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Establishing Baseline Data for Short- and Long-Term Monitoring to Evaluate Remedy Effectiveness for a Mercury Contaminated Sediment System

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INTRODUCTION

Mercury (Hg) was used in the manufacturing process at a facility in Waynesboro, Virginia between 1929 and 1950. In the course of the process, Hg was released and subsequently migrated into surface water, sediments, soils, and biota of the South River. Interim remedial measures have been designed to control bank erosion, an important source of Hg loading to the South River. Monitoring plans have been developed to quantitatively evaluate remedy effectiveness over both short- and long-term periods based on remedial action objectives (RAOs). Monitoring plans are iterative and can be modified within the framework of adaptive management. Details of both the short- and long-term monitoring (STM and LTM, respectively) including aspects of the adaptive management framework, are presented.

APPROACH

- Builds on previous studies that characterized site conditions
  - Hg fate and transport
  - Human health and ecological risk
  - Pilot remediation projects
- Spatial extent: South River and South Fork Shenandoah River (Figure 1)
- STM: 2 to 10 years
- LTM: >10 years
- Similar overall goals, spatial and temporal differences
- Adaptive management framework for remedial decision-making

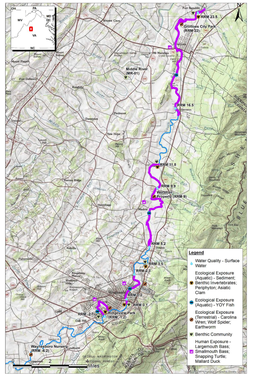


Figure 1. Study Area

SHORT-TERM MONITORING

- STM spatially limited to specific Bank Management Areas (BMAs)
- BMAs: locations that contribute greatest Hg load (Figure 2)
- Specific bank treatments selected for each BMA
- STM designed to measure a reduction of bank erosion and Hg loading (Table 1) (Figure 3)

Figure 2. BMAs Selected Based on Erosion / Hg Concentrations

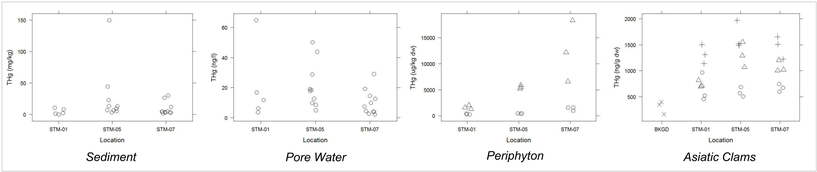
SHORT-TERM MONITORING *(continued)*

Table 1. STM Response Objectives and Metrics

Short-Term Remedial Action Objectives				Monitoring Plan Designs	Monitoring Frequency	Analytical Parameters	Adaptive Management Outcomes	
General Objective	Performance Objective	Metric	Success Criteria	General Station Locations			Contingency Actions	Decision Analysis
Reduce Mercury Transport and Exposure	Increase in Bank Stability	Topography	Reduced Erosion	Shore Based LiDAR Surveys Conducted at Each BMA	3 Years Annually Post Storm	Average Annual Erosion Rate	Structural / Vegetative Stabilization	Effectiveness
		Vegetation	>80% Cover; <10% Invasives	Vegetation Plots at Each BMA	3 Years Annually Post Storm	Cover and Species Composition	Vegetation Enhancement	Effectiveness
		Design and Implementation	Landowner Approvals Permits	BMA Properties	NA	NA	NA	Implementation
	Reduce Mercury Loading from Bank	Surface Sediment	>75% Hg Reduction	Transects Spaced 100-200' at each BMA	3 Years Biannually	IHg and MeHg Concentrations	NA	Effectiveness
		Pore Water	>75% Hg Reduction	Transects Spaced 100-200' at each BMA	3 Years Biannually	IHg and MeHg Concentrations	NA	Effectiveness
		Periphyton	>75% Hg Reduction	Downstream of Representative BMAs (Nearshore)	3 Years Biannually	IHg and MeHg Concentrations	NA	Effectiveness
		Asiatic Clam Sampling	>75% Hg Reduction	Downstream of Representative BMAs (Nearshore)	3 Years Biannually	IHg and MeHg Concentrations	NA	Effectiveness
	Reduce In-Channel Mercury Exposure	Periphyton	>50% Hg Reduction	Downstream of Representative BMAs (Channel)	10 Years Annually	IHg and MeHg Concentrations	NA	Conceptual System Model
		Asiatic Clam Sampling	>50% Hg Reduction	Downstream of Representative BMAs (Channel)	10 Years Annually	IHg and MeHg Concentrations	NA	Conceptual System Model
Maintain or Improve Riparian and Aquatic Habitat	Improve Bank Vegetation	Vegetation	>80% Cover; <10% Invasives	Vegetation Plots at Each BMA	3 Years Annually	Cover and Species Composition	Vegetation Enhancement	Effectiveness
	Improve In-Stream Habitat	Rapid Bioassessment Protocols	Visual Stream Classification	Downstream of Representative BMAs	Quaterly for First Year Bi Annually for years 2-10	Rapid Bioassessment Protocol Scores	NA	Effectiveness

