Application of the Enhanced Adaptive Management Model for Mercury Remediation in the South River, VA

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South River Overview

• Background / History
• South River Science Team
  – Conceptual Model
  – Proposed bank stabilization
• Adaptive Management
• Enhanced Adaptive Management
South River Timeline

• 1930 – 1950
  – Mercuric sulfate in rayon production

• 1970s
  – Mercury in fish tissue discovered
  – Natural recovery remedy selected

• 1980s and 1990s
  – South River and South Fork
    Shenandoah River monitoring

• 2001
  – First meeting of South River
    Science Team held

• 2002 – 2013
  – Scientific studies and pilots

• 2014
  – RCRA permit modification
South River Science Team

• Formed in 2001
• Technical focal point of extensive scientific studies and pilots
• Collaborative – Commonwealth of Virginia, federal agencies, national experts, academia, NGOs, consultants, and DuPont
South River Conceptual Model
## Mercury Loading to the South River

<table>
<thead>
<tr>
<th>Mass Loading of Mercury to Fish Tissue *</th>
<th></th>
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<tbody>
<tr>
<td>3% to 5%</td>
<td>Plant site outfalls</td>
</tr>
<tr>
<td>40% to 60%</td>
<td>Eroding banks (historic deposits)</td>
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<tr>
<td>15% to 35%</td>
<td>In-channel sediments</td>
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<tr>
<td>5% to 20%</td>
<td>Other</td>
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</tbody>
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*first 10 river miles downstream of plant
Project Uncertainties

• Conceptual site model
  – Mass balance / mass loading
  – Bioavailable pool of mercury
  – Complexities of mercury cycling
  – Threshold concentrations
  – In-channel recovery processes
  – Restoration time frames

• Achievable remedial goals
  – Technical impracticability limitations

• Permitting and access agreements

• Public acceptance
Remedial Action Objectives (RAOs)

• Short-Term RAOs (Phase 1 Interim Measure)
  – Reduce mercury transport and exposure
  – Improve bank habitat in the first two miles downstream of the plant

• Long-Term RAOs
  – Reduce methylmercury exposure
  – Improve habitat conditions throughout the South River and South Fork Shenandoah River

• Cleanup Goals
  – Determined by RCRA process
  – Adaptive management options considered
Phase 1: Bank Remediation

Bank remediation areas based on erosion rates and mercury bank concentrations

Roughly 90% of total mercury bank loading attributable to 20% - 25% of banks
<table>
<thead>
<tr>
<th>Plan</th>
<th>• Determine management options</th>
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<tbody>
<tr>
<td></td>
<td>• Define key desired outcomes</td>
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<tr>
<td></td>
<td>• Identify performance indicators</td>
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<td></td>
<td>• Develop management strategies/actions</td>
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<tr>
<td>Do</td>
<td>• Monitor selected performance indicators</td>
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<td></td>
<td>• Implement strategies and actions to achieve objectives</td>
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<tr>
<td>Evaluate and Learn</td>
<td>• Evaluate management effectiveness</td>
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<tr>
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<td>• Discuss findings and recommendations</td>
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<tr>
<td>Adjust</td>
<td>• Adjust management actions to enhance effectiveness</td>
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<td>• Periodically review overall management program</td>
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(based on Jones, 2005)
Enhanced Adaptive Management (EAM)

- Provides a framework to learn from remedial actions
- Promotes focused monitoring and studies to reduce uncertainty
- Supports evaluation of responses under phased implementation
- Includes decision model to compare remedial alternatives
EAM Key Elements: Decision Model

- Prioritize management strategies and identify uncertainties (Phase 1 bank remedial alternatives)
- Evaluate alternatives based on variable weighting of the following:
  - Effectiveness
  - Habitat improvements
  - Implementability
  - Cost
  - Stakeholder goals
- Track conflicting objectives and trade-offs
EAM Key Elements: Decision Analysis

- Define potential range of future outcomes
- Multiple tools for evaluation and analysis
  - Statistical and graphical techniques
    - Compare range of baseline conditions with range of post-remedy outcomes
  - Dynamic mercury cycling model
    - Constrains conceptual site model and mass balance
    - Predicts outcome of remedial actions
  - Relative risk model
    - Frames range of baseline and post-remedy risks, including those not associated with mercury
    - Assesses unintended consequences and benefits
EAM Key Elements: Monitoring and Analysis Plan

- Collect data on key site conditions to inform management decisions
  - Pre-remedy baseline monitoring
  - Post-remedy monitoring
EAM Key Elements:
Monitoring and Analysis Plan (cont’d)

- Linked to RAOs and evaluation criteria
  - Mercury and methylmercury in abiotic and biological media
  - Physical and biological system parameters
  - Representative ecological community and population conditions
  - Public and landowner acceptance, permitting, and access
  - Implementation, management, and monitoring costs
  - Stakeholders’ interests throughout the watershed
South River Phase 1  EAM

Remedial Options

- Enhanced Vegetative Stabilization
- Structural Stabilization
- Institutional Controls
- Removal
- Other

Monitoring Data → Mercury Cycling Model → Relative Risk Model → Statistical Evaluation → Stakeholder Feedback → Outcome

Outcome:
- Adjust Approach for Miles 2-4
- Consult/Discuss
- Evaluate (EAM) and Report
- Consult/Discuss
- Adjust CSM or Approach for Miles 0-2

Relative Risk Model

Stakeholder Feedback
Benefits

• Adaptive Management
  – Promotes flexible decision making given uncertainties
  – Provides opportunity for iterative learning through careful monitoring of the effects of management options
  – Advances understanding of chemical, biological, and social processes in light of specific actions

• Enhanced Adaptive Management (EAM)
  – Provides framework for the reduction of uncertainty through iterative actions
  – Allows prediction of range of outcomes from remedial actions
  – Documents (and archives) assumptions
  – Ensures that adaptive management is not “trial and error”
Acknowledgements

• South River Science Team
• DuPont Team
• URS Team
• Anchor QEA Team
• Virginia Department of Environmental Quality

Visit the South River Science Team’s website at www.southriverscienceteam.org
QUESTIONS