Feasibility Studies

Remedy Selection: Planning for Success & Lessons Learned

Tuesday, May 7, 2019
Quinebaug Valley
Community College
742 Upper Maple Street
Daniele, CT

Wednesday, May 8, 2019
UMass Lowell Inn and Conference Center
50 Warren Street
Lowell, MA

Wednesday, June 26, 2019
Fireside Inn and Suites
25 Airport Road
Lebanon, NH

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Topics

- Developing remedial alternatives
- Evaluating alternatives
- Presumptive remedies
- Developing cost estimates
- Managing public perception
- Lessons learned

EPA

Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA

Interim Final

EPA/540/G-89/004
Feasibility Study

The process of developing and evaluating remedial options for waste site cleanup, based on the results of site characterization, to support an informed risk management decision on the most appropriate remedy.

Other versions/names for a Feasibility Study

Corrective Measures Study (CMS) – RCRA sites
Analysis of Brownfields Cleanup Alternatives (ABCA) - Brownfields projects
Remedial Alternatives Analysis (RAA) (e.g. New York)
Remedial Action Plan (RAP) (e.g. New Hampshire)
Corrective Action Plan (e.g. Vermont)
FS is part of the Site Investigation Report (e.g. Rhode Island)
FS – Development and Screening of Alternatives

General Response Actions

- Defined for each contaminated medium – soil, sediment, groundwater, surface water

- Examples:
  - Containment (e.g. capping, encapsulation, hydraulic control)
  - Removal/treatment/disposal
  - Destruction (e.g. in-situ/ex-situ)
  - Institutional actions (e.g. access restrictions, monitoring)
FS – Development and Screening of Alternatives

Identify and screen technologies

- For each General Response Action and contaminated medium – soil, sediment, groundwater, surface water
- Resources for finding technologies
  - EPA's clu-in.org
  - ITRC
  - Federal Remedial Technologies Roundtable
  - M. Marley's presentation in this workshop
- Screen technologies based on:
  - Effectiveness
  - Implementability
  - Cost

Resources for identifying remedial technologies

About Remediation Technologies

Activated Carbon-Based Technology for In Situ Remediation | Air Sparging | Bioreactor Landfills | Bioremediation | Combining Remedies for More Effective Site Cleanup | Electrokinetics | Evapotranspiration Covers | Fractured Rock | Environmental Fracturing | Ground-Water Circulating Wells | In Situ Chemical Reduction | In Situ Flushing | In Situ Oxidation | Multi-Phase Extraction | Nanotechnology: Applications for Environmental Remediation | Natural Attenuation | Optimizing Site Cleanups | Permeable Reactive Barriers | Phytotechnologies | Sediments | Soil Vapor Extraction | Soil Washing | Solidification | Solvent Extraction | Thermal Treatment Ex Situ | Thermal Treatment In Situ
### FS – Development and Screening of Alternatives

Screen technologies for effectiveness (mostly), implementability, and relative cost (very rough)

<table>
<thead>
<tr>
<th>Remedial Technology</th>
<th>Process Options</th>
<th>Effectiveness</th>
<th>Implementability</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collection</td>
<td>Subsurface drain</td>
<td>Effective for downgradient fracture flow interception</td>
<td>Very difficult to implement, requires deep trenching through rock</td>
<td>Very high capital, low O&amp;M</td>
</tr>
<tr>
<td>Treatment</td>
<td>Physiochemical treatment</td>
<td>Effective and reliable, conventional technology, requires sludge disposal.</td>
<td>Readily implementable.</td>
<td>High capital, moderate O&amp;M</td>
</tr>
<tr>
<td>Discharge</td>
<td>POTW</td>
<td>Effective and reliable, proper pretreatment required.</td>
<td>Readily implementable, permit required.</td>
<td>High capital, low O&amp;M</td>
</tr>
<tr>
<td>Ground Water General Response Actions</td>
<td></td>
<td>Effectiveness and reliability require site-specific determination.</td>
<td>Readily implementable, permit required.</td>
<td>Moderate capital, low O&amp;M</td>
</tr>
<tr>
<td></td>
<td>Local stream</td>
<td>Effective and reliable.</td>
<td>Permit required.</td>
<td>High capital, very low O&amp;M</td>
</tr>
<tr>
<td></td>
<td>POTW</td>
<td>Effective and reliable.</td>
<td>Permit required.</td>
<td>High capital, low O&amp;M</td>
</tr>
<tr>
<td></td>
<td>Pipeline to river</td>
<td>Effective and reliable.</td>
<td>Permit required.</td>
<td>High capital, low O&amp;M</td>
</tr>
</tbody>
</table>