Baseline STM Results

Figure 3. Total Mercury in Abiotic and Biotic Media



LONG-TERM MONITORING

LTM evaluates ecosystem changes with regard to Hg throughout the South River and South Fork Shenandoah River watersheds (Figure 4)

Human Exposure

- Total Hg and methylmercury
- Largemouth / smallmouth bass
- Snapping turtle
- Mallard duck

Terrestrial Exposure

- Total Hg and methylmercury
- Adult Carolina wren
- Wolf spiders
- Earthworms

Aquatic Exposure

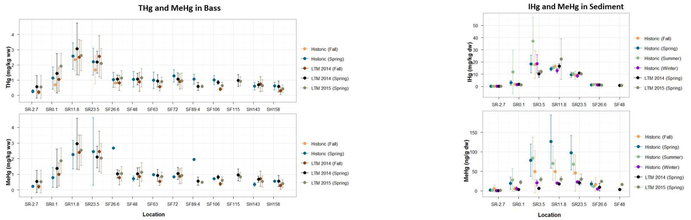
- Total Hg and methylmercury
- YOY fish
- Sediment
- Benthic invertebrate tissue
- Periphyton

Water and Habitat Quality

- Surface water total and methylmercury
- Benthic community assessment
- Substrate condition

LONG-TERM MONITORING *(continued)*

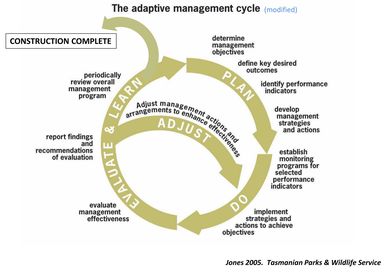
Figure 4. Baseline LTM Results



ADAPTIVE MANAGEMENT

- Structured / iterative decision-making process (Figure 5)
- Defines specific objectives of remediation
- Integrates monitoring data with historical data
- Evaluates remedial effectiveness / potential attainment of RAOs
- Provides a range of alternatives
- Reduces uncertainty

Figure 5. Adaptive Management Approach[1]



[1] Jones, G. 2005. Is the management plan achieving its objectives? In: Worboys, G., T. De Lacy, and M. Lockwood. Protected area practice management. Principles and practice. Oxford University Press.

DISCUSSION

- Plans provide a monitoring approach in a flexible framework to evaluate the effectiveness of the remedial actions based short-term and long-term RAOs
- Inform future remedial action, as necessary

Path Forward

- Baseline data collected in 2014 / 2015
- Final design / permitting for bank treatments

The work described in this poster has been performed in conjunction with the South River Science Team (SRST), a multi-stakeholder group including representatives from local, state and federal governments, academia, environmental groups and DuPont. The SRST is a collaborative team created to provide input into the watershed-level, risk-based assessment framework to address mercury in the system.
www.southriverscienceteam.org