

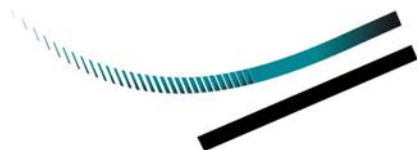


Contrasts in LNAPL Risk Factors for Different Petroleum Products

Presented by:

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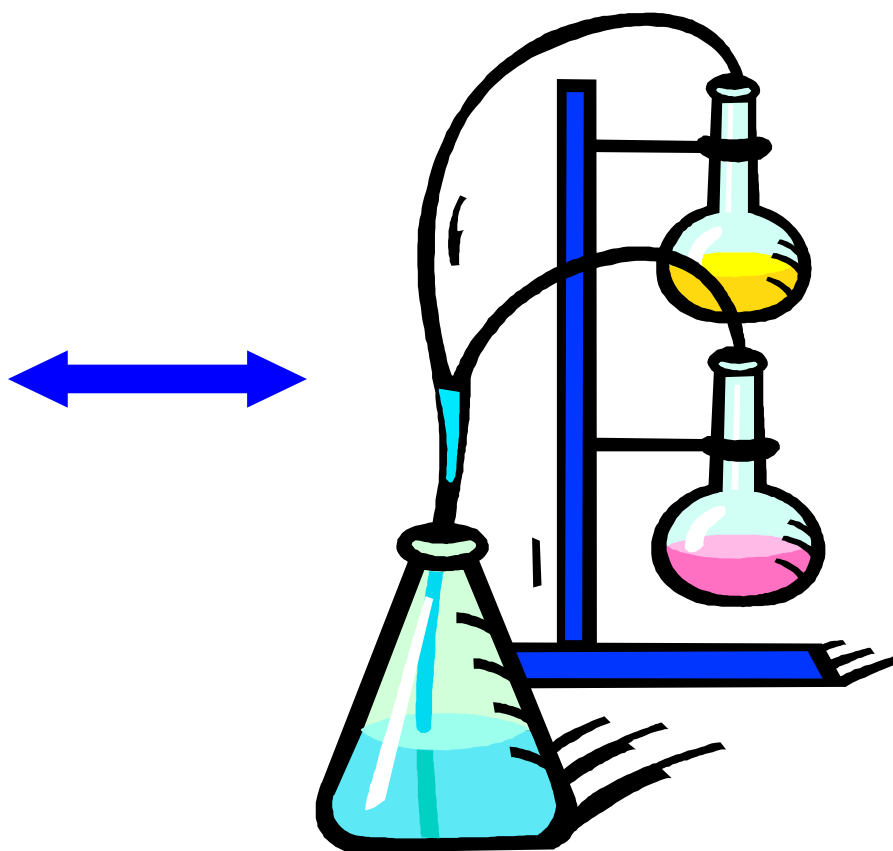
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Two Key Components - Both Important

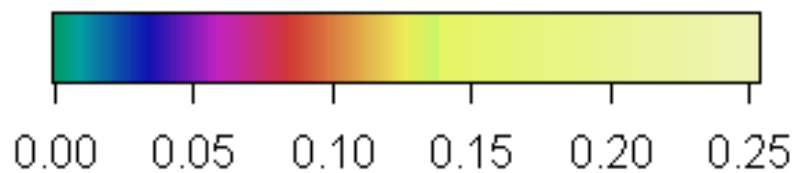
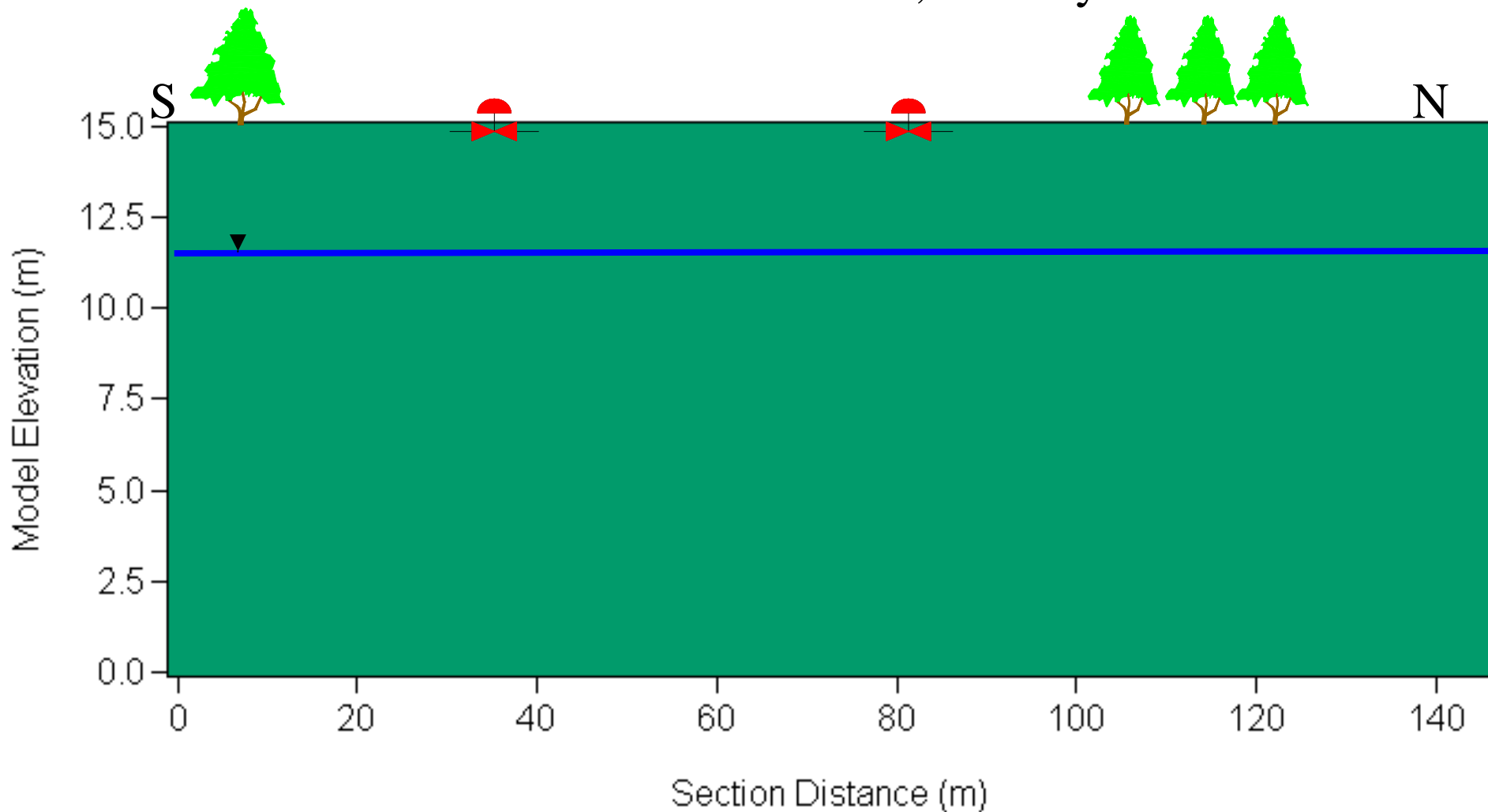
Physics of Release