EPA/540/G-89/004, Fig 4-5
Assemble site-wide alternatives

- Should provide a range of options for managing risk
- Should address all contaminated media
- Ranges can be grouped into general categories
  - No action/limited action
  - Source control (e.g. containment vs. removal/treatment)
  - Management of migration (MOM) for groundwater
- For small sites, 2 to 3 alternatives
- For large sites, 5 to 8 alternatives
- Each alternative should be described to a degree sufficient to support cost estimating (e.g. conceptual design, including site layout, list of major components, process flow diagram, quantity estimates)
Role of Treatability Studies

- Obtain data to evaluate feasibility of a treatment technology to site conditions (e.g. lab tests for enhanced biodegradation, destruction efficiency of chemical oxidation)
- Reduce performance and cost uncertainties ahead of detailed analysis of alternatives
- Typically involves bench-scale testing, not a pilot-scale study

FS – Detailed Analysis of Alternatives

- Alternatives are individually assessed against a set of evaluation criteria
- Alternatives are compared against each other
- Provides basis for remedy selection by decisionmakers
FS – Detailed Analysis of Alternatives

Nine Evaluation Criteria

Effectiveness

1. Overall protection of human health and the environment
2. Compliance with applicable or relevant and appropriate requirements (ARARs)
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, and volume through treatment
5. Short-term effectiveness

Implementability

6. Implementability
7. Cost

Cost

8. State (support Agency) acceptance
9. Community acceptance

Threshold criteria – must be met

Primary balancing factors

Modifying criteria – addressed after FS is completed

Threshold criteria – must be met

1. Overall protection of human health and the environment
   - Does the alternative achieve adequate protection and describe how site risks are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls?
   - Does the alternative pose any unacceptable short-term or cross-media impacts?

2. Compliance with ARARs (applicable or relevant and appropriate requirements)
   - Does the alternative comply with:
     - Chemical-specific ARARs (e.g. MCLs)
     - Location-specific ARARs (e.g. preservation of historic sites)
     - Action-specific ARARs (e.g. RCRA technology standards)
     - Other criteria, advisories, and guidances
Balancing criteria –

3. Long-term effectiveness and permanence

• Magnitude of residuals risks from treatment residuals or untreated waste remaining
• Adequacy and reliability of controls to manage treatment residuals or untreated waste (e.g. caps, slurry wall, pump-and-treat system)

4. Reduction of toxicity, mobility, or volume through treatment – preference for permanent and significant reduction

• Treatment process used and contaminants treated
• Amount of hazardous materials destroyed or treated
• Degree of expected reduction measured as a percentage or order of magnitude
• Degree to which treatment is irreversible
• Type and quantity of residuals remaining after treatment

5. Short-term effectiveness

• Protection of the community during remedial action
• Protection of workers
• Potential adverse environmental impacts during construction and implementation
• Time until remedial response objectives are achieved

6. Implementability

• Technical feasibility (construction, operation, reliability, ease of undertaking)
• Administrative feasibility (permits, access agreements)
• Availability of services and materials (contractors, equipment, disposal facilities)
Balancing criteria –

7. Cost

- Capital cost
- Annual O&M cost
- Present worth cost

Modifying criteria –

8. State (support agency) acceptance
9. Community acceptance

- State and community acceptance are addressed in the Record of Decision once public comments are received – applies to sites where public notice of remediation plans are required

