Contrasts in LNAPL Risk Factors for Different Petroleum Products

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Two Key Components - Both Important

Physics of Release

Chemistry of Release
Simulated Transient LNAPL Release, Time 3 Late-Time

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The Range of Impacts Depend on the LNAPL

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

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Oil Products Vary Physically

Light Oils

Heavy Fuel & Crude Oils
Each Have Differing Chemistry

Gasoline

Jet A

Diesel

Motor Oil
Effective NAPL Conductivity

\[ K = k_r k_i \frac{\rho_f g}{\mu_f} \]
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

**Silty Sand**

- Gasoline
  - 0.5m
  - 1m
  - 2m
- Diesel
  - 0.5m
  - 1m
  - 2m

**Clean Sand**

- Gasoline
  - 0.5m
  - 1m
  - 2m
- Diesel
  - 0.5m
  - 1m
  - 2m

**Relative Mass or Conductivity**

- Green bars represent Relative Mass.
- Red bars represent Relative K.

**Legend**

- Gasoline
- Diesel

**Different Depths**

- 0.5m
- 1m
- 2m
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.