AOC 4 Monitoring Program: Technical Briefing Paper

This briefing paper summarizes the objectives, approach, and status of the monitoring program for Area of Concern (AOC) 4 of the former DuPont Waynesboro manufacturing facility (site) in Waynesboro, VA. AOC 4 includes the South River downstream of the site and a portion of the South Fork Shenandoah (SFS) River. Interim remedial measures are being designed to control mercury loading from eroding river banks and the site (Anchor QEA et al., 2014). A monitoring program to test the efficacy of remedial measures is appended to the design work plan.

The monitoring program contains both a short-term monitoring plan and a long-term monitoring plan, which differ in terms of relevant spatial and temporal scales, but are both designed to provide information to monitor achievement of remedial action objectives (RAOs) described in the Phase 1 Interim Measures Design, Implementation and Monitoring Work Plan (Anchor QEA et al., 2014). The RAOs are listed in Table 1. Short-term RAOs are expected to be addressed through interim measure construction, while long-term RAOs take into account future corrective actions to be implemented.

References

- ✓ Anchor QEA, LLC, URS Corporation, and E. I. du Pont de Nemours and Company. 2014. Phase 1 Interim Measures Design, Implementation and Monitoring Work Plan. South River, Area of Concern 4. Final Report, August 2014.
- ✓ URS, 2012. Final Report: Ecological Study of the South River and a Segment of the South Fork Shenandoah River, Virginia. Fort Washington, Pennsylvania. Final report prepared by URS Corporation. September 2012.

The short- and long-term monitoring plans detail specific monitoring and data interpretation methods to address specific objectives. Both monitoring plans rely on characterization of current baseline conditions in the river system. Existing data sets collected as part of the Ecological Study (URS 2012) and VDEQ 100-Year Monitoring Program for the South River, provide initial background data for establishment of baseline conditions. Additional baseline monitoring will include focused supplemental data collection as necessary, to support ongoing monitoring. The short- and long-term monitoring plans are summarized in the following sections. Additional details are presented in Appendices D and E of the Interim Measures Work Plan (Anchor QEA et al., 2014).

Short-Term Monitoring Plan

The short-term monitoring plan is designed to measure improvements over relatively rapid timeframes (e.g., 2 to 10 years) and small spatial scales, such as adjacent to a particular remedial target (e.g., eroding bank). Short-term monitoring plan elements, including details such as sample frequency and location are included as Table 2.

First and foremost, the short-term monitoring will assess whether the physical specifications of a remedy are being met, and ensure that the physical integrity of the remedy is repaired should it be affected by flooding or other events.

Secondly, the short-term monitoring will provide chemical and biological information that will feed into the relative risk model and the adaptive management approach.

Combined, these data will allow for feedback on the efficacy, integrity, and performance of the remedy, and whether or not the remedial action objectives are being met.

Long-Term Monitoring Plan

The long-term monitoring is designed to measure potential mercury exposures to humans and ecological receptors, as well as monitor habitat improvements and responses to remediation. While the short-term monitoring will be focused primarily in the South River at or near those areas where bank management area remedies are being implemented, the long-term plan is designed to cover a timeframe of many years to decades, and a much larger area, including watersheds of the South River and SFS River. Sample locations and methodologies are based on the extensive data collected by the South River Science Team. The monitoring elements are listed in Table 3 lists along with sampling details, including sample locations, sample frequency and sample sizes.

Similar to the short-term monitoring plan, chemical and biological results from the long-term monitoring will also feed into the relative risk modeling and the adaptive management approach. In this way, both the short- and long-term information will be used as input to management decisions regarding the efficacy of remedial actions, the need to alter approaches or evaluate new or improved technologies, or to maintain and/or repair areas as necessary.

Most importantly, the monitoring information will help in estimating changes in the potential exposures and risks to humans and ecological receptors that result from changes in mercury loading to the South River and SFS River. It is expected that once remedial actions have been implemented in the South River, the mercury loading should decline and be accompanied by a concomitant reduction in potential mercury exposures and potential risks to humans and ecological receptors. There will be open and frequent outreach and communication with local communities, physicians and health clinics, and relevant public-health groups throughout the implementation and monitoring of the remedial strategy.

Table 1
Remedial Action Objectives
AOC 4 Monitoring Program Briefing Paper
South River and a Segment of the South Fork Shenandoah River

Time Frame	General Response Objectives	Performance Objective	Measurable Metric
Short-Term (2-10 years)	Reduce mercury transport and exposure and improve bank habitat functions within the upper two miles of the South River	Conduct and/or maintain bank remediation actions in the upper two miles of the South River to achieve sustainable reductions in mercury concentrations and improve water quality and bank habitat functions within this reach	Bank erosion rates, measured using detailed topographic surveys, and/or root analysis; establishment of bank vegetation; and mercury concentrations in physical media and biological tissues
Long-Term (10+ years)	Reduce MeHg exposure and improve habitat conditions throughout the South River and SFS River	Conduct and/or maintain remediation actions that sustain reductions in tissue MeHg concentrations and improve water quality and habitat functions throughout the South River and SFS River	Mercury concentrations in biological tissues and physical media, and bank and in-channel habitat metrics

