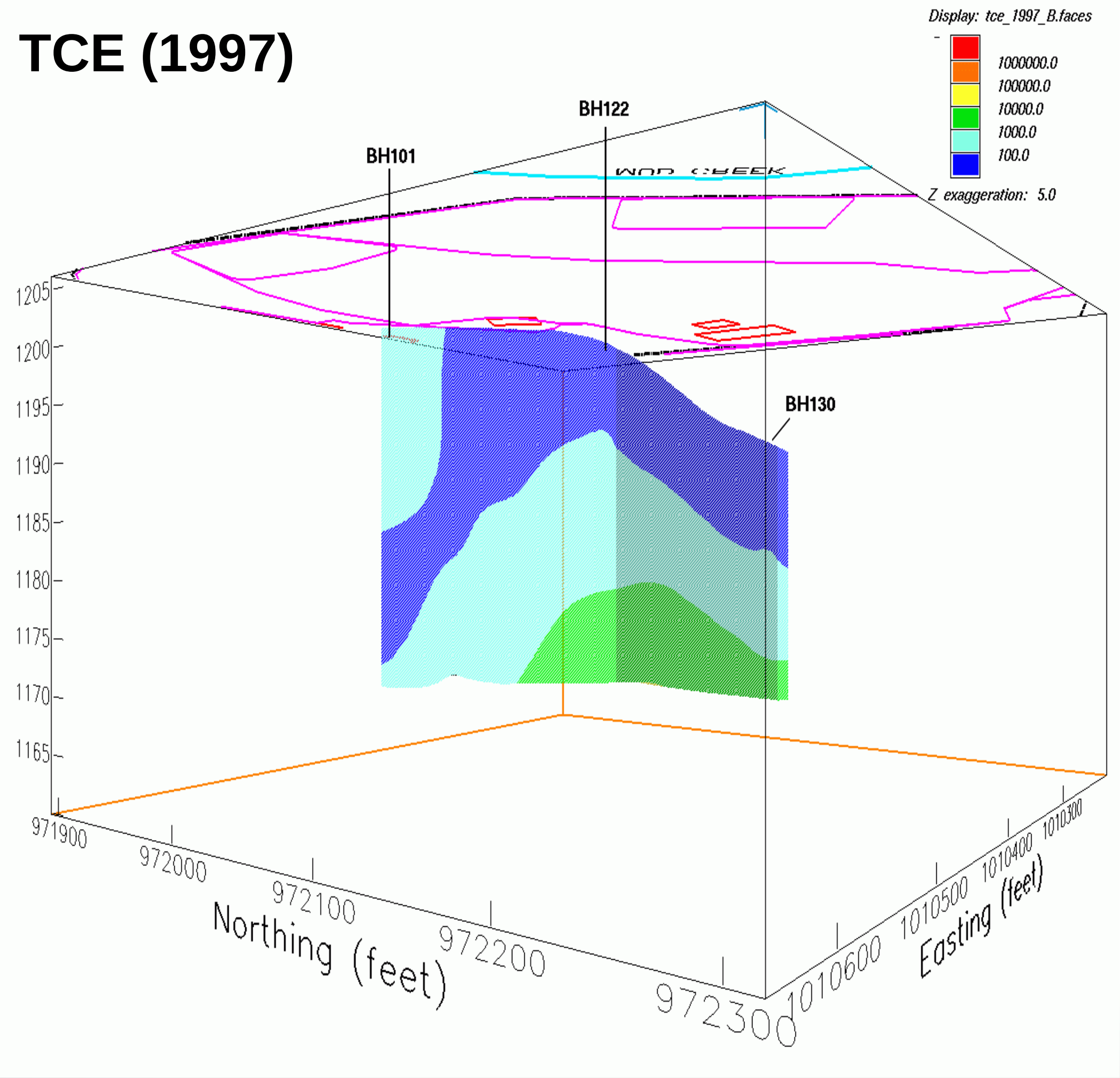


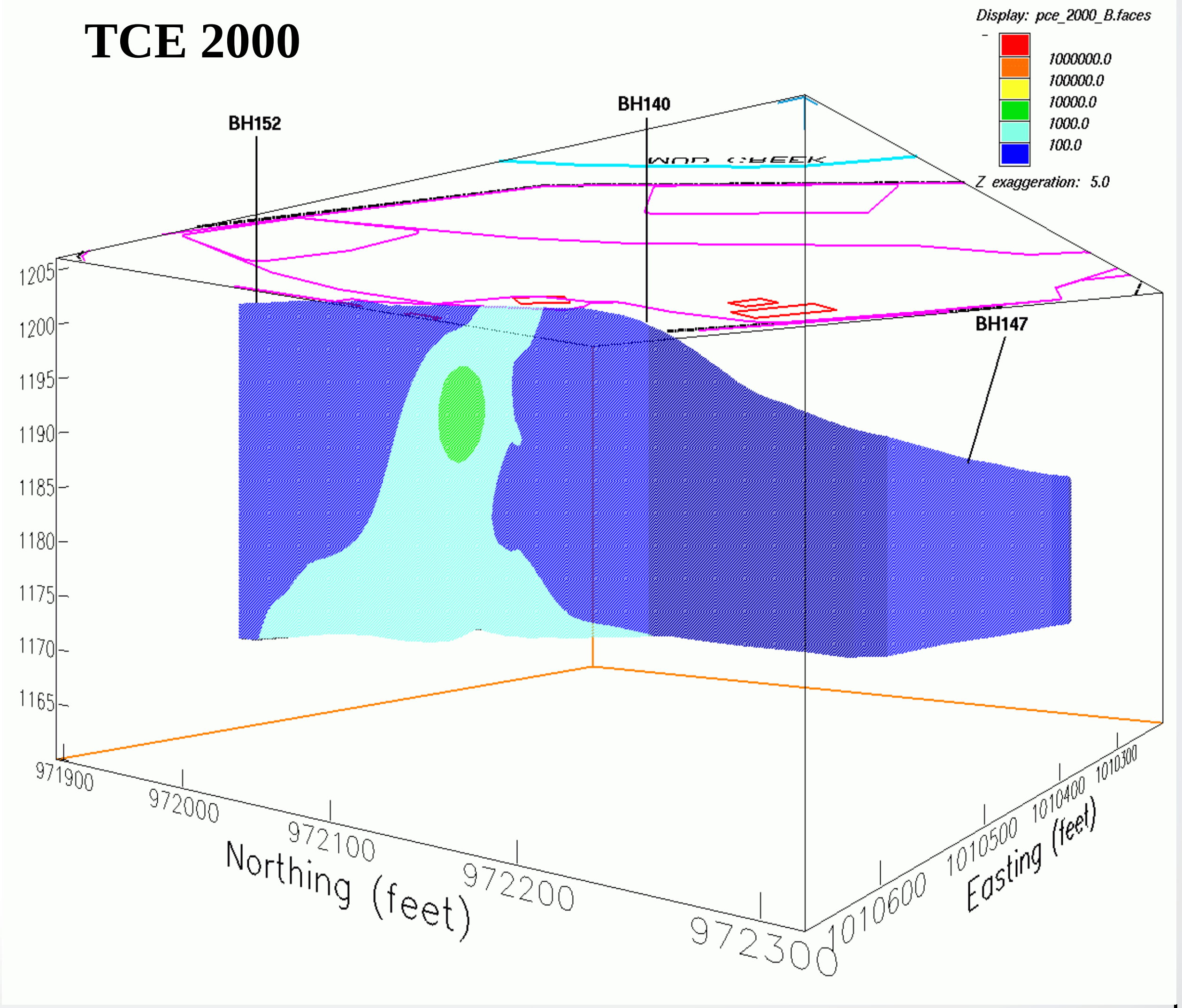
Removes VOCs before they get to the groundwater



