CVEN 4474/5474 Hazardous Waste Management

- Selecting Optimal Remediation Methods
- Remedial Design

Steps Toward Site Clean-up

- Risk assessment completed based on site data
- Identified major hazards
- Discussed “how clean is clean”
  - Background levels, ARARs, acceptable risk
  - How to get site cleaned to acceptable levels?
  - Select a remediation strategy

Options for site clean-up include:

- Off site ex-situ
  - Ex: dig up soil and send to landfill
- On site ex situ
  - Ex: dig up soil and incinerate on site
- In situ
  - Ex: bioventing
- … specific technologies from EPA experience, textbook, web-sites, …

Which clean-up method(s) is BEST?

Challenges to find the “best” option:

- Stakeholders disagree on GOAL (public, EPA, PRPs) - “clean”
- Complicated site conditions
- Long-term process and may require a combined approach
- Evolving knowledge on what works & new processes

Approach to Select Remedy

("Feasibility Study" FS -> ROD by EPA
1. Define the problem
   RI and risk assessment
2. Establish Objectives
   ARARs, RBCA, background,….
3. Develop Alternatives
4. Analyze Alternatives and Select Remedy
   (5. Implement & Monitor)
   RD, RA, long term monitoring, may change due to results

Step 3 Develop Alternatives

I. Identify all technologies that MAY apply
   “master list” including on and off site
II. Screen list to eliminate inappropriate environ. & human health protection
    no adverse environ. Effects technology feasible cost
    (constraint-based elimination)
III. Remedial Action Alternatives
    approx. 3-6 to analyze in detail inc. “no action” baseline
Step 4: Analyze alternatives based on Criteria

I. Non-cost criteria
- overall protection of human health & environ.
- compliance with clean-up goals
- long-term effectiveness
- long-term reliability
- short-term effectiveness (time to implement; worker/public risk during implementation)
- reduce toxicity, mobility, &/or vol contam
- implementability (treatability sty needed; innovative equipment or skills,…..)
- regulator and community acceptability

II. Cost - of full life-cycle
- capital (built it now $)
- operation and maintenance over life ($/yr * # yrs)
- monitoring over life ($/yr * yrs)

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Example: which is best?
- Present worth $1 - 1.2 M
- Present worth $0.5M - 1M
- Capital $0.5M, O&M+monitoring
  - $0.01M for 30-100 yrs
    - $PW = capital + A * [(1+i) \(^n\) - 1 / i(1+i)\(^n\)]
    - Assume i = 6%, n=30 yrs
    - $PW = $0.5M + $0.01M[4.74/0.345] = $0.64M
    - if 100 yrs: PW = $0.67M
    - if ignore time value of money $0.8 - 1.5M

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Logical way to combine non-cost & cost factors for decision:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Wt</th>
<th>Raw score</th>
<th>Wt'd score</th>
</tr>
</thead>
<tbody>
<tr>
<td>PW cost</td>
<td>40</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>non-cost</td>
<td>60</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

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Step 4: Analyze alternatives based on Criteria

II. Cost - of full life-cycle
- capital (built it now $)
- operation and maintenance over life ($/yr * # yrs)
- monitoring over life ($/yr * yrs)

combined present worth cost
- Uncertainty & range included (both capital + O&M)

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End of Step 4.
Recommend remedy
- Which option(s) best
  - Best weighted score
  - Explain in words
- Negotiate with public, EPA, PRPs
  - Must convince all parties
- ROD
  - Legal document binding the selected remedial action (can be altered if needed)

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Step 5. Implement & Monitor

I. Remedial design (RD) usually by consultant hired by PRP with oversight by EPA
- Preliminary design
- Intermediate design (30,50%)
- Final design (plans&specs; O&M plan; construction QA plan; contingency plan)

II. Remedial Action (RA)
- Construct or implement remedy

III. Long-term Monitoring
- Prove meeting clean-up limits
### Alternatives: Soil
- Incineration
- Soil washing
- Composting
- Bioslurry
- Solidification/stab.
- Thermal desorption
- Soil flushing
- Surfactant flushing
- Soil vapor extraction
- Bioremediation
- Phytoremediation
- In-situ reactive zones
- Solidification/Stab.
- Vitrification

### Alternatives: Groundwater
- Pump and treat
  - Incineration
  - GAC adsorption
  - Ion exchange
  - Biodegradation
  - Air stripping
  - Membrane separation
  - Chemical treatment
  - UV/Chem treatment
- Air sparging
- Biodegradation
- Reactive zone
- Phytoremediation

### Alternatives: Soil Vapor
- SVE
  - Incineration
  - GAC adsorption
  - Catalytic oxidation
  - Biofilter
  - Biotricking filter
  - Bioscrubber
  - Suspended bioreactor
- Biodegradation
- (bioventing)
- Heated air extraction

### Other considerations:
- Ultimate fate is important
  - Moving contamination -> ultimately needs a “grave” unless it is fully treated
- Treating mixtures
- Metals vs organics
  - Metals can’t be destroyed, just change form and location
  - Organics can be destroyed to CO2, water, etc.