Chemistry of Release

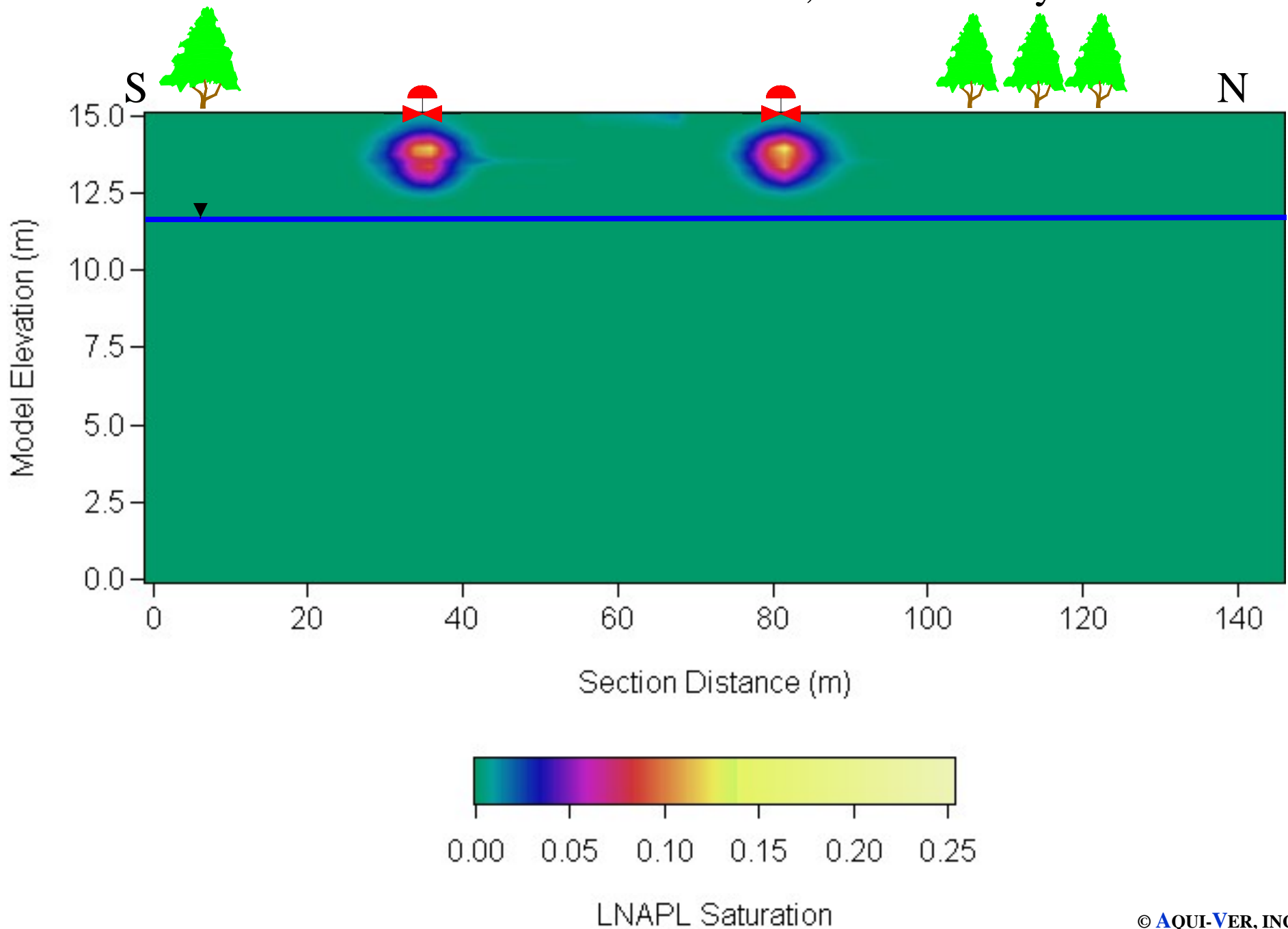


Simulated Transient LNAPL Release, 2 Darcy Sand Time 0

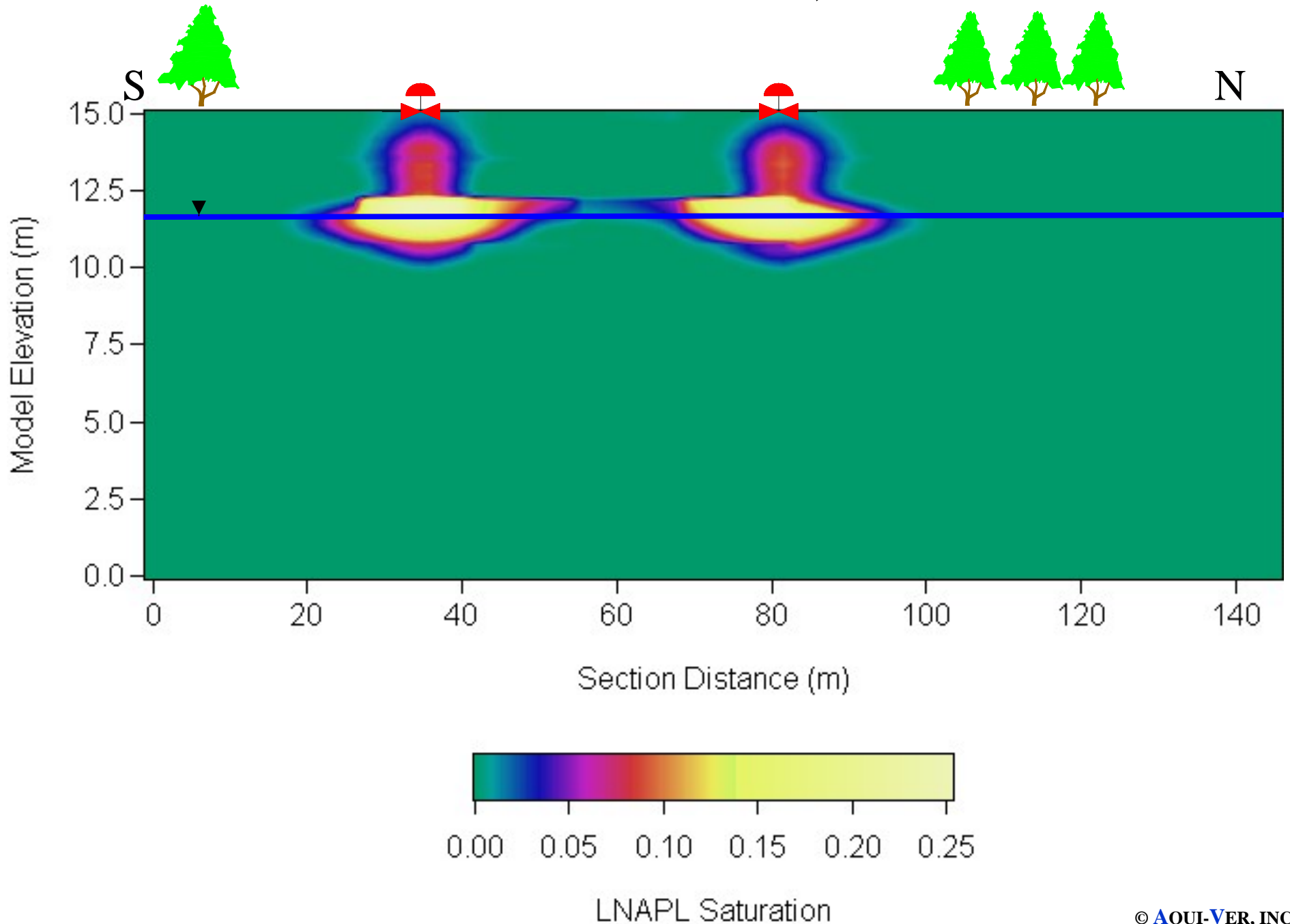


LNAPL Saturation

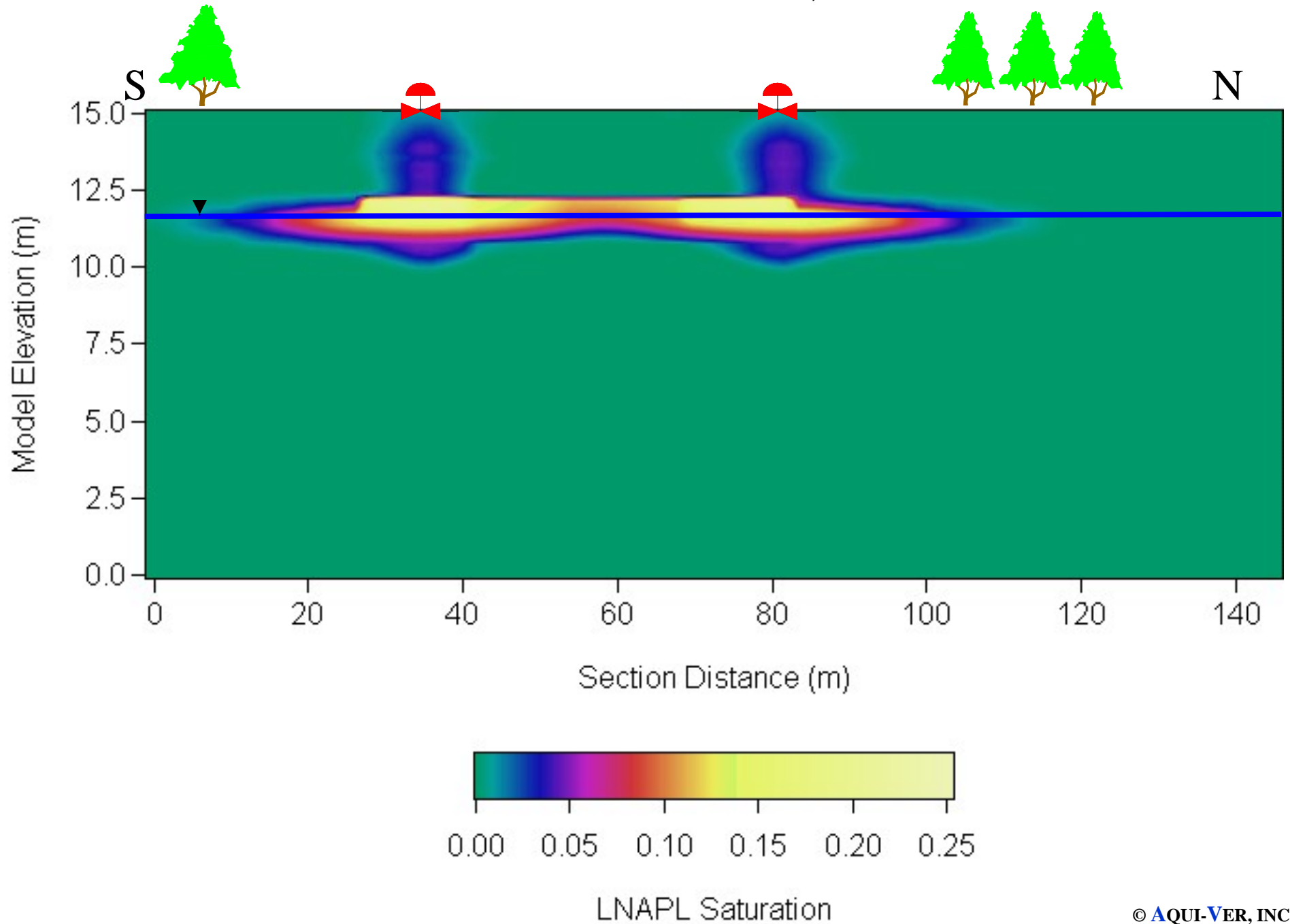