http://www.pnl.gov/main/publications/external/technical_reports/PNNL-21843.pdf

VOC Contaminant Removal with Time

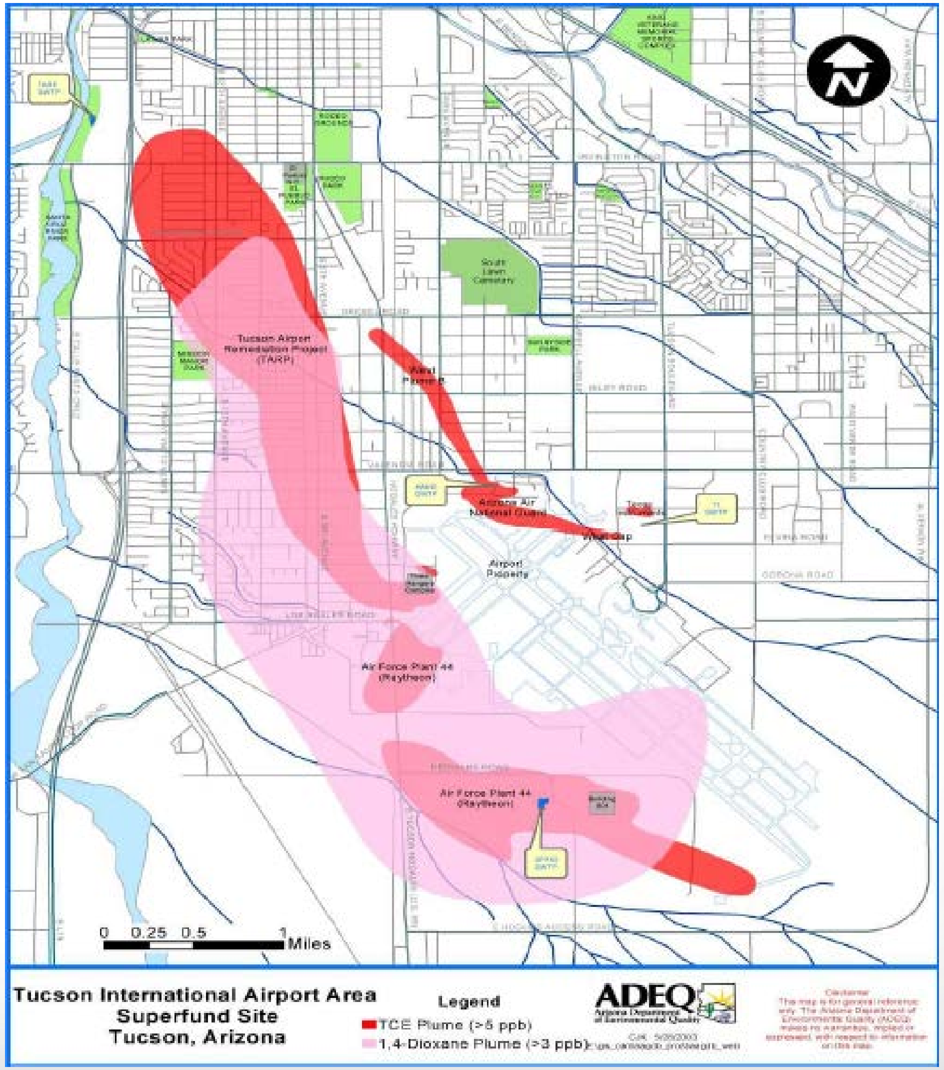




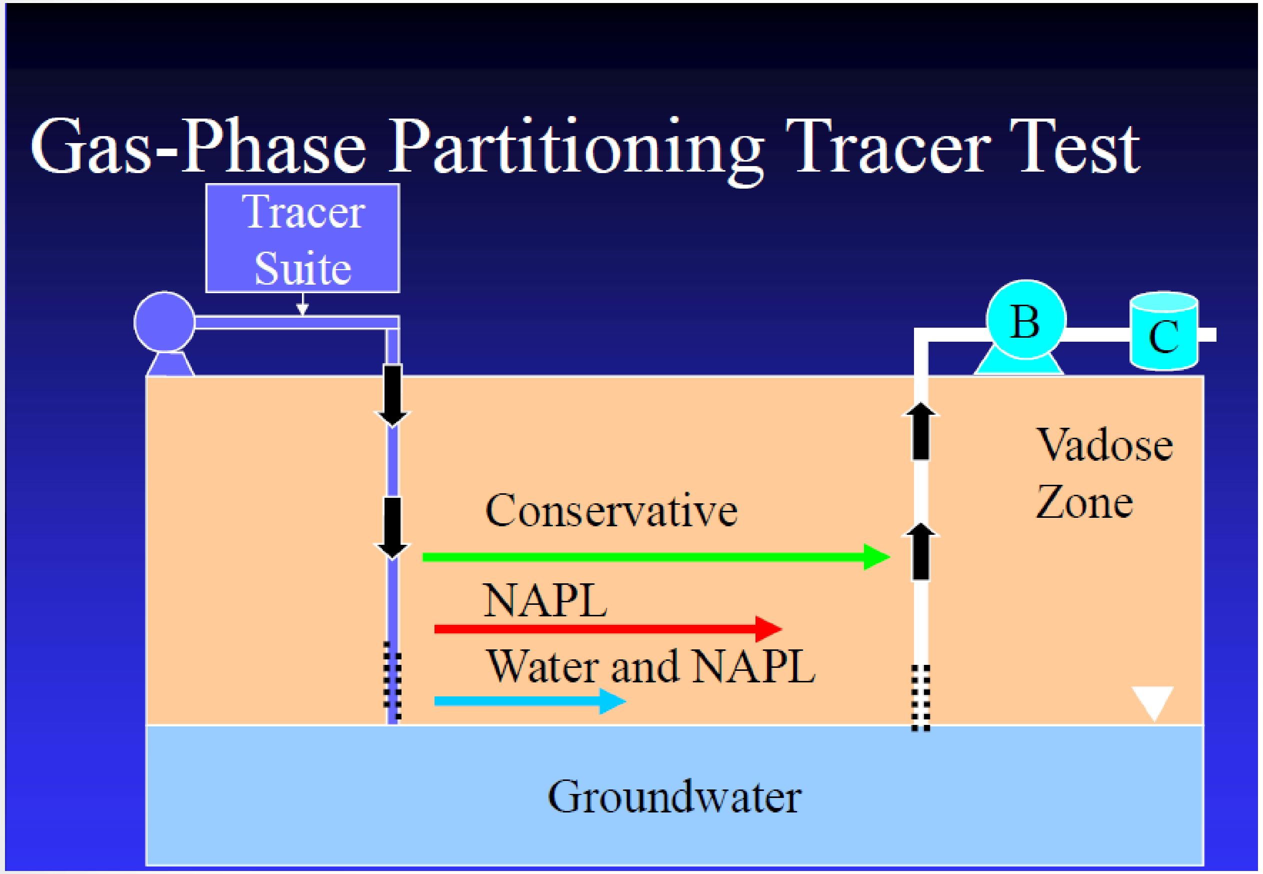
But when do you stop remediating?