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**Detailed Analysis of Alternatives – State examples**

<table>
<thead>
<tr>
<th>Jurisdiction Reference</th>
<th>USEPA CERCLA</th>
<th>NH Env-Or 606.12</th>
<th>NY DER-10</th>
<th>VT IRCP Sec 35-503</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluation Criteria for Remedial Alternatives</td>
<td>Protection of human health &amp; environment</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Compliance with ARARs</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Long-term effectiveness and permanence</td>
<td>Effectiveness and reliability</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Reduction of toxicity, mobility, or volume</td>
<td>Risk reduction</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Short-term effectiveness</td>
<td>Time to achieve no further action criteria</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Implementability</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Cost</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>State acceptance</td>
<td>Future land use</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Community acceptance</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

---
FS Last Step - Comparative Analysis of Alternatives

- Identifies the advantages/disadvantages of each alternative relative to one another
- Narrative discussion of strengths/weaknesses relative to one another for each criterion
- Caution using scoring/ranking systems – can lead to controversy
- Identifies the preferred alternative based on the comparative analysis

After the FS

For CERCLA sites and State sites subject to public notice

- The EPA or State agency prepares a Proposed Plan or Proposed Remedial Action Plan
- Proposed Plan is the subject of a public meeting and public comment period (typically 30 days)
- EPA or State Agency then issues a Record of Decision (ROD) or approval of the remedial action plan
- Once the ROD is issued, remedial design can begin, followed by remedial action

For State sites not subject to public notice

- The FS leads to a proposed Remedial Action Plan, or the FS can be combined with Remedial Action Plan
- Once the State approves the Remedial Action Plan, remedial design can begin, followed by remedial action
Presumptive Remedies

EPA: preferred technologies for common categories of sites that based on past implementation experience are presumptively appropriate for addressing site contaminants and can be used to accelerate the remedy selection process.

Many states also recognize these presumptive remedies or have additional ones.

Presumptive Remedies – intended to accelerate the FS and ultimate timeframe to cleanup.

Streamlined steps

Eliminated steps
## Presumptive Remedies

<table>
<thead>
<tr>
<th>Site/Contaminants</th>
<th>EPA Presumptive Remedies</th>
</tr>
</thead>
</table>
| Volatile organic compounds in soils (and groundwater) | • Soil vapor extraction  
• (Multi-phase extraction)  
• Thermal desorption  
• Incineration |
| Metals in soils | • Reclamation/recovery  
• Immobilization (solidification, stabilization)  
• Containment (vertical and horizontal barriers) |
| Wood treaters | • For organics: Incineration, bioremediation, dechlorination  
• For Inorganics: immobilization |
| Municipal Landfills | Containment (capping, leachate collection, LF gas treatment, institutional controls) |

### Diagram:

![Presumptive Remedy: Supplemental Bulletin Multi-Phase Extraction (MPE) Technology for VOCs in Soil and Groundwater](https://clu-in.org/download/toolkit/finalapr.pdf)

**Two-phase extraction**
Presumptive Remedies – Guidance Documents

Presumptive Remedies – New Jersey Example

N.J.A.C. 7:26E 5.3 Table 5.1
Presumptive Remedies for Soil Contamination at Schools, Child Care Centers, and Residences

<table>
<thead>
<tr>
<th>Contamination type</th>
<th>Subcategories/Scenarios</th>
<th>Presumptive Remedy/Remediation Goal</th>
<th>Remedial Action - Schools, Child Care Centers, and Type II Residential</th>
<th>Remedial Action - Type I Residential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Historic Fill and/or all other discharged contaminants not otherwise excluded in N.J.A.C.7:26E-5.3</td>
<td>1) Play Areas Loose Fill Surface (e.g., mulch, sand, etc.)</td>
<td>Restricted Use</td>
<td>Option #1.</td>
<td>Same engineering control requirement as schools, child care centers and Type II Residential</td>
</tr>
</tbody>
</table>