Simulated Transient LNAPL Release, Time 1 Early-Time



Simulated Transient LNAPL Release, Time 2 Mid-Time



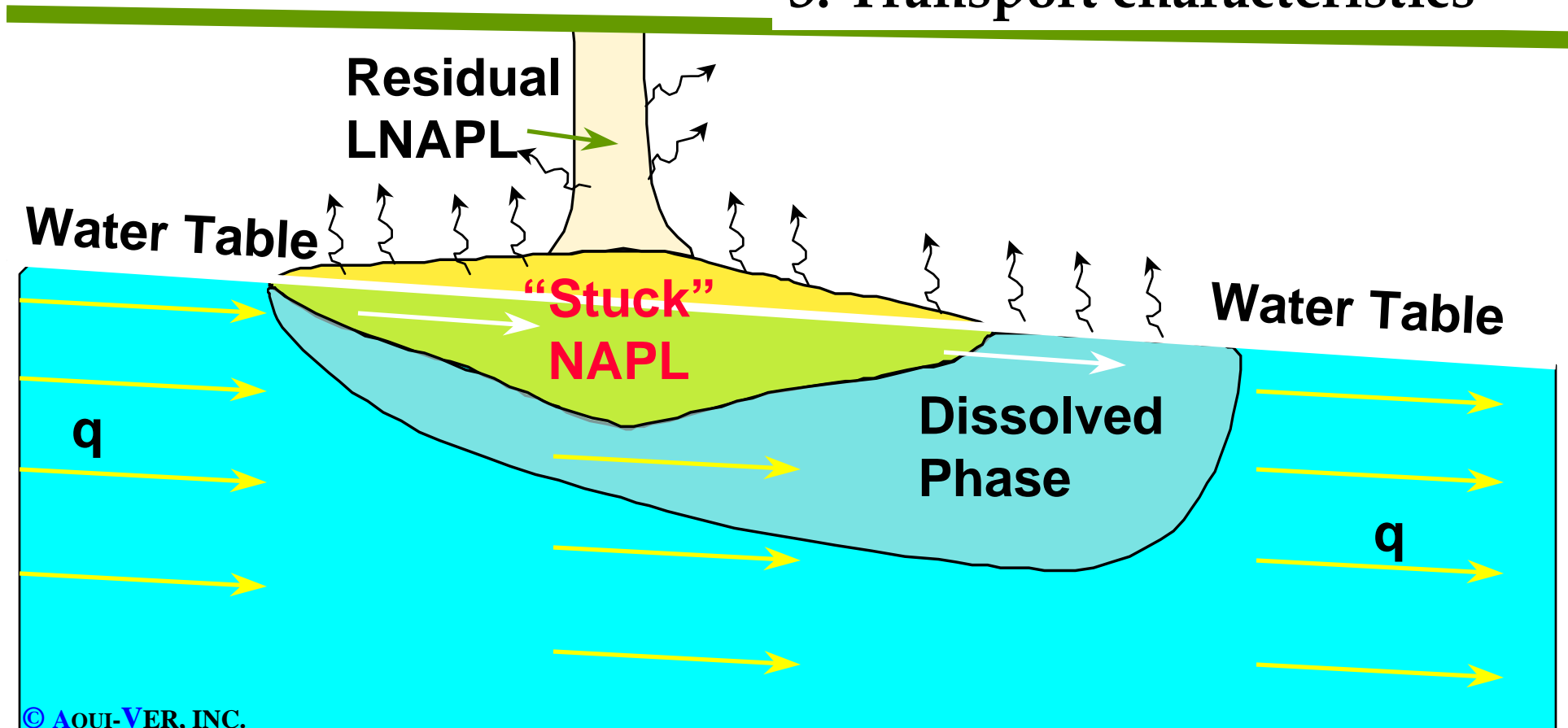
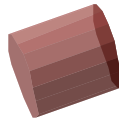
Simulated Transient LNAPL Release, Time 3 Late-Time



