

Volume III of III

APPENDICES C THROUGH G

Ecological Risk Assessment Report for Former DuPont Waynesboro Site Area of Concern (AOC) 4

South River and a Segment of the South Fork of the Shenandoah River, Virginia

Date: May 1, 2015

Project No.: 18986567.01440



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Appendix C
Mercury Ecological Effects Analysis

Mercury Ecological Effects Analysis AOC4 Ecological Risk Assessment Report Former DuPont Waynesboro Plant, Waynesboro, Virginia

1.0 Introduction

The purpose of the effects analysis is to identify threshold concentrations of THg and MeHg in exposure media that may result in adverse effects to representative ecological receptors identified in the CSM (See Table 3-8 in the main Report). This section reviews the site-specific and literature-derived ecological effects information for mercury and identifies, where possible, the benchmark concentrations for the effects representing the assessment endpoints (See Table 3-9 in the main Report).

As a general approach, measures of various exposures (based on abiotic media concentrations, tissue residues, and estimated daily doses) within AOC-4 will not only be compared against the effects benchmarks identified in this section, but they will also be compared against the same measures of exposures in the site-specific Reference Reaches (e.g., upstream of AOC-4). Such an approach is consistent with the ERA guidelines and provides additional lines of evidence in evaluating the potential ecological risks in AOC-4.

2.0 Benthic Macroinvertebrates

Potential effects to benthic invertebrates exposed to mercury in AOC-4 were evaluated based on the Sediment Quality Triad (SQT) investigations and tissue residue approaches, as discussed in the following subsections.

2.1 Sediment Quality Triad (SQT) Evaluation

As indicated in Section 3.2.4 (in the main Report), as a part of the Ecological Study, a SQT investigation was conducted to evaluate potential mercury-associated toxicity to benthic macroinvertebrates in AOC-4 across a gradient of sediment THg concentrations. A summary of the key elements of the SQT investigation that are pertinent to evaluating potential site-specific effects to benthic macroinvertebrates associated with mercury exposure is presented below.

2.1.1 Sediment Chemistry Evaluation

The results of sediment mercury analyses were compared to generic sediment quality benchmarks (SQBs) to evaluate the potential for mercury-associated effects based on bulk sediment chemistry. Generic SQBs are typically derived from large co-occurrence databases of sediment chemistry and toxicity data from a wide range of freshwater environments. The resulting SQBs have limited relevance to site-specific exposures and may not reflect a reliable cause/effect relation between exposure to an individual constituent, particularly mercury, and an ecological effect observed in test organisms exposed to a mixture of chemical and non-chemical stressors that may be acting together in a sediment toxicity test. Because contaminant concentrations tend to co-vary in

sediments (Long et al., 1998, Smith and Jones, 2006), concentrations of multiple constituents are likely to be correlated with observed toxicity, even when the concentration of the constituent in question is not sufficiently high enough to contribute significantly to toxicity (Fuchsman et al., 2006).

Recognizing the limitations of co-occurrence SQBs, THg concentrations were compared to the severe effects level (SEL) of 2.0 mg THg/kg developed by Persaud et al. (1992). An SQB was not identified from the available literature sources of ecological screening values to evaluate potential exposure to MeHg in sediments.

2.1.2 Pore Water and Surface-Water Chemistry Evaluation

Invertebrate exposure to mercury in aqueous media within the benthic environment may be associated with pore water or surface water. Aqueous exposure of infaunal benthic invertebrates is primarily associated with exposure to pore water; epifaunal benthic invertebrates are exposed primarily to surface water at the sediment-surface water interface, but may also be exposed to pore water in shallow sediment.

Aqueous toxicity studies were evaluated to identify potential effects associated with exposure to mercury in pore water and surface water. Studies presenting concentration-response relationships for survival and growth endpoints for benthic invertebrate test organisms were prioritized in the effects analysis (Chibunda, 2009; Azevedo-Pereira and Soares, 2010; Valenti et al., 2005). Studies using benthic invertebrate test organisms were also queried from the EPA ECOTOX (ECOTOXicology) database to provide additional aqueous endpoints for mercury. Selected studies focused on exposure to freshwater benthic invertebrate test organisms to provide a toxicity dataset relevant to conditions in the South River; test organisms from marine or estuarine environments were excluded.

In studies establishing concentration-response relationships for relevant benthic test organisms exposed to aqueous mercury, statistically significant reductions in growth were observed at lower aqueous mercury concentrations than reductions in survival (Chibunda, 2009; Azevedo-Pereira and Soares, 2010; Valenti et al., 2005). Chibunda (2009) reported no significant reduction in 14-day survival of *Chironomus riparius* exposed to THg concentrations in filtered pore water up to 85,000 ng THg/L; Valenti et al. (2005) reported no significant reduction in the survival of juvenile rainbow mussel (*Villosa iris*) exposed to a solution of mercuric chloride (HgCl_2) containing 114,000 ng THg/L over a 21-day exposure. Figure C-1 presents a cumulative frequency distribution of average median lethal concentrations (LC_{50}) for benthic test organisms exposed to THg in filtered and unfiltered aqueous media over various durations. The distribution indicates that the vast majority of lethal responses to THg in are associated with aqueous exposures exceeