

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
- ↕ FS 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

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)

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

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

Criteria	Wt %	Raw score			Wt'd score		
		Alt A	Alt B	Alt C	Alt A	Alt B	Alt C
PW cost	40	2	5	10	0.8	2	4
non-cost	60	8	5	0	4.8	3	0
Total	100	10	10	10	5.6	5	4

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)

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. Longterm 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
 - Biotrickling 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.