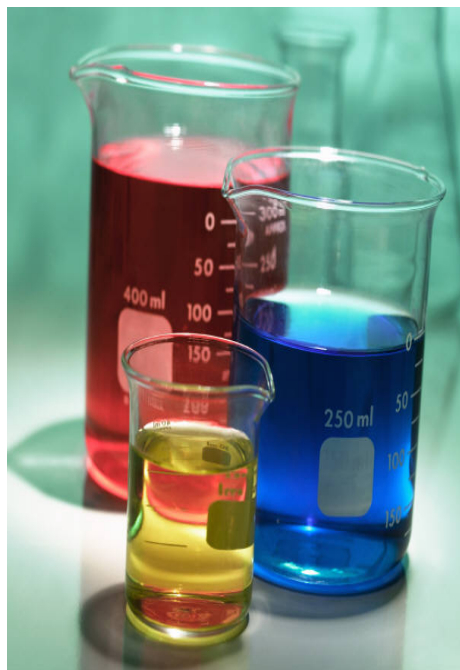
The Range of Impacts Depend on the LNAPL

1. Distribution of spill
2. Chemical character of spill
3. Transport characteristics

Release Source



Oil Products Vary Physically



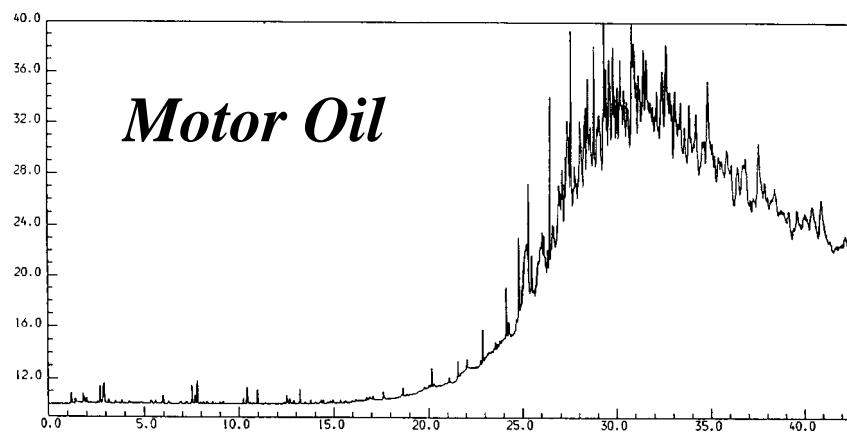
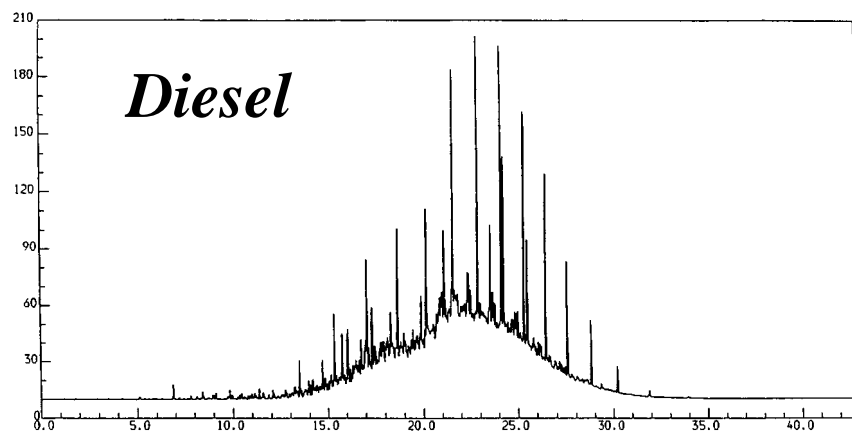
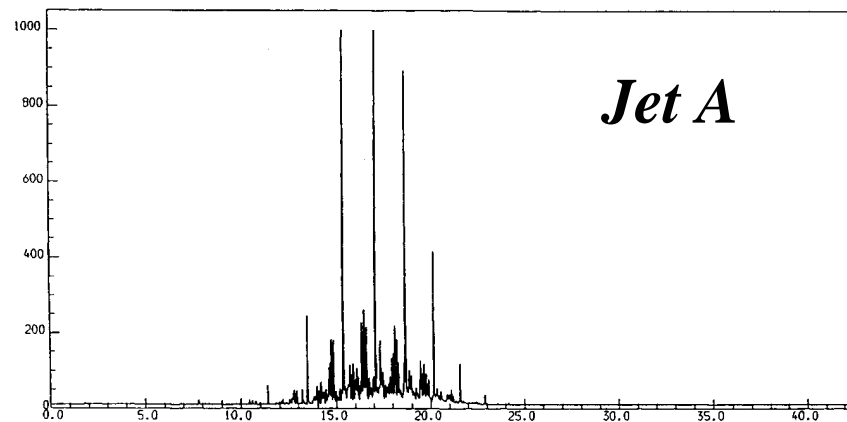
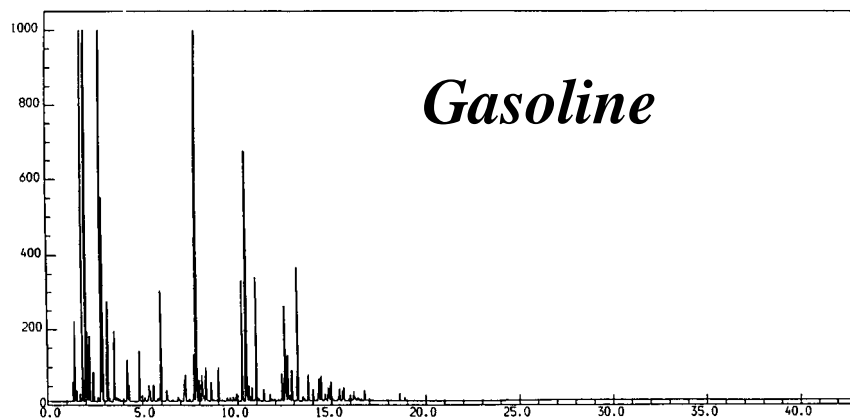
Light Oils