Notes:
SFS: South Fork Shenandoah
MeHg: methylmercury

Table 2
Short-Term Monitoring Scope Summary
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South River and a Segment of the South Fork Shenandoah River

Short-Term Remedial Action Objectives				Monitoring Plan Designs			Adaptive Management Outcomes	
General Objective	**Performance Objective**	**Measurable Metric**	**Preliminary Success Criteria**	**General Station Locations**	**Monitoring Frequency**	**Analytical Parameters**	**Contingency Actions**	**Decision Analysis**
Reduce Mercury Transport and Exposure	Increase in Bank Stability	Topography	Reduced Annual Erosion Rate	Shore Based LiDAR Surveys Conducted at Each BMA	Annually for First 3 Years; Post-storm	Average Annual Erosion Rate	Structural and/or Vegetative Stabilization	Refine Effectiveness Estimates
		Vegetation	>80% Cover; <10% Invasives	Vegetation Plots at Each BMA	Annually for First 3 Years; Post-storm	Cover and Species Composition	Additional Vegetation Enhancement	Refine Effectiveness Estimates
		Design and Implementation	Landowner Approvals and Permits	BMA Properties	NA	NA	NA	Refine Implementation Estimates
	Reduce Mercury Loading from Bank	Surface Sediment	>75% Mercury Concentration Reduction	Downstream of Representative BMAs (Nearshore)	Twice Annually for First 3 Years	IHg and MeHg Concentrations	NA	Refine Effectiveness Estimates
		Periphyton	>75% Mercury Concentration Reduction	Downstream of Representative BMAs (Nearshore)	Twice Annually for First 3 Years	IHg and MeHg Concentrations	NA	Refine Effectiveness Estimates
		Asiatic Clam Sampling	>75% Mercury Concentration Reduction	Downstream of Representative BMAs (Nearshore)	Twice Annually for First 3 Years	IHg and MeHg Concentrations	NA	Refine Effectiveness Estimates
	Reduce In-Channel Mercury Exposure	Periphyton	>50% Mercury Concentration Reduction[a]	Downstream of Representative BMAs (Channel)	Annually for First 10 Years	IHg and MeHg Concentrations	NA	Refine CSM
		Asiatic Clam Sampling	>50% Mercury Concentration Reduction[a]	Downstream of Representative BMAs (Channel)	Annually for First 10 Years	IHg and MeHg Concentrations	NA	Refine CSM
Maintain or Improve Riparian and Aquatic Habitat	Improve Bank Vegetation	Vegetation	>80% Cover; <10% Invasives	Vegetation Plots at Each BMA	Annually for First 3 Years	Cover and Species Composition	Additional Vegetation Enhancement	Refine Effectiveness Estimates
	Improve In-Stream Habitat	Rapid Bioassessment Protocols	Visual Stream Classification	Downstream of Representative BMAs	Quaterly for the First Year and Semi Annually (Q1/Q3) for years 2-10	Rapid Bioassessment Protocol Scores	NA	Refine Effectiveness Estimates

Notes:
NA - Not applicable
IHg - Inorganic Mercury
MeHg - MethylMercury
CSM - Conceptual Site Model
BMA - Bank Management Area
a, May be applicable for long-term evaluations rather than for short-term evaluations.

Table 3
Long-Term Monitoring Scope Summary
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South River and a Segment of the South Fork Shenandoah River