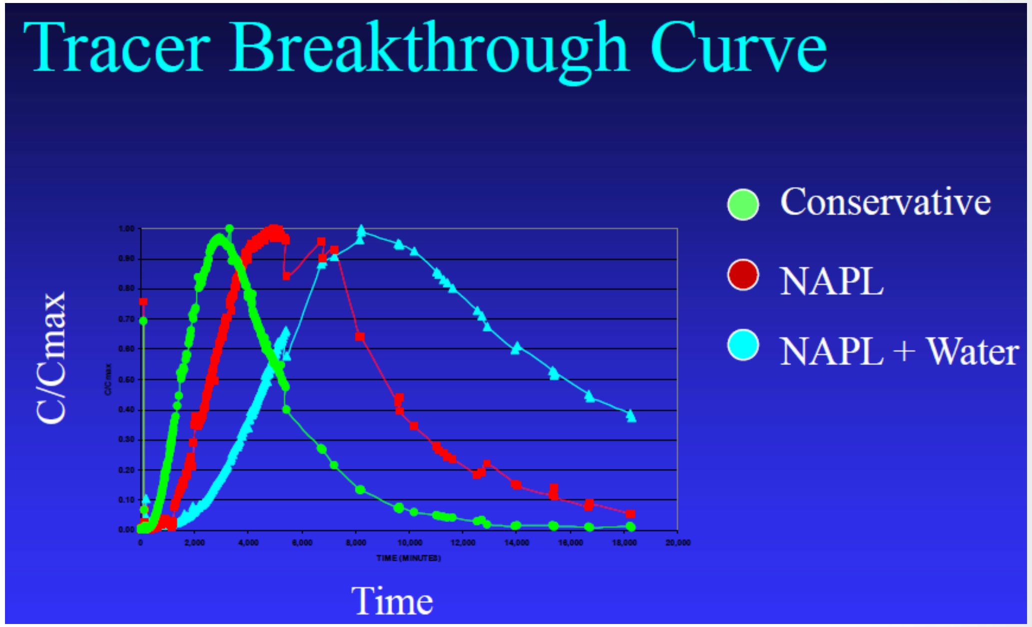
Vadose Zone Clean-up goals depend on infiltrating water's impact on underlying groundwater

Another project

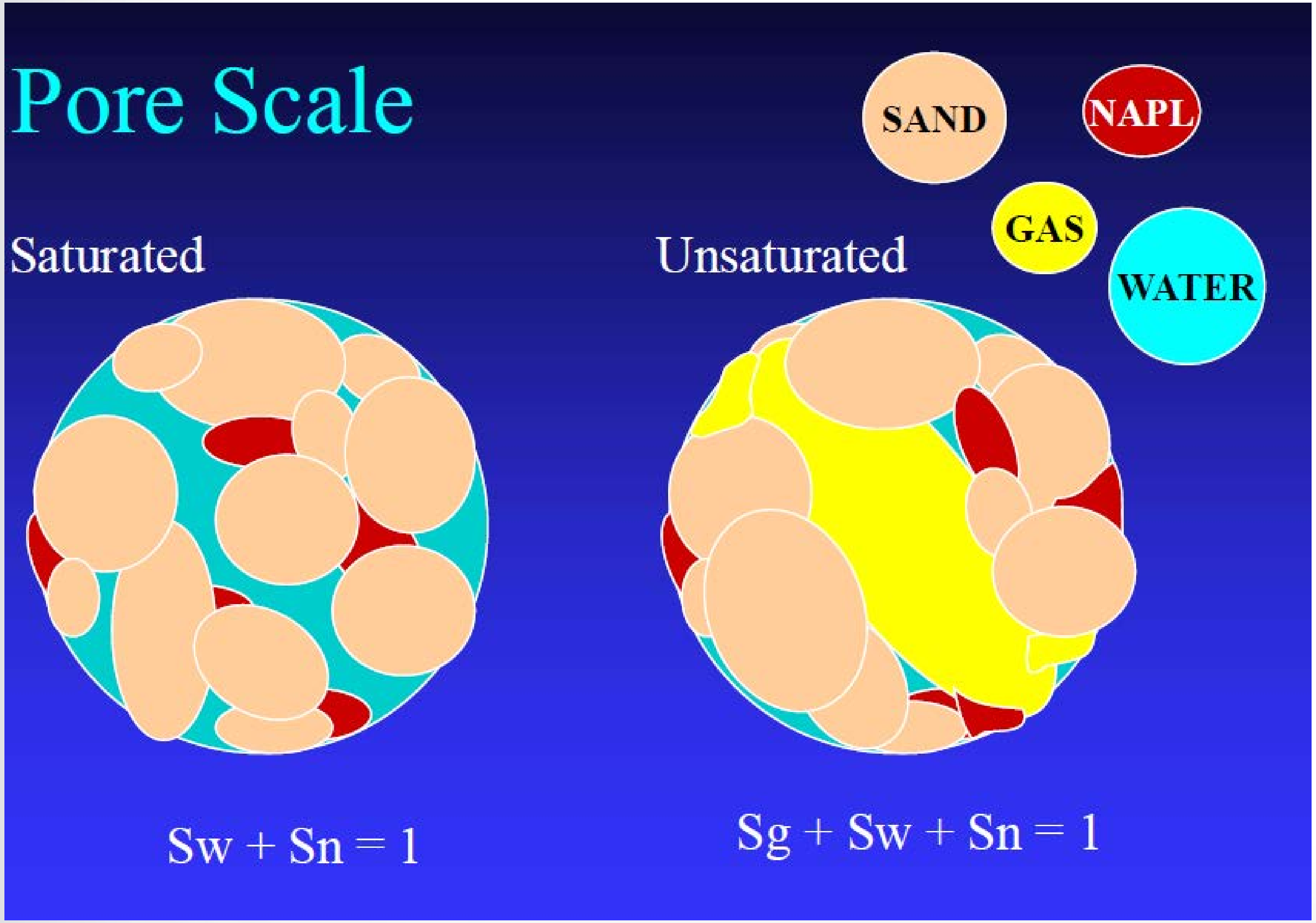


Vadose Mass in Place



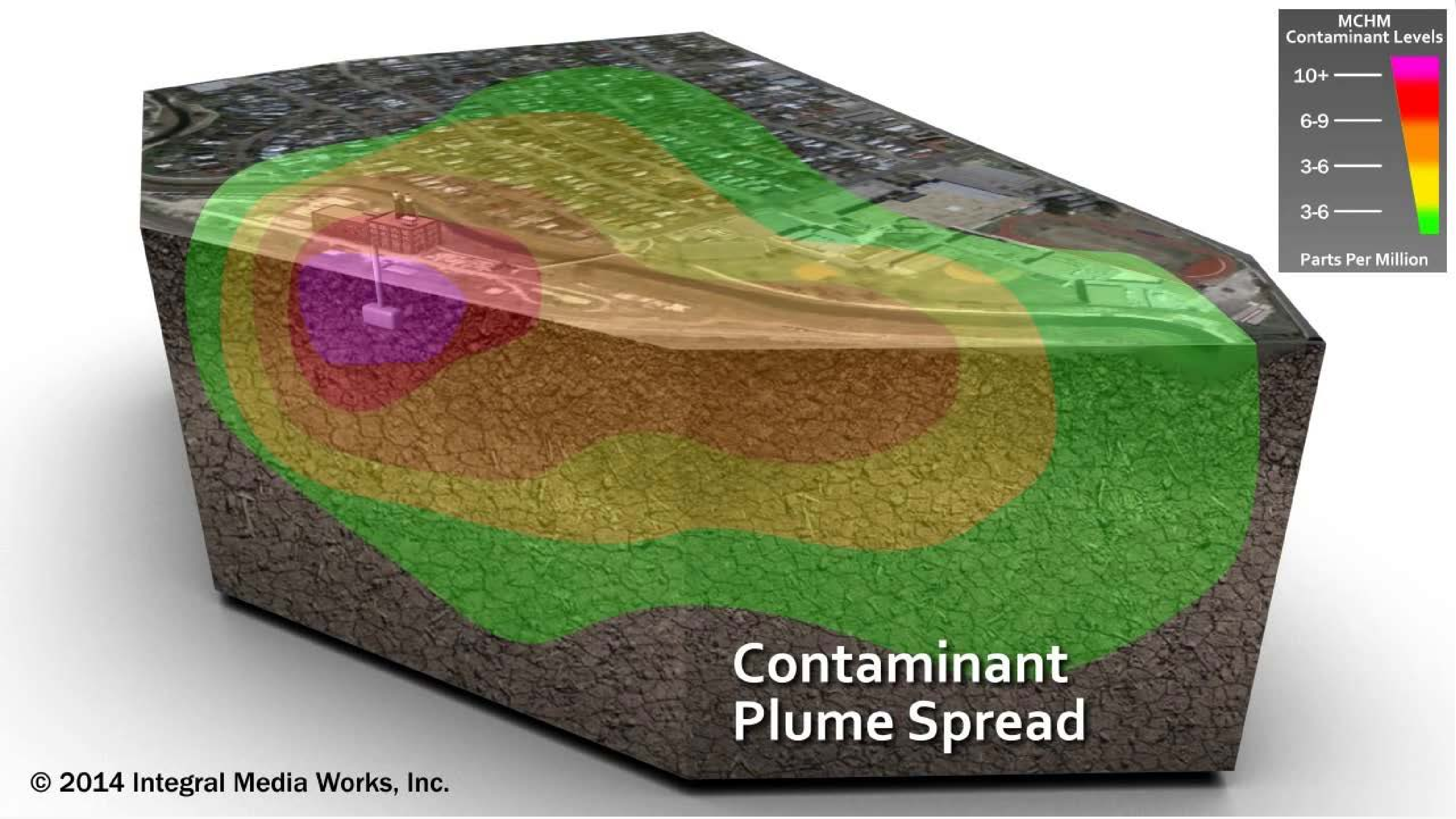


Partitioning Tracer



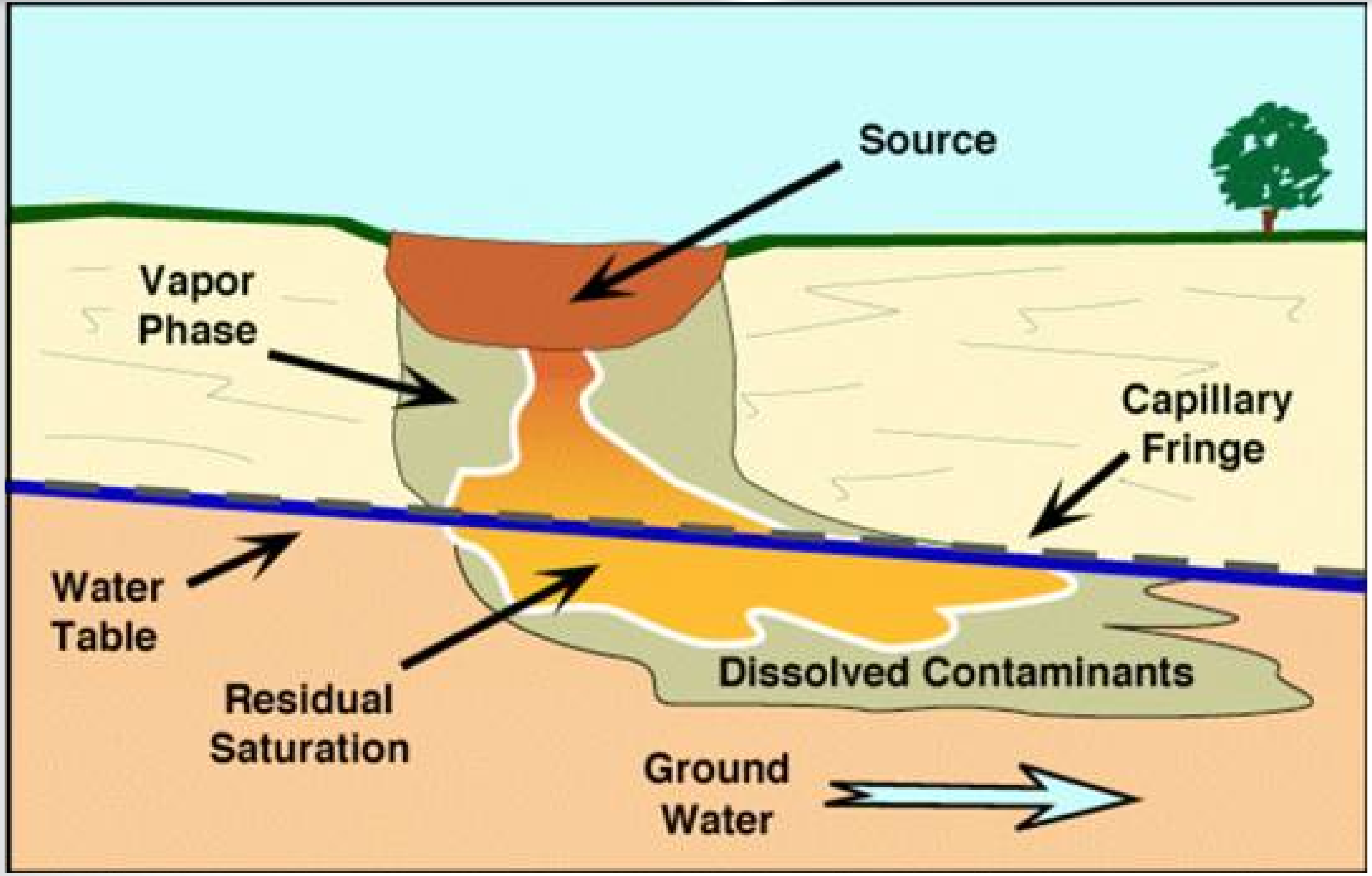
Assessing remaining contaminant mass in the vadose zone

