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Application of a Weight-of-Evidence Evaluation in a Complex Terrestrial Ecological Risk Assessment

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ABSTRACT

A weight of evidence (WoE) framework was applied to assess potential ecological risks to terrestrial receptors due to mercury (Hg) exposure in a riparian system along a historically-impacted river. In ecological risk assessment (ERA), the WoE evaluation integrates multiple lines of evidence that are closely linked to measurement endpoints (MEs) associated with a particular assessment endpoint (AE) for a receptor (Table 1). In ERA, the WoE evaluation has typically been limited to the evaluation of potential ecological risks to benthic receptors. In the current application of the WoE framework, an overall evaluation of terrestrial receptors is performed.

MEs and AEs were selected for eight representative terrestrial receptors, ranging from terrestrial plants to an insectivorous bat. Three characteristics of the MEs were integrated, including: 1) their relative importance; 2) the potential for effects that they represent; and 3) the concurrence among them.

The resulting WoE evaluation provided a holistic assessment of the terrestrial receptors in the riparian system under consideration. The overall finding of the evaluation was consistent with the trophic transfer potential of bioaccumulative methylmercury (MeHg). Although uncertainties were identified, the evaluation identified potential risks of adverse effects for the carnivorous birds and the insectivorous songbirds due to dietary exposures to MeHg, a finding relevant to the remedial decision-making. In this presentation, specific examples of the approach, outcomes, and uncertainties of the WoE evaluation are discussed.

ERA APPROACH

Assessment Reaches

16 Assessment Reaches, including 14 Study Reaches, one Buffer Reach, and one Upstream Reference Reach (Figure 1)

Receptors/Assessment and Measurement Endpoints

11 terrestrial receptors, 11 AEs and 13 MEs (Table 4)

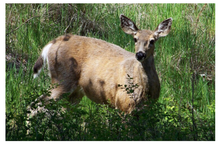
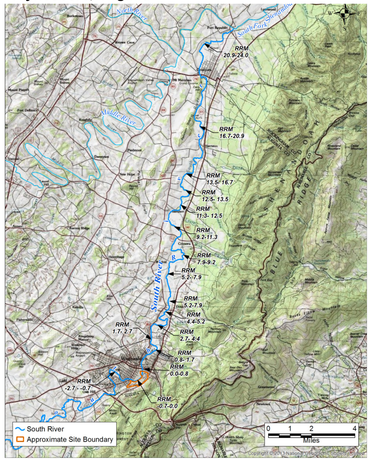


Figure 1. Site Location Map Former DuPont Plant, Waynesboro, Virginia



WEIGHT-OF-EVIDENCE APPROACH

Table 1. WoE Metric

WoE Elements	Metric	Description
Evidence of Effects	Yes/No/Uncertain	Based on comparisons to reference reaches and /or no-effects benchmarks.
Relative Weight	1 to 5, with 5 representing the greatest weight	Based on scores and scaling values for 11 attributes (Menzie et al., 1996); See Table 2 and Equation 1.
Level of Potential Effects	Low, Medium, High	Based on no effects or low effects-based Hazard Quotients (HQ); See Table 3.

Table 2. Measurement Endpoint Attributes to Assign Relative Weight

General Attribute	Specific Attribute	
Association between ME and AE	• Biological linkage • Stressor to response correlations	• Utility of the measure to judge environmental harm
Data quality	• Extent to which data quality objectives (DQOs) are met	
Study design and execution	• Site specificity • Sensitivity of the ME • Spatial representativeness	• Quantitative representativeness • Standard methods • Temporal representativeness
Environmental harm	• Objective measure for judging environmental harm	

Equation 1. Final Weight of the ME (ME_W)[1]

$$ME_W = \left(\sum_{i=1}^{10} scaling\ value \times score \right) \Big/ 4$$

[1] *Menzie et al. (1996). A weight-of-evidence approach for evaluation ecological risks. Human and Ecological Risk Assessment 2(2):277-304.*

Table 3. Level of Potential Effects

Level	Basis
Low	$HQ_{Low\ Effects} \leq 1$, $HQ_{No\ Effects} \leq 2$
Medium	$1 < HQ_{Low\ Effects} \leq 2$, $2 < HQ_{No\ Effects} \leq 4$
High	$HQ_{Low\ Effects} > 2$, $HQ_{No\ Effects} > 4$

RESULTS

Table 4. WoE Matrix for the Representative Study Reaches

RRM 0.0-0.8	ME_W 1	2	3	4	5
Low			A^{No} B^{Un} C^{Un} D^{No} F^{Un} H^{Un} J^{No} K^{No}		
Medium					
High					

RRM 4.4-5.2	ME_W 1	2	3	4	5
Low			A^{No} B^{Un} C^{Un} H^{Un} J^{No} K^{No}	G^{No}	
Medium			F^{Yes}	E^{Yes}	
High			D^{Yes}		

RRM 12.5-13.5	ME_W 1	2	3	4	5
Low			A^{No} B^{No} H^{Un} J^{No} K^{No}		
Medium			F^{Yes}		
High			C^{Yes} D^{Yes}		

SFSR	ME_W 1	2	3	4	5
Low			A^{No} B^{No} F^{Un} H^{Un} J^{No}		
Medium				E^{Un}	
High			C^{Yes} D^{Yes} K^{Yes}		

Notes:

RRM, Relative River Mile; ME_W, Weight of the Measurement Endpoint; SFSR – South Fork Shenandoah River
ME Designations:
A - Soil Chemistry - Plants; B - Soil Chemistry - Invertebrates; C - Dose Rate Modeling (DRM) - Eastern screech owl; D - DRM - Tree swallow; E - Tissue Chemistry - Tree swallow (blood); F - DRM - American robin; G - Tissue Chemistry - American robin (blood); H - DRM - Short-tailed shrew; I - Tissue Chemistry - Short-tailed shrew (fur); J - DRM - White-tailed deer; K - DRM - Big brown bat; L - Tissue Chemistry - Big brown bat (blood); M - Tissue Chemistry - Big brown bat (fur).

WoE Matrix for the Study Reaches

- Generally uncertain or no evidence of effects
- MEs intermediate to high relative importance (i.e., ME_W = 3 or 4)
- Range of potential for adverse effects (low, medium, and high)

Overall Findings

- Evidence of effects, medium to high potential for adverse effects, and intermediate to high ME_W downstream of RRM 2.7 for screech owl and tree swallow MEs
- Potential ecological risks toward carnivorous birds and insectivorous songbirds, consistent with the trophic transfer potential of bioaccumulative MeHg

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.southriversciencteam.org