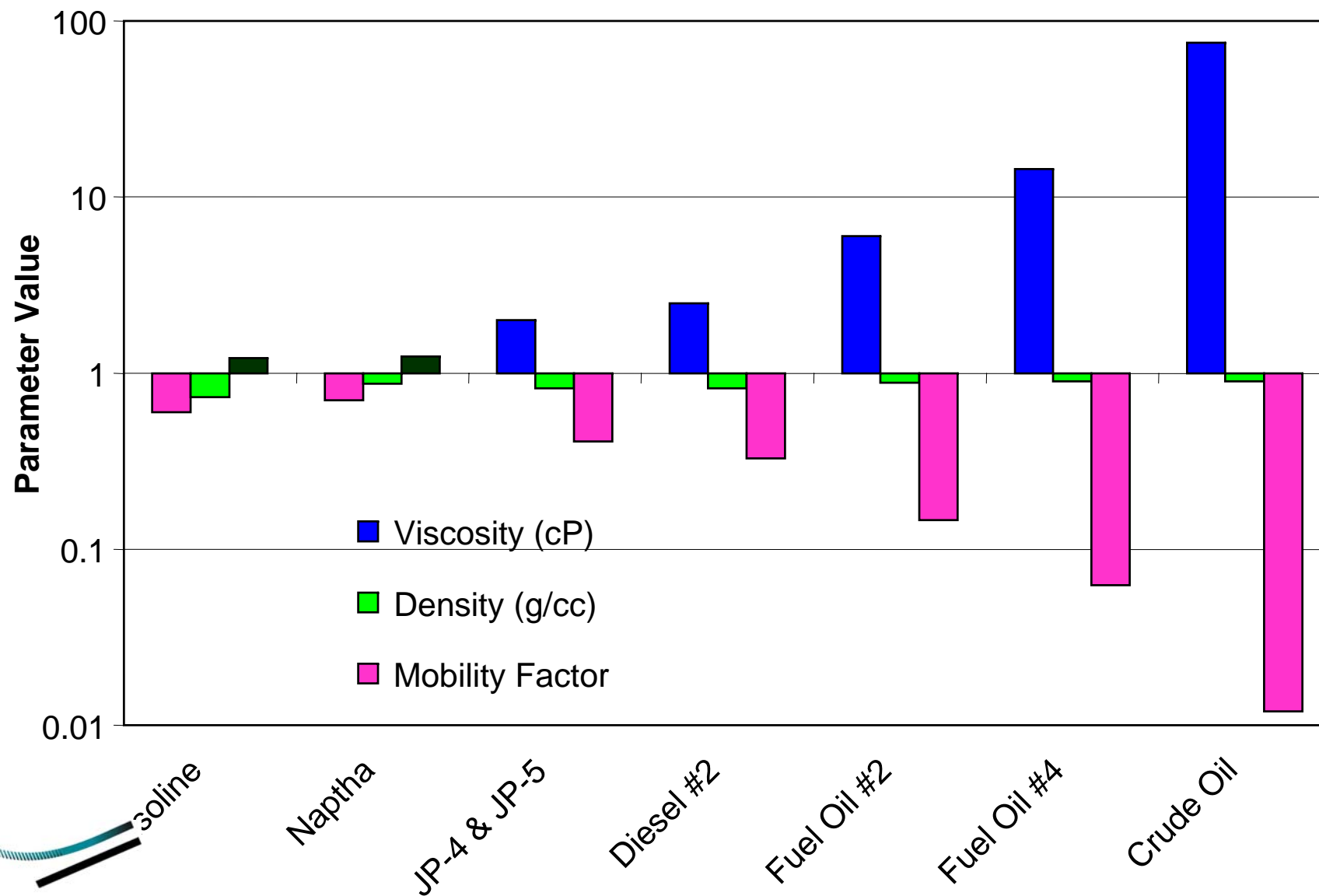
Heavy Fuel & Crude Oils



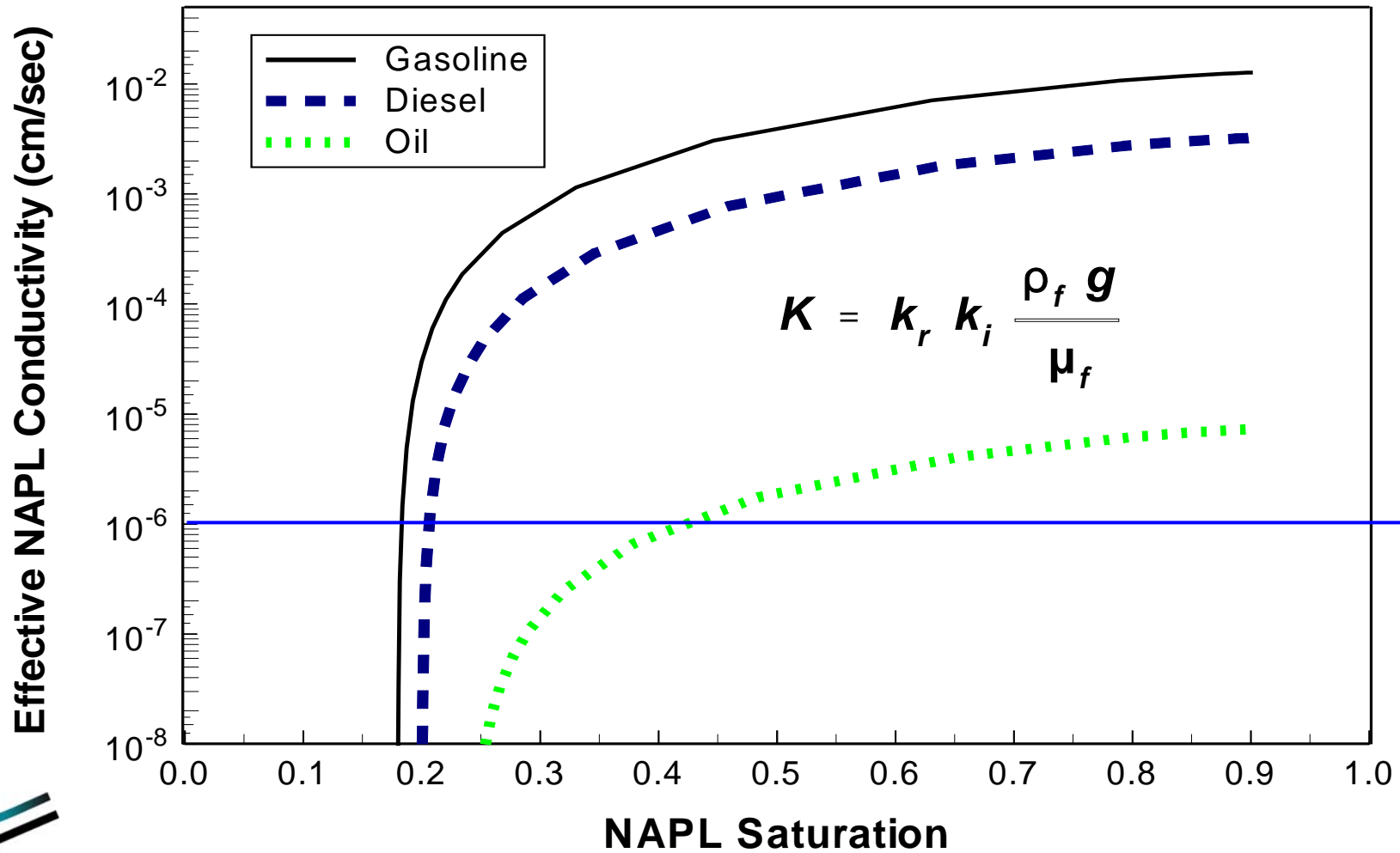
Each Have Differing Chemistry



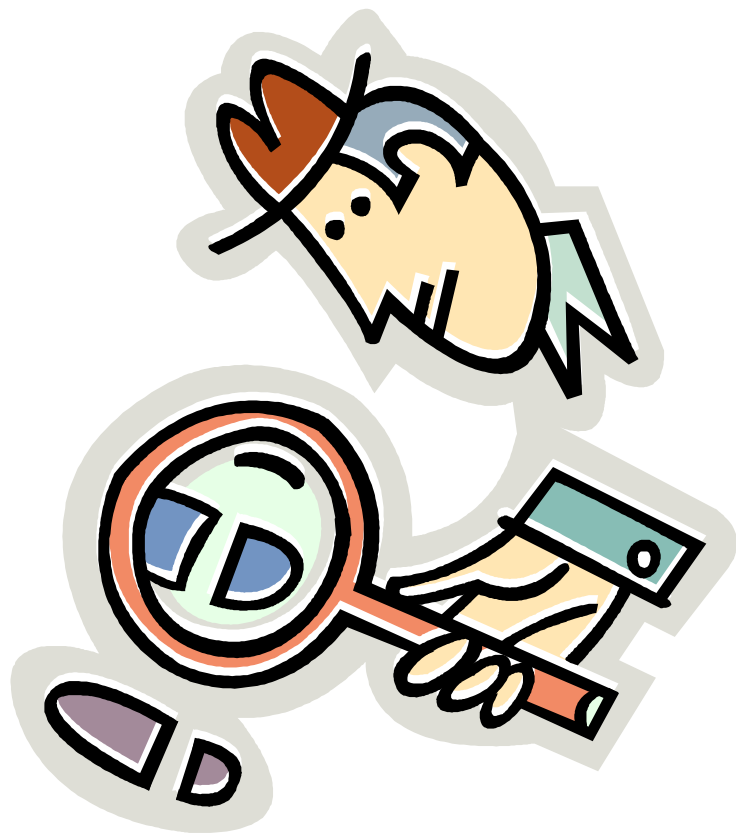