Contaminant Groundwater Movement



https://www.youtube.com/watch?v=Tv8imh0_bn4

Calculating GW Impacts from Infiltrating Water



Infiltrating Water Hydrology

- Richards Equation
- Green and Ampt
- Horton
- Others

Water carries contaminants

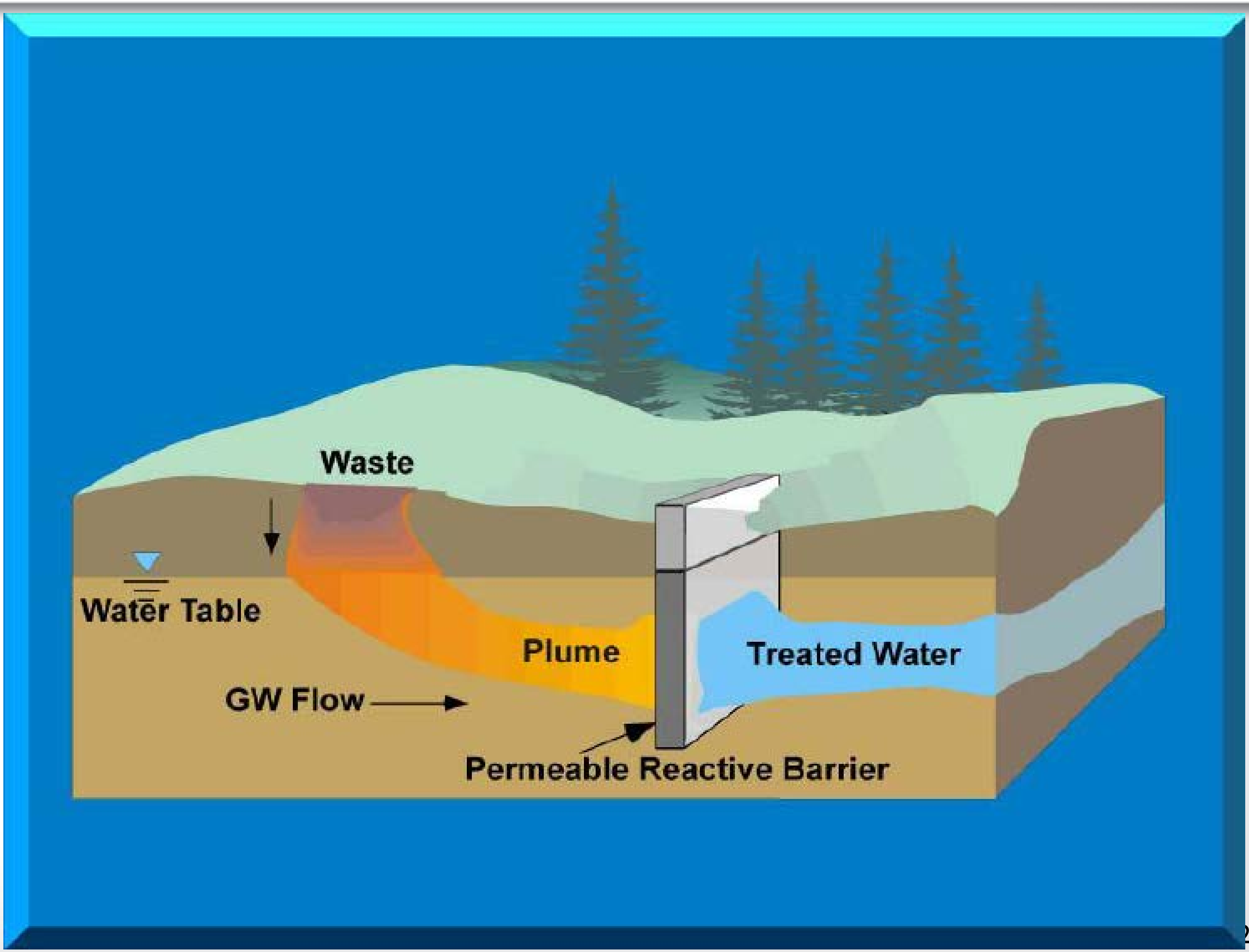
- Dissolved/Advection
- Diffusion

https://www.google.com/search?q=groundwater+contamination+plume&tbm=isch&source=iu&ictx=1&fir=HGq2UmwaiKNPgM%253A%252C-2eoCXo2YflJoM%252C_&usg=__eSQaEk3loL8rG3dPz3ZFDPHCw6E%3D&sa=X&ved=0ahUKEwjc246m5N_XAhWlIOAKHQ1xBXgQ9QEISDAD#imgdii=8dyd2S3zDM1MOM:&imgrc=4hHC9aug03lZPM:

Ground Water Treatments

Reactive Barriers

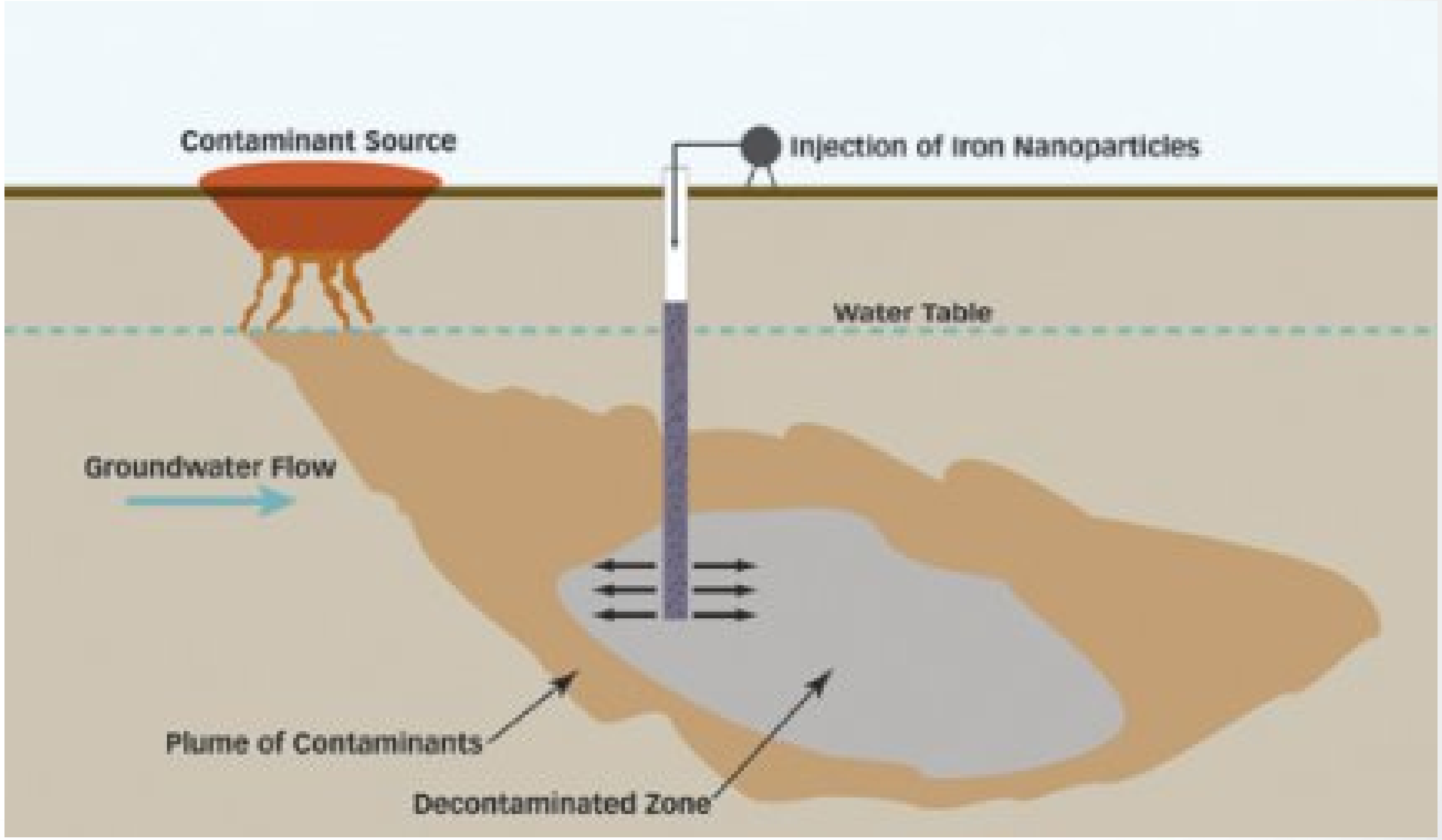
https://www.google.com/search?q=reactive+barrier+figures&tbm=isch&source=iu&ictx=1&fir=tC_kNR2uLBtgrM%253A%252ChpMoJRs-vjMKuM%252C_&usg=__Bhyj1owDbOWQG7ZkOgyZBFoYgg0%3D&sa=X&ved=0ahUKEwjeiKqNw-HXAhVPct8KHW8QAwcQ9QEITzAH#imgrc=tC_kNR2uLBtgrM:



In Situ Destruction

Inject
Bioremediation
- Oxygen
- Nutrients

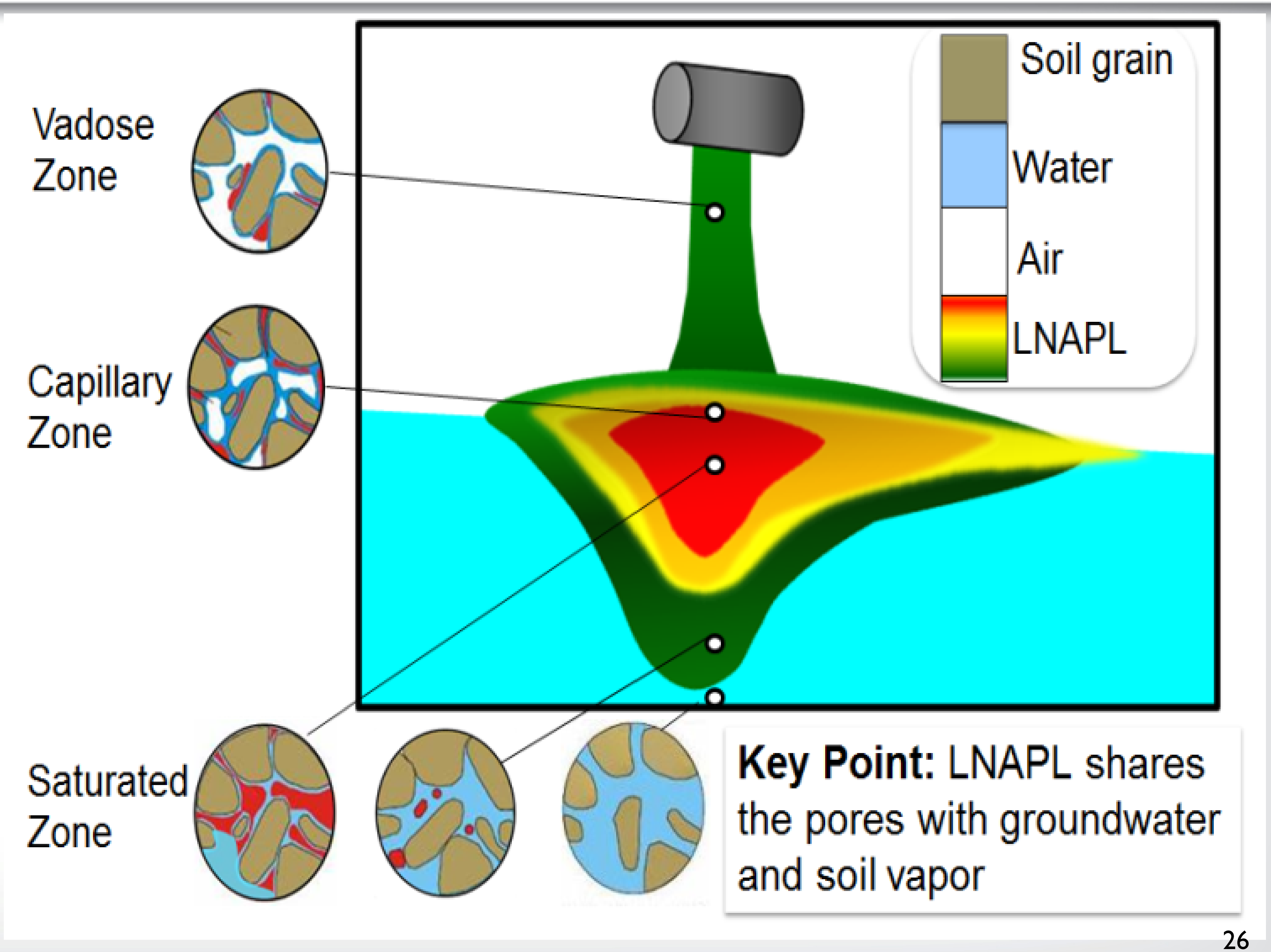
Chemical Oxidation
- Zero Valent Iron
- Permanganate
- Peroxide



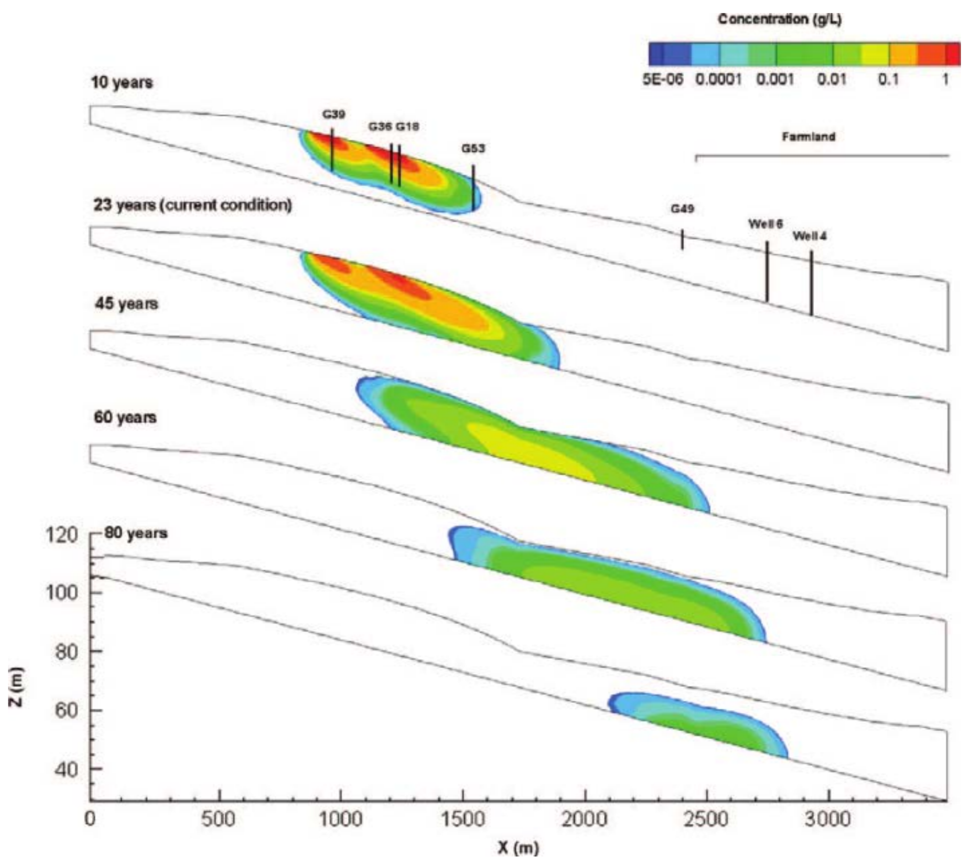
LNAPLs in the subsurface

LNAPL – Light Non-Aqueous Phase Liquid

https://www.google.com/search?q=lnapl+figures&tbm=isch&tbo=u&source=univ&sa=X&ved=0ahUKEwjK68CiyuHXAhVMMd8KHSFvBT0Q7AkIVw&biw=1280&bih=918#imgdii=p6xYhUOqol4dDM:&imgrc=PBOhil7Kri5sfM:

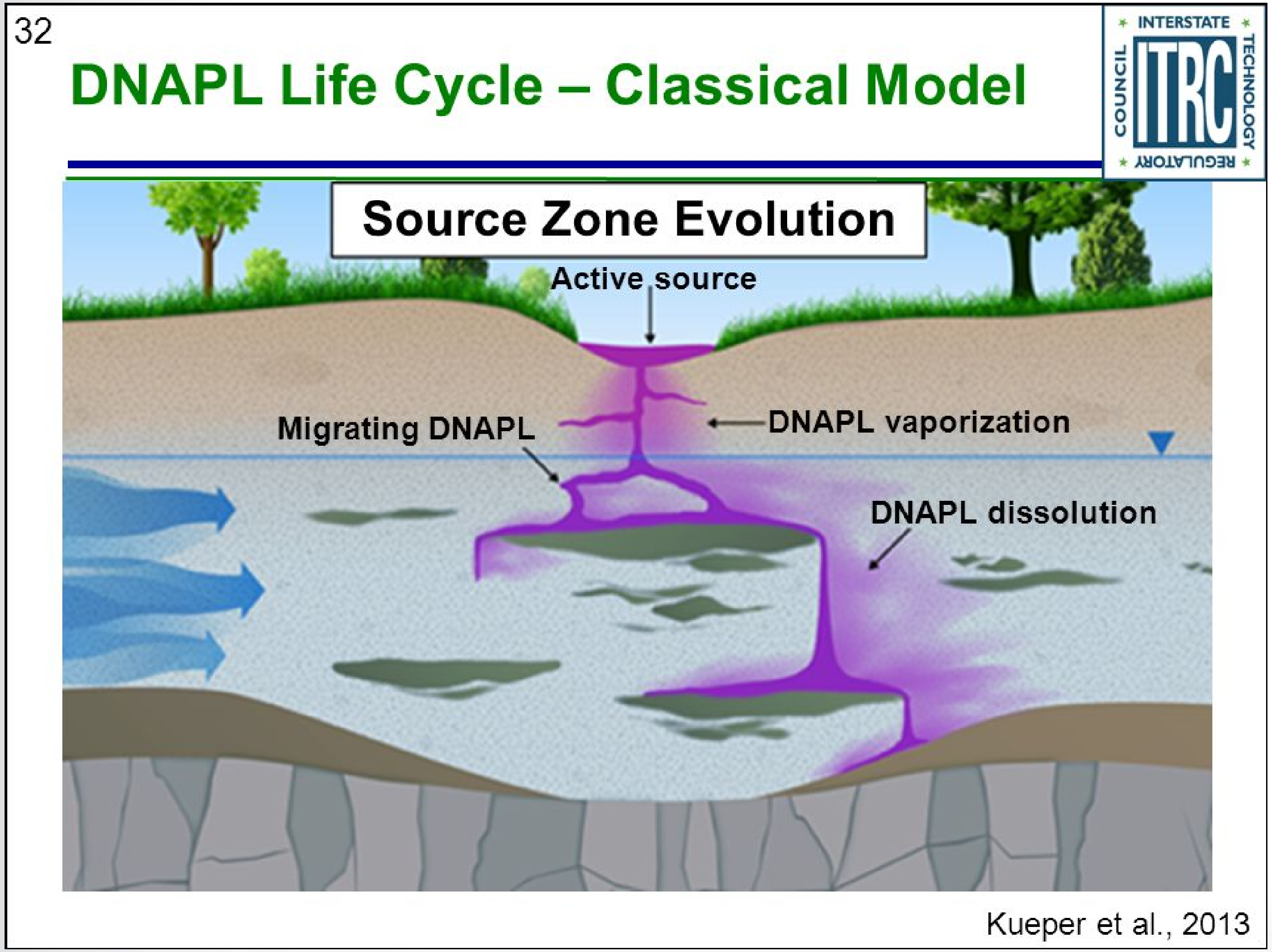


LNAPL in the Subsurface with Time



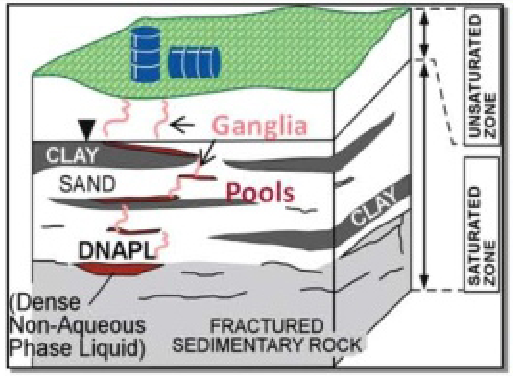
https://www.google.com/search?q=lnapl+figures&tbm=isch&tbo=u&source=univ&sa=X&ved=0ahUKEwjK68C iyuHXAhVMMd8KHSFvBT0Q7AkIVw&biw=1280&bih=918#imgrc=Q9S7pGqFlucFEM:

DNAPLs in the Subsurface



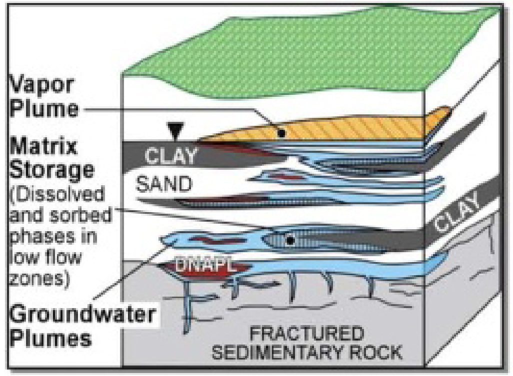
DNAPL – Dense Non-Aqueous Phase Liquid

DNAPLS in the Subsurface with time



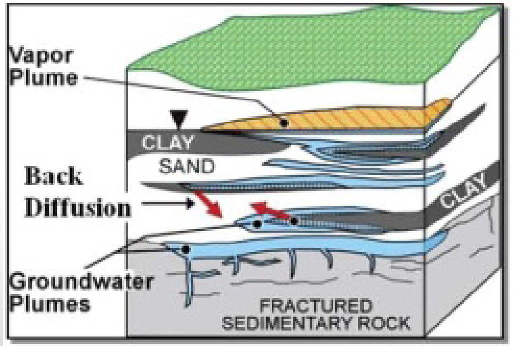
EARLY SOURCES

Relatively low Pool Fraction
Ganglia prevalent, pools at interfaces
Nascent vapor / groundwater plumes
Little matrix diffusion
VOCs in DNAPL and sorbed phases
VOCs primarily in transmissive zones



MATURE SOURCES

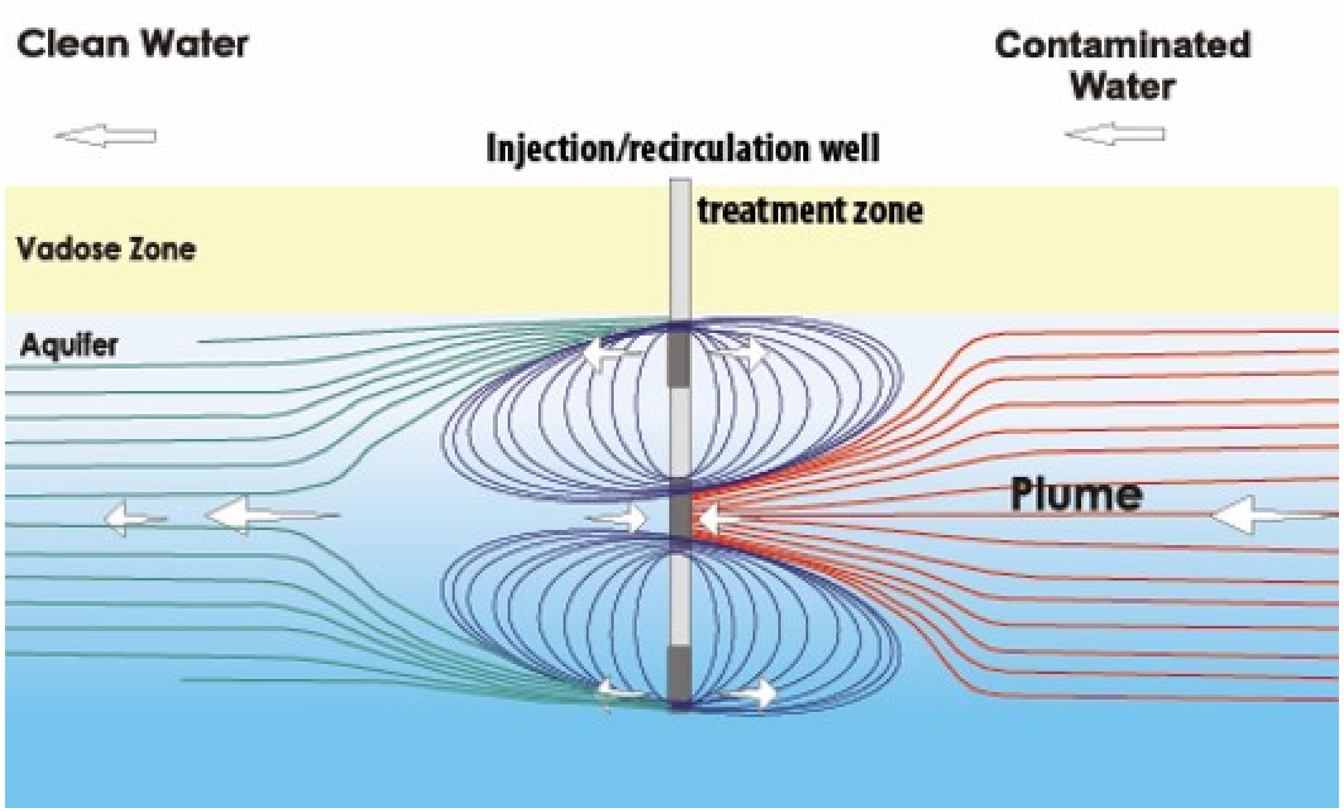
Pool Fraction increases
Ganglia preferentially depleted
Pools partly depleted, leaving ganglia
Mass discharge plateaus
Matrix diffusion in source and plume



