Planning Treatment Trains and Concurrent Remedies

Failing to plan is... planning to waste a lot of ________ (fill in the blank).
“CAP to Closure”

• What does this mean?
• How many states require one?
• Do you usually reach NFA in one try?
• Is the CAP ever updated?
  • How are modifications made?
  • How are costs reconciled?
• How do you judge remedial progress?
Adaptive Site Management

Remediation Management of Complex Sites (ITRC, November 2017)
21 Technology “Tools”

1. Excavation
2. Skimming
3. Vacuum enhanced skimming (LNAPL & vapor)
4. Total liquid extraction (LNAPL & water)
5. Multi-phase extraction (LNAPL, water, & vapor)
6. Water/hot water flooding
7. Surfactant-enhanced subsurface remediation
8. Cosolvent flushing
9. Steam injection
10. Electrical resistance heating
11. Air sparging/soil vapor extraction (AS/SVE)
12. In-situ chemical oxidation
13. Natural source zone depletion (NSZD)
14. Physical or hydraulic containment
15. In-situ soil mixing (stabilization)
16. Thermal conduction heating
17. In-situ smoldering
18. Biosparging/bioventing
19. Enhanced anaerobic biodegradation
20. Activated carbon
21. Phytotechnology

LNAPL Site Management: LCSM Evolution, Decision Process, and Remedial Technologies (ITRC, March 2018)
LNAPL Remedial Technology Groups

- **Mass Control** - Contain LNAPL at a defined boundary
- **Mass Recovery** - Remove LNAPL mass to limit migration
- **Phase Change** - Abate unacceptable COCs

Technologies (i.e. processes) sometimes overlap groups.

LNAPL Site Management: LCSM Evolution, Decision Process, and Remedial Technologies (ITRC, March 2018)
Processes

- Phase Change
- Mass Control / Recovery
# Technically Achievable

## Examples Include:

<table>
<thead>
<tr>
<th>Remedial Mechanism</th>
<th>Technically Achievable Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. LNAPL Recoverability</td>
<td>LNAPL Transmissivity (0.1 to 0.8 ft²/day)</td>
</tr>
<tr>
<td>2. Volatilization</td>
<td>Vapor Pressure (~1 kPa at 15°C)</td>
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<tr>
<td>• AS</td>
<td>PID emissions stable, &lt;xxx ppm</td>
</tr>
<tr>
<td>• SVE</td>
<td></td>
</tr>
<tr>
<td>3. Injection</td>
<td>Soil texture limits delivery of oxidant/other media</td>
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<tr>
<td>• ISCO</td>
<td></td>
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<tr>
<td>• Carbon</td>
<td></td>
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<tr>
<td>4. Biodegradation</td>
<td>Rate of degradation won’t achieve goal in timeframe</td>
</tr>
<tr>
<td>• Biovent / Biosparge</td>
<td></td>
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<tr>
<td>• NSZD/MNA</td>
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</table>
“Treatment Train”
(Consecutive Remedies)

• **PLANNING** to use multiple remedial technologies *in sequence* to achieve closure

• Sequence remedial technologies based on contaminant concerns and remedial objectives
  
  • Consider starting with a primary technology (excavation?) tailored for higher contaminant mass
  
  • Continue with a 2nd treatment technology (ISCO?) and possibly a tertiary polishing step (CBI?) to address remaining contaminant mass and to eliminate contaminant concerns
Treatment Trains

**Bad**
- Unplanned, lack SMART objectives, metrics for transition, milestones and endpoints uncertain
- “Throwing” more technologies at the problem

**Good**
- When planned with SMART objectives, metrics for transition, milestones and endpoints defined
- Orderly implementation
SMART?

- **S**pecific - Targeted treatment area and technology-specific endpoints are clearly stated
- **M**easurable – Performance metrics that demonstrate progress towards the endpoint
- **A**greed Upon – Concerns, goals, objectives, treatment areas, metrics, endpoints
- **R**ealistic – Demonstrated ability to achieve objective
- **T**ime-Based – Target date of remedial endpoint being achieved

Achieving a remedial endpoint does not necessarily mean that all contaminant concerns have been eliminated
Concurrent Remedies

• Using multiple technologies on a site at the same time, in different target zones due to differing contaminant concentrations
  • Use primary technologies in the source area (e.g. excavation).
  • Use secondary or tertiary technologies on periphery of contaminated area, and in deeper zones.

• Still rely on SMART performance metrics to measure remedial progress
Example: Treatment Areas
Don’t forget the third dimension!!!
Performance Metrics

Measurable characteristics that track the progress of a selected technology to achieve a remedial objective and abate a contaminant concern

ASK: What conditions do you expect to change as you remediate the site? And how quickly?
Performance Metrics

• Technology-specific!
• Track progress toward endpoint
• Verify that remedy is being implemented effectively
• Allow for mid-course corrections
• Allow for CSM updates
Performance Metrics Examples
(What you measure)

• AS/SVE – Concentrations in emission samples (e.g. PID, benzene, CO$_2$, CH$_4$)

• ISCO - Data to evaluate distribution of an in-situ application (e.g. pH, ORP, DO, SO$_4^{2-}$)

• SVE - Interim or final soil confirmation samples

• MNA – Organic/ inorganic/ biological samples
Remedial Milestones
(Interim Objectives)

Anticipated points to evaluate progress towards a remediation technology endpoint.

(a schedule)
Remedial Milestone Examples

- LNAPL reduction = 10% of volume estimate per quarter or /month
- Emissions decrease 25% per quarter or /month
- Dissolved phase concentrations remediated to 25%, 50%, 75% of endpoint (with timeframe)

Remember!
Declines are exponential, not linear (90% of the result takes 10% of the time?)
Endpoints

• Also technology-specific!
• Defined as:
  1. LNAPL concern has been addressed, or
  2. Practicable limit of the technology reached

• If technology reaches its practicable limit before LNAPL concern is abated, then the endpoint marks the transition to the next technology in the treatment train
Endpoint Identification

• Predetermined value that describes when a technology has achieved the limits of beneficial application
• Should account for expectations of the selected remedial technology
• Does not necessarily eliminate all contaminant concerns described in the CSM

The endpoint may not be your site goal!