Relative Mobility of Different Products to Water



Effective NAPL Conductivity



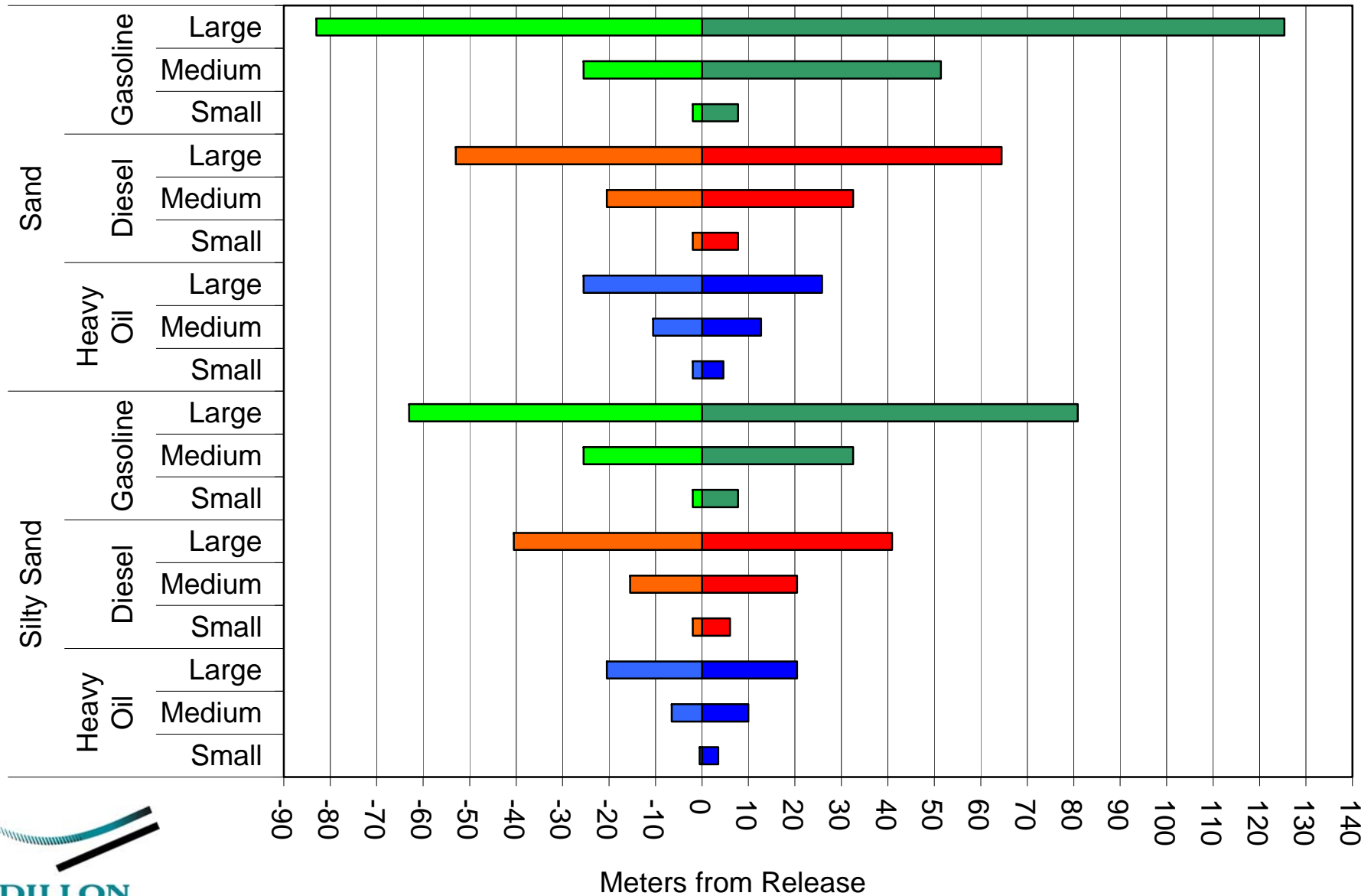
What the Heck Does All that Mean?