AGED/TREATED SOURCES

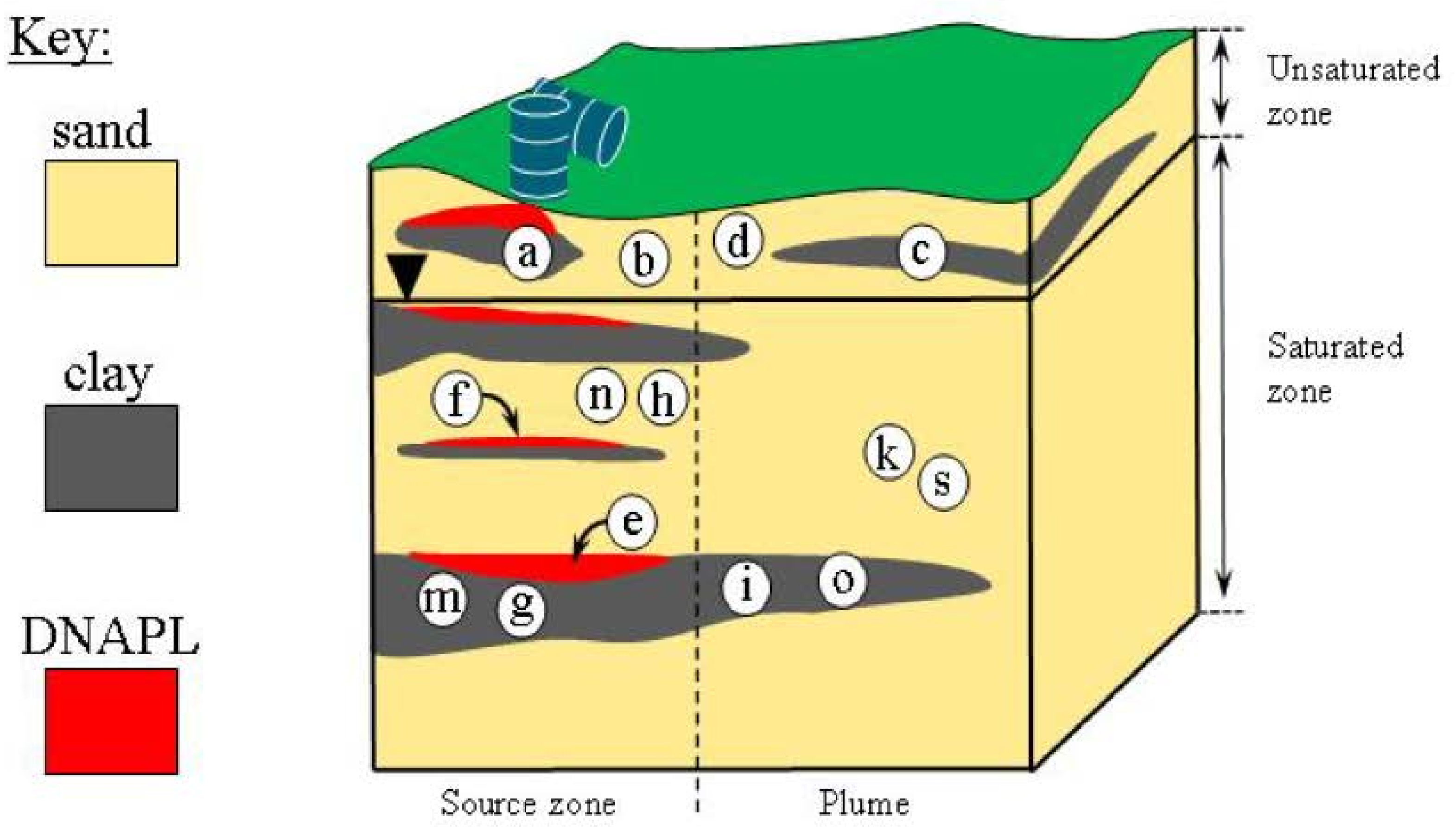
Little to no DNAPL remains
Mass discharge greatly reduced
Low VOCs in transmissive zones
Back diffusion / desorption continue

Injection\Extraction



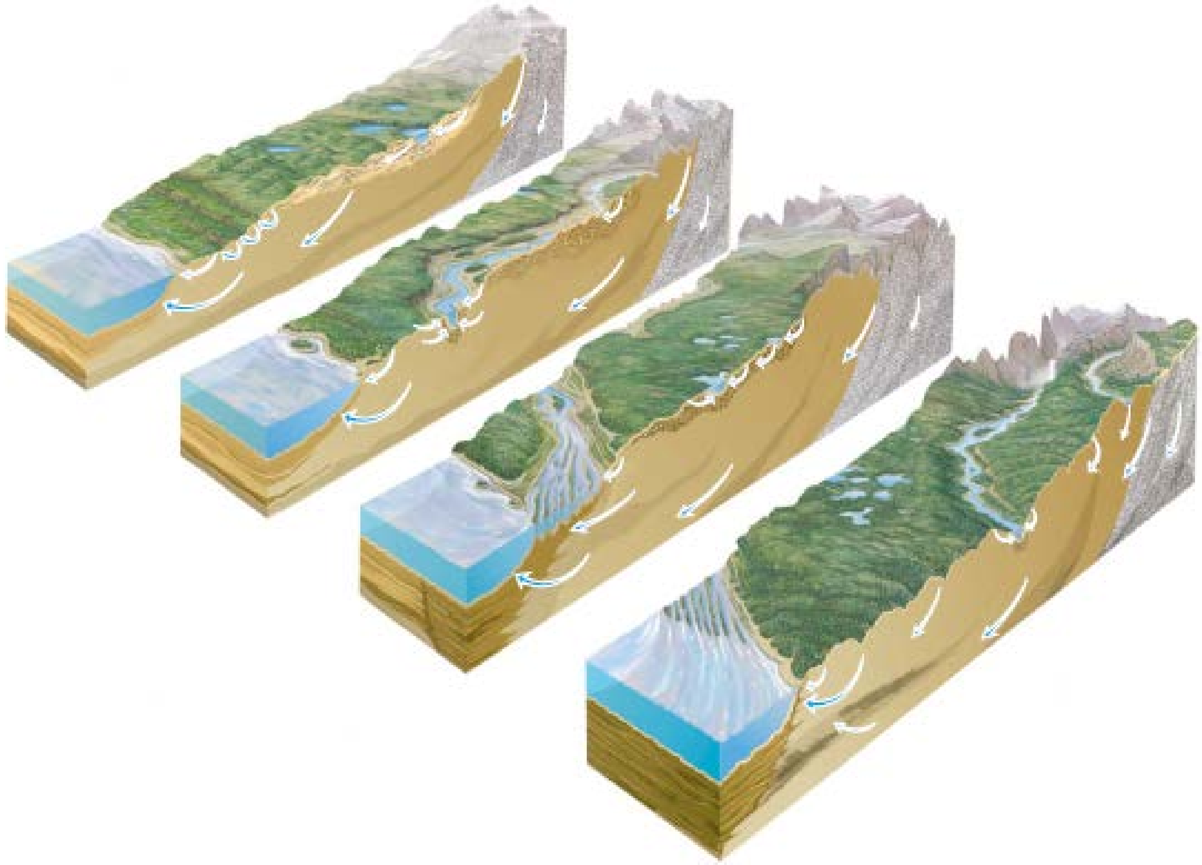
https://superfund.arizona.edu/projects/current_projects/groundwater-contamination-acid-mine-drainage

GW Pump and Treat



http://www.itrcweb.org/GuidanceDocuments/IntegratedDNAPLStrategy_IDSSDoc/IDSS-1.pdf

Surface Water – Groundwater Interactions



U.S. Geological Survey Circular 1139 **1998**

Conclusions

- A knowledge of the subsurface is important to many fields
- The success of removal of fluids can be greatly impacted by subsurface characteristics
- The subsurface is
  - Complex
  - Heterogenous
  - Hidden

Questions

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