Option #1. Barrier - Minimum of one foot clean loose fill material; Buffer - Minimum of one foot clean loose fill material; Demarcation - Geotextile fabric, and Inspection - Quarterly

Option #2. Barrier - Minimum of two feet clean loose fill material; Buffer - Minimum of two feet clean loose fill material; Demarcation - Visible contamination boundary marker or geotextile fabric; and Inspection - Semi-annual
FS Cost Estimates

A Guide to Developing and Documenting Cost Estimates During the Feasibility Study

https://semspub.epa.gov/work/HQ/174890.pdf

Exhibit 7-3
Expected Cost Estimate Accuracy Along the Superfund Pipeline

https://semspub.epa.gov/work/HQ/174890.pdf
Key Components of FS Cost Estimates

Capital Costs – costs to construct the remedial action
   • Contractor costs
   • Professional/technical services, including design, construction management, PM

Annual Operations & Maintenance (O&M) Costs – post-construction costs
   • Remedial system operations
   • Groundwater monitoring
   • Reporting

Periodic Costs – costs incurred every few years
   • Equipment replacement
   • 5-year reviews
   • Site closeout

How to Develop the Cost Estimate

1. Describe the alternative.

2. Identify major cost items, including quantities and unit costs, for capital, annual O&M, and periodic components

3. Apply contingency

4. Add professional/technical services costs

5. Calculate present value
Example Cost Presentation

Capital Costs:
- Mobilization / Demobilization $106,723
- Monitoring, Sampling, Testing, and Analysis $60,838
- Site Work $12,940
- Air Sparging / Soil Vapor Extraction $252,851
- Passive Treatment Wall $2,028,564
- Off-Site Treatment / Disposal $1,550
- CONSTRUCTION SUBTOTAL $2,463,465
  - Contingency (10% scope + 15% bid) 615,866
- SUBTOTAL $3,079,331
  - Project Management (5%) 153,967
  - Remedial Design (8%) 246,346
  - Construction Management (6%) 184,760
- TOTAL $3,664,404

Total Contingency = Scope contingency (see table) + Bid contingency (10 to 20%)

https://semspub.epa.gov/work/HQ/174890.pdf
### Exhibit 5-8
Example Percentages for Professional/Technical Services Capital Costs

<table>
<thead>
<tr>
<th>Capital Cost Element</th>
<th>&lt; $100K (%)</th>
<th>$100K-$500K (%)</th>
<th>$500K-$2M (%)</th>
<th>$2M-$10M (%)</th>
<th>&gt; $10M (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Management</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Remedial Design</td>
<td>20</td>
<td>15</td>
<td>12</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Construction Management</td>
<td>15</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

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### Exhibit 4-5
Example Present Value Calculation for a Remedial Alternative

<table>
<thead>
<tr>
<th>Year</th>
<th>Capital Costs ($)</th>
<th>Annual O&amp;M Costs ($)</th>
<th>Periodic Costs ($)</th>
<th>Total Cost ($)</th>
<th>Discount Factor at 7%</th>
<th>Total Present Value Cost at 7% ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1,800,000</td>
<td>0</td>
<td>0</td>
<td>1,800,000</td>
<td>1.00</td>
<td>1,800,000</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>50,000</td>
<td>0</td>
<td>50,000</td>
<td>0.935</td>
<td>46,800</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>50,000</td>
<td>0</td>
<td>50,000</td>
<td>0.873</td>
<td>43,700</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>50,000</td>
<td>0</td>
<td>50,000</td>
<td>0.816</td>
<td>40,800</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>50,000</td>
<td>0</td>
<td>50,000</td>
<td>0.763</td>
<td>38,200</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>50,000</td>
<td>10,000</td>
<td>60,000</td>
<td>0.713</td>
<td>42,800</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>50,000</td>
<td>0</td>
<td>50,000</td>
<td>0.666</td>
<td>33,300</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>50,000</td>
<td>0</td>
<td>50,000</td>
<td>0.623</td>
<td>31,200</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>50,000</td>
<td>0</td>
<td>50,000</td>
<td>0.582</td>
<td>29,100</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>50,000</td>
<td>0</td>
<td>50,000</td>
<td>0.544</td>
<td>27,200</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>50,000</td>
<td>50,000</td>
<td>100,000</td>
<td>0.508</td>
<td>50,800</td>
</tr>
<tr>
<td>Total</td>
<td>1,800,000</td>
<td>560,000</td>
<td>50,000</td>
<td>2,360,000</td>
<td></td>
<td>2,180,000</td>
</tr>
</tbody>
</table>
### Exhibit 6-3
**Example Comparative Cost Summary**