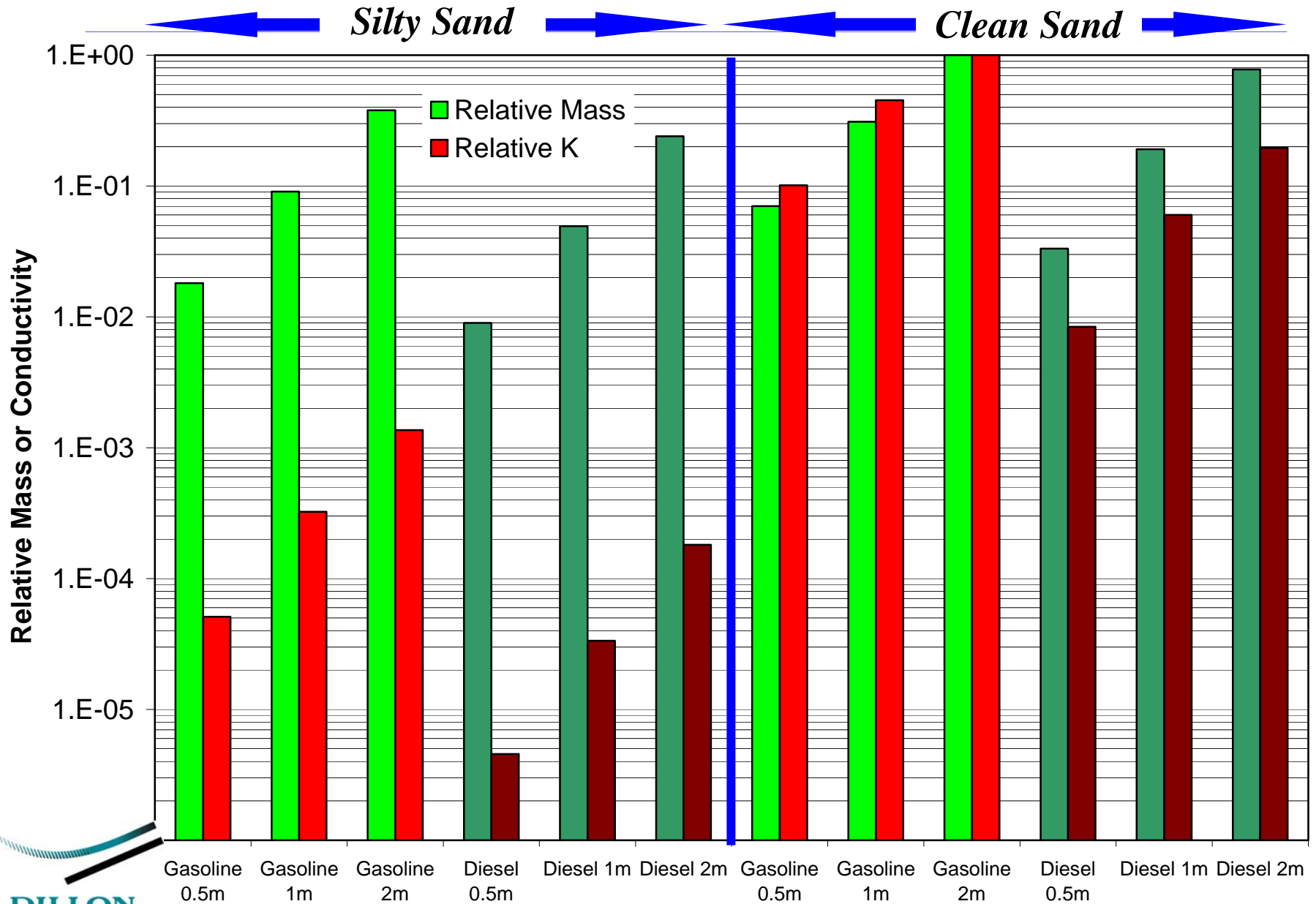
- Each product will behave differently
 - Physically & chemically
- Each has a different relevance
 - Different fate & transport
 - Different receptor implications
 - Different cleanup implications
- But, NAPL is often treated uniformly
 - From a reaction point of view
 - Remove it from the ground
 - And expectations tend to be uniform
- All that is out of step with realities
 - Physical & chemical

Comparative Lateral LNAPL Migration

(converse is true for vertical migration)



Relative Mobility & Mass Comparison



Chemistry Contrasts & Flux Magnitude

(for same LNAPL & geologic conditions)

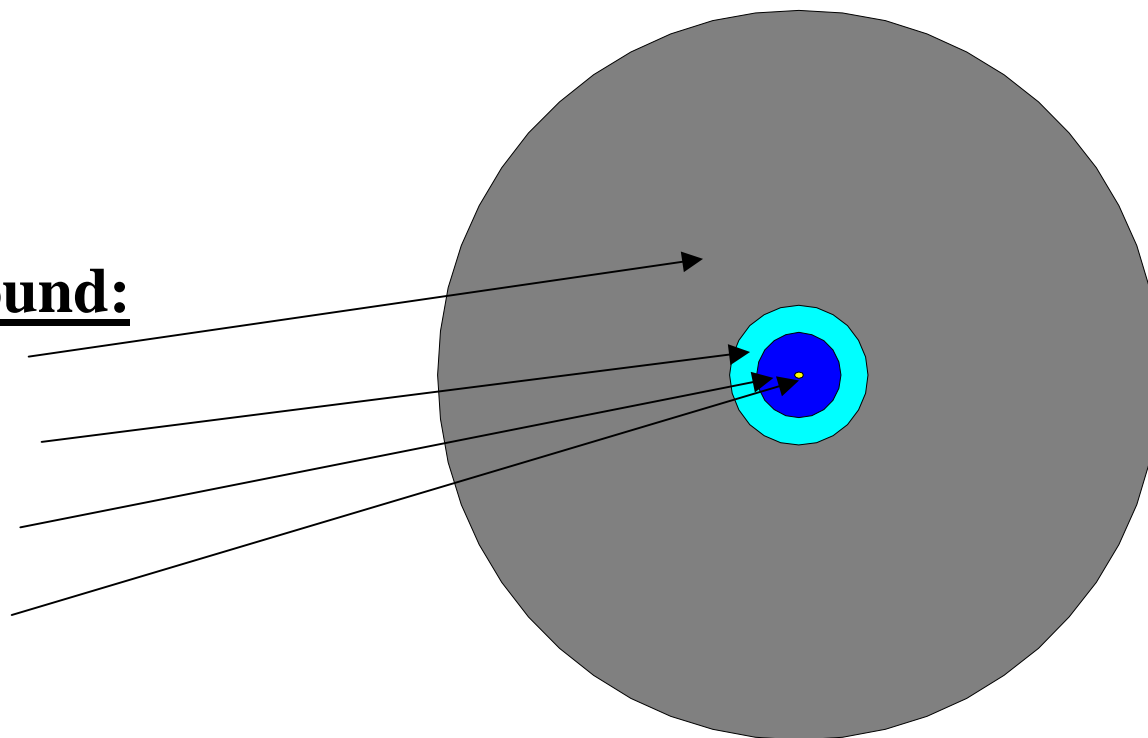
Chemical Compound:

