Mine Cleanup
Hydraulic mining damage at Pioneer Pit
Considering Cleanup Options

- Off-Site Disposal
- On-Site repository (above or below ground)
- Cover and stabilization
- All should include erosion controls and revegetation planning
- All may require treatment of acid mine drainage
Off-Site Disposal

- Consider off-site impacts
- Consider impacts to air and climate resulting from off-site disposal
- Consider off-site disposal reg. requirements
- Consider impacts to site stability post-extraction
- Consider the future cleanup (long term O&M); what’s next?
Emissions rates for Option A alone (based on estimated number of truck-days required, emission factors, and 1,100 mile roundtrip to nearest disposal facility).

<table>
<thead>
<tr>
<th>Air contaminant</th>
<th>Quantity over trip duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen oxides (NO&lt;sub&gt;x&lt;/sub&gt;)</td>
<td>354 tons</td>
</tr>
<tr>
<td>Carbon monoxide (CO)</td>
<td>34 tons</td>
</tr>
<tr>
<td>Volatile organic compounds (VOCs)</td>
<td>6 tons</td>
</tr>
<tr>
<td>Particulate matter</td>
<td>5 tons</td>
</tr>
<tr>
<td>Sulfur dioxide (SO&lt;sub&gt;2&lt;/sub&gt;)</td>
<td>&lt;1 ton</td>
</tr>
<tr>
<td>Carbon dioxide (CO&lt;sub&gt;2&lt;/sub&gt;)</td>
<td>23,085 tons</td>
</tr>
</tbody>
</table>

Send it back to the mine!
On-Site Repository

- Consider liner and cap design
  - Drainage (materials may be moist)
- Apply substantial erosion controls
- Consider design life
  - Use RUSLE to determine appropriate thickness
- Examples of use include arsenic, mercury and radiologicals
Tailings Pile at BV/Klau Mine
Excavation and Rep. Construction
Repository Drainage System
Completed Repository
In-Situ Stabilization

- Regrade and/or cover
- Attempt to cut-off exposure pathways
- Decrease mobility and leachability of contaminants
- Will the cover withstand erosion?
Rinconada Mine
Gambonini Mine Stabilization

Sloping, cover and revegetation
Blue Ledge Stabilization

Sedimentation basin construction
Create a “reactive cover” by Decreasing Bioavailability *in-situ*

- Various substances can be used to decrease bioavailability (and therefore toxicity) *in-situ*
  - Biosolids and Water Treatment Residuals (other OM)
  - Amendments
    - Limestone, use for arsenic, lead, zinc, cadmium
    - Phosphate, use for lead sites
  - Basis provided by bioavailability & ecotoxicity tests
- See the new white paper *Amendments for Ecological Restoration*
McCleur Tailings Site

• The McCleur Tailings Site is an abandoned mine with high arsenic and lead concentrations in soil
  – Estimated bioavailability before and after treatment with biosolids, limestone and phosphate.
  – Demonstrated a reduction in bioavailability and leachability
  – Demonstrated that the site could be revegetated for erosion control
Biosolids

Primary Treatment
Secondary Treatment
Tertiary Treatment

Raw water 
Primary effluent 
Secondary effluent 
Tertiary effluent 

Settling 
Biological 
Chemical 
Flocculation 
Filtering 

Residences 
Commercial Industrial 

Biosolids treatment/ stabilization 

Residues
Biosolids

- Produced by all municipalities
- Use regulated under 40 CFR 503
- 70% of biosolids are now land applied
- Cost - "subsidized" by municipality

Courtesy of H. Compton, EPA & Dr. S. Brown, U. Wash.
In-vitro bioavailability

- Physiologically Based Extraction Test (PBET) & others
- Correlated to past in-vivo bioavailability studies
Soil Characteristics

Tailings

- Tailings A
  - Total Lead 3%,
  - 30,000 ppm
  - Total Arsenic 300 ppm
  - pH 2.3

- Tailings B
  - Total Lead 0.2%,
  - 2,000 ppm
  - Total Arsenic 200 ppm
  - pH 2.7
High Iron Compost Addition
Reduction in Lead Availability

Soil A

Soil B
Achievements

• After removal of tailings and waste rock from the stream bed, amendments were used to bind heavy metals and create a growth media for plants
  – Achieved stability of the pile and stream channel, limited runoff and erosion
  – Achieved decrease in toxicity to a protective level
# Options Analysis

<table>
<thead>
<tr>
<th>Options</th>
<th>Consistency with RBCG</th>
<th>Consistency with Land-Use</th>
<th>Feasibility &amp; Special Considerations</th>
<th>Costs &amp; Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Option A:</strong></td>
<td>Consistent with achieving the cleanup goal b/c waste will be disposed off-site</td>
<td>No risk of re-exposure to small areas due to human or animal perturbation</td>
<td>It may be physically impossible to remove some contamination. These areas will likely require cover (true of all options).</td>
<td>Costs and duration of cleanup are extremely high b/c of transportaton and disposal</td>
</tr>
<tr>
<td>Disposal off-site</td>
<td></td>
<td></td>
<td></td>
<td>Estimated $37,127,000 to $44,552,000 (inc. 20% contingency)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Minimum 3 seasons</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Large uncertainty</td>
</tr>
</tbody>
</table>
## Option B

| **Option B:** Disposition in an on-site repository | Consistent with the cleanup goal b/c waste will be encapsulated on-site  
Highest level material may be difficult to stabilize/shield | Low to medium risk of re-exposure due to human or animal perturbation  
May create a small area of restricted use land (temporarily) | May be difficult to manage long-term stability of cover (requires design & monitoring) | Costs and duration of cleanup are moderate  
Moderate uncertainty – best estimate approx.  
$10,000,000  
Approx. 1 construction season  
Moderate uncertainty |
|---|---|---|---|---|

Consistent with the cleanup goal b/c waste will be encapsulated on-site. Highest level material may be difficult to stabilize/shield. Low to medium risk of re-exposure due to human or animal perturbation. May create a small area of restricted use land (temporarily). May be difficult to manage long-term stability of cover (requires design & monitoring). Costs and duration of cleanup are moderate. Moderate uncertainty – best estimate approx. $10,000,000. Approx. 1 construction season. Moderate uncertainty.
## Option C

<table>
<thead>
<tr>
<th><strong>Option C:</strong> Regrading &amp; covering <em>in-situ</em></th>
<th>Consistent with achieving the cleanup goal b/c waste will be covered with clean material</th>
<th>Medium risk of re-exposure due to human or animal perturbation. May require larger areas of restricted use land compared to Opt. B (temporarily)</th>
<th>May be difficult to manage long-term stability of cover (requires design &amp; pot. monitoring). Requires significantly more material than Opt. B.</th>
<th>Costs and duration of cleanup are moderate to high-importation of fill for cover will have substantial costs which will depend upon the proximity of the borrow source. No Cost estimate made. Large uncertainty</th>
</tr>
</thead>
</table>
Erosion Controls

• Erosion controls and revegetation planning
• Channel design
  – HDSC
  – Channel Worksheet.xls
  – Stream Corridor Restoration Guide
  – Channel Pro
• Revegetation
  – Seek University or local Conservation Corps assistance
  – Use native plant guides
Erosion Control – blankets, bales, slope
Confirmation Sampling

- Traditional sampling w/ reversed assumptions
- Radiologicals require scanning & sampling
- Others?
Happy Campers!
Questions?

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  – Allen.HarryL@epa.gov