Monitoring Element	Objective	Measurements	Proposed Sampling Frequency	Samples per Location	Locations
Monitor Potential Human Exposure					
Largemouth Bass Smallmouth Bass	● Monitor trends in human exposure to MeHg in adult fish ● Develop non-lethal mercury monitoring techniques for the South River	● THg and MeHg in filets and biopsy plugs ● Total length, weight	Twice annually (May and October)	10 bass (SMB and LMB)	**South River:** RRM -2.7* RRM 0.1 to 2.3 RRM 5.2 to 11.8 RRM 16 to 23.5 **SFS:** Lynwood, VA near Rt. 708 bridge (RRM 26) Shenandoah, VA boat ramp (RRM 48) Newport Landing (RRM 63) Hamburg, VA near Rt. 211 bridge (RRM 72) Fosters Landing near Rt. 684 bridge (RRM 89) Bentonville Landing near Rt. 613 bridge (RRM 106) Karo Landing (RRM 115) **Shenandoah River:** Rt. 17/50 bridge (RRM 143) Berryville, VA near Rt. 7 bridge (RRM 158)
Snapping turtle[1]	● Monitor trends in human exposure to MeHg in snapping turtles	● THg and MeHg in turtle blood or nail tissue[2] ● Total length, weight	Once annually (May-July)	3	
Mallard duck[1]	● Monitor trends in human exposure to MeHg in mallard ducks	● THg and MeHg in breast muscle tissue ● Sex, reproductive status ● Length, weight	Once annually [October - January (waterfowl hunting season)]	3	
Community outreach	● Monitor trends in human exposure to mercury, including adherence to the fish consumption advisory	● Outreach to non-English-speaking communities (e.g., the Promotores de Salud program and outreach to other non-English language groups) ● Physician and clinic newsletters ● Angler surveys	● Annual outreach to non-English speaking groups, local physicians, and health clinics ● Once every 3 years for the angler survey	NA	Focused on Waynesboro, but also including the downstream locales of Dooms, Crimora and Grottoes. Also dependent on locations of local/state health clinics.
Monitor Ecological Exposure					
Aquatic					
YOY fish	● Monitor exposure of YOY fish to MeHg in water and dietary items ● Monitor exposure of ecological receptors (e.g., piscivorous birds) to MeHg in YOY fish ● Document potential declines in exposure due to remediation	● THg and MeHg in whole fish	Once annually (August - October)	10	RRM -2.7* RRM 0.1 to 2.3 RRM 5.2 to 11.8 RRM 16 to 23.5 SFS near Lynwood, VA (RRM 26) SFS near Shenandoah, VA (RRM 48)
Sediment	● Monitor exposure of invertebrates to sediment MeHg ● Monitor natural recovery of sediment	● THg and MeHg in sediment collected from coarse grained beds	Once annually (May)	3	RRM -2.7* RRM 0.1 RRM 3.5 RRM 11.8 RRM 23.5 SFS near Lynwood, VA (RRM 26) SFS near Shenandoah, VA (RRM 48)
Benthic invertebrates	● Monitor exposure to invertivorous ecological receptors (e.g., YOY fish) ● Monitor responses to decreasing mercury loads	● Tissue THg, MeHg in Mayfly tissue	Twice annually (May and October)	3	
Periphyton	● Monitor THg and MeHg in periphyton, which is an important exposure medium for benthic invertebrates ● Provide a data set for comparison with short-term monitoring elements	● THg and MeHg in periphyton	Twice annually (May and October)	3	
Asiatic clam tissue	● Provide a data set for comparison with short-term monitoring elements	● Tissue THg, MeHg in asiatic clam tissue	Twice annually (May and October)	3	
Terrestrial					
Adult Carolina Wren	● Monitor songbird exposure to MeHg	● THg in blood ● Weight	Once annually (June - July)	3-8 individuals	**South River (Reference):** Waynesboro Nursery (RRM -6.2)* Ridgeview Park (RRM -1.2)* **South River:** RRM 0.1 to 2.3 Wertman Property (RRM 9) Grottoes City Park (RRM 22) **SFS:** Power Dam (RRM 31) Shuller's Island (RRM 50) Long Bend Farm (RRM 66) Bealer's Ferry (RRM 85)
Wolf Spiders (family Lycosidae)	● Monitor exposure of terrestrial ecological receptors to MeHg in spiders ● Monitor MeHg transfer between aqueous and terrestrial compartment of the South River	● THg and MeHg in spiders ● Size	Once annually (June - July)	5 individuals	
Earthworms	● Monitor exposure of terrestrial ecological receptors to MeHg in earthworms ● Monitor potential terrestrial MeHg bioaccumulation	● THg and MeHg in earthworm tissue and soil	Once annually (June - July)	3 composite samples	
Water Quality and Habitat Quality Monitoring					
Water quality**	● Monitor trends in water quality ● Provide information on inter-annual ● Continue to describe behavior of mercury species in South River	● Surface water: THg, MeHg**, TSS, TOC, DOC, water quality parameters (T, pH, DO, conductivity), and nutrients (Phosphorous)*	Monthly**	1 to 2**	**South River:** RRM -2.7* RRM 0.2 RRM 2.3 RRM 5.2 RRM 9.9 RRM 16.5 RRM 23.5 **SFS:** Lynnwood, Rt 708 (RRM 26) Shenandoah, below dam (RRM 48) Rt. 663
Benthic invertebrate Community	● Monitor improvements to benthic community and benthic habitat	● Benthic community (300 count subsampling)	Twice per year	6	RRM -2.7* RRM 0.1 RRM 3.5 RRM 11.8 RRM 23.5 Middle River*
		● Substrate condition	Once per year	--	

Notes:

DO: dissolved oxygen; DOC: dissolved organic carbon; MeHg: methylmercury; RRM: relative river mile; SFS: South Fork Shenandoah River; T: temperature; THg: total mercury; TOC: total organic carbon; TSS: total suspended solids; YOY: Young-of-Year; LMB: Largemouth bass; SMB: Smallmouth bass

* Reference area

** Sampling conducted in concert with VADEQ routine monitoring; as a result, some parameters are analyzed on a different frequency or for different numbers of replicates

1, Final determination of which additional species, if any, that will be monitored will be made in collaboration with VDH and the regulatory agencies

2, Data have shown good correlation between Hg in muscle and Hg in blood and nails; thus, non-lethal methods will be employed where possible

NA, Not applicable