MTBE @ 2%

Benzene @ 2%

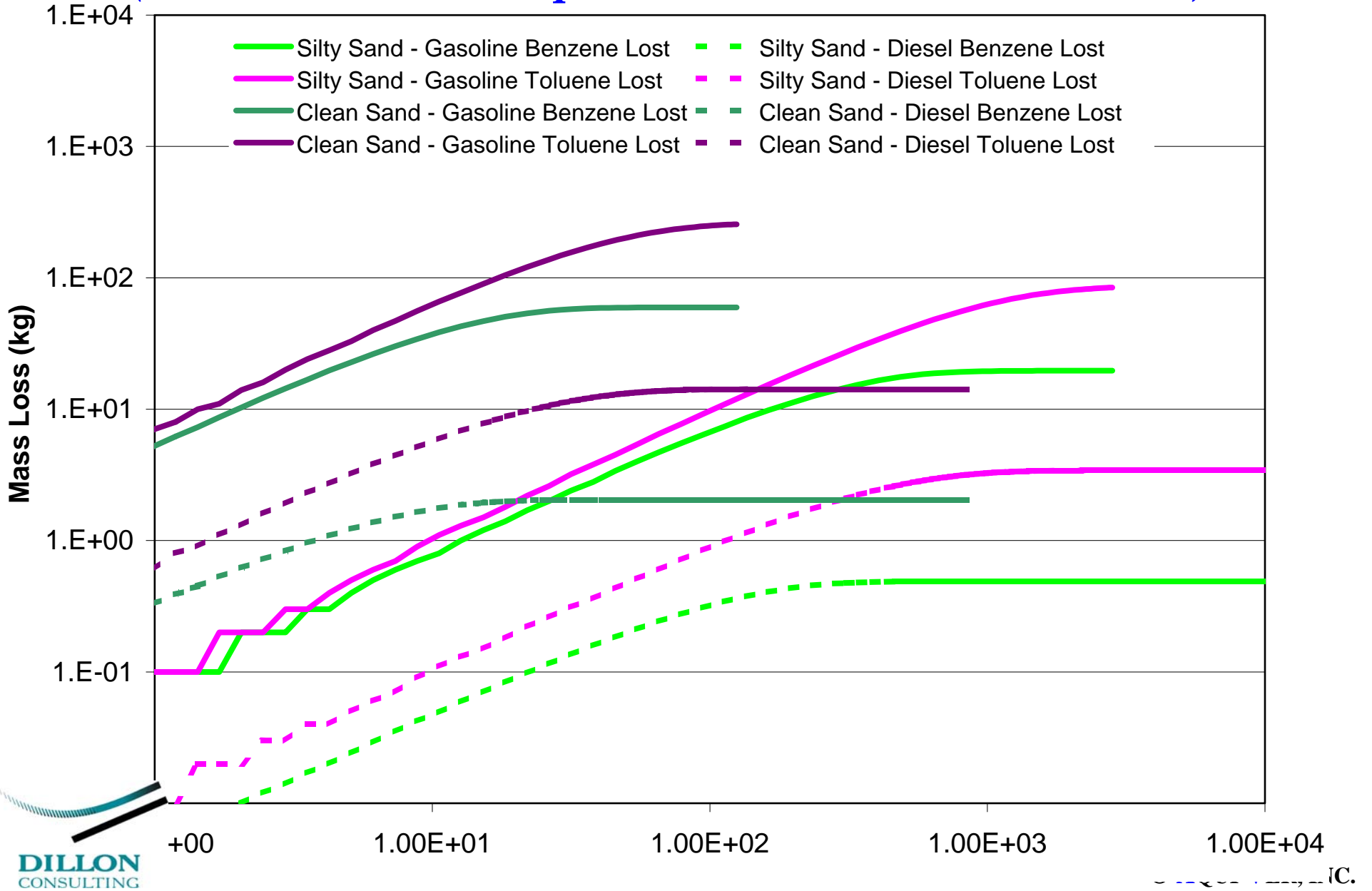
Xylenes @ 7.5%

Fluorenes @ 2%



Mass Loss Comparisons

(cumulative water/vapor mass loss into environment)



How Does All that Stack Up?



- Heavier oils are far less risk
 - Though light oils may also pose no risk
- Gasoline is much more mobile
 - ~10x more than diesel
 - ~ 100s - 1000s times more than heavier oils
- Fuel oils present much lower mass fluxes
 - Less loading to the environment
 - 100s to many 1000s times less risk
- In total, these contrasts are on different playing fields
 - Why is our management on the same one?

LNAPL Management Considerations



- Tend to focus on LNAPL mobility evaluations
 - Weight of evidence
 - Residual saturations
 - Site specific mobility calculations
 - Inherent mobility (bail-down & tech evaluations)
- LNAPL plumes stabilize with time as saturations decrease
- Residual LNAPL as secondary source
 - Dissolved Phase / Vapor Phase
- Incorporate risk-based principles
 - risk magnitude / risk longevity
 - Risk reduction

Business Considerations



- LNAPL liability issues (ex. SOX)
 - Financial statements
 - Third party disclosure
- Establish LNAPL liability management policy
 - How to define?
 - Environmental approach (tier 1, 2, 3)
 - Accounting approach
- Demonstrate LNAPL liabilities are under control
 - How to measure ?
- Manage ongoing LNAPL assessment/remediation
 - Portfolio approach
 - Reduction in overall liability
 - Fiscally sustainable and responsible

Enhanced LNAPL Management Strategy



- Characterize site(s) to delineate extent of LNAPL (and associated) impacts
 - including LNAPL chemistry
- Confirm stability of LNAPL plumes and associated impacts
 - Technically defensible
 - Identify trans-boundary and receptor/pathway concerns
- Evaluate and rank LNAPL site(s) on a risk basis
 - Strategic portfolio management
 - Be aware of other drivers (real estate)
- Manage Expenditures
 - Focus on high risk/high liability sites
 - Cash flow and annual budget considerations
 - External and internal economic factors

LNAPL Summary

- Physical properties of product are directly related to hydrocarbon mobility and related risk factors
 - True for all ‘phases’ of impact
 - Ex. Gasoline greater concern than Diesel
- Strategic management of LNAPL sites incorporating risk-based approaches direct remedial/management effort to greatest risk/liability reduction
 - Maximize effective \$\$
- **Critical to distinguish between product types when evaluating and managing LNAPL sites.**