<table>
<thead>
<tr>
<th>Site:</th>
<th>Base Year:</th>
<th>Location:</th>
<th>Date:</th>
<th>Phase:</th>
<th>Feasibility Study (+30% to +50%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Former Industrial Site</td>
<td>2000</td>
<td>Any City, Any State</td>
<td>April 12, 2000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### COMPARISON OF TOTAL COST OF REMEDIAL ALTERNATIVES

<table>
<thead>
<tr>
<th>Description</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 3</th>
<th>Alternative 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Project Duration (Years)</td>
<td>No Action</td>
<td>Limited Action/</td>
<td>In Situ</td>
<td>Ex Situ</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>Natural Attenuation</td>
<td>Treatment</td>
<td>Treatment</td>
</tr>
<tr>
<td>Capital Cost</td>
<td>$0</td>
<td>$147,000</td>
<td>$3,677,000</td>
<td>$5,390,000</td>
</tr>
<tr>
<td>Annual O &amp; M Cost</td>
<td>$0</td>
<td>$41,000</td>
<td>$206,000</td>
<td>$146,000</td>
</tr>
<tr>
<td>Total Periodic Cost</td>
<td>$0</td>
<td>$68,000</td>
<td>$72,000</td>
<td>$43,000</td>
</tr>
<tr>
<td>Total Present Value of Alternative</td>
<td>$0</td>
<td>$690,000</td>
<td>$6,501,000</td>
<td>$6,649,000</td>
</tr>
</tbody>
</table>

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**Resources for FS Cost Estimates**

[https://frtr.gov/costperformance/remediation/](https://frtr.gov/costperformance/remediation/)

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[https://frtr.gov/costperformance/remediation/](https://frtr.gov/costperformance/remediation/)

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[https://frtr.gov/costperformance/remediation/](https://frtr.gov/costperformance/remediation/)
Public Perception – requires effective communication

• Meet/speak with the regulator to present and discuss potential remedial alternatives before launching the FS (or CMS, RAP, RAA, etc.)

• Establish whether the project requires public notice and set a schedule

• Establish a Community Relations Plan for the project (either formal or informal)
  - Mail/Email list
  - Project website and/or Facebook page
  - Fact sheets
  - FAQs
  - Provide update flyers after key milestones
  - Informational meetings w/local government officials
  - Informational meetings w/abutters
  - Informational meetings w/the public (one-on-one or group)
  - Caution with “town hall” style Q&A sessions – break up into small groups and use “science fair” style presentations/discussions
  - Refer to EPA and State guidance documents on Community Relations Plans

Resources for FS Cost Estimates

https://frtr.gov/costperformance/remediation/
FS Lessons Learned

- Engage the regulator early regarding potential alternatives to be presented in the FS.
- Use tables, charts, and figures to streamline presentation of remedial technology screening and alternatives evaluation – avoid long narrative text.
- Keep the number of alternatives to a minimum, particularly for small sites (e.g. 2 or 3 at most)
- Use presumptive remedies where they fit with site conditions.
- Flesh out the remedial alternative (i.e. conceptual design) to a sufficient degree to support cost estimating.
- Use the EPA’s Cost Estimating guidance for consistent format
- Engage with the community early in the process with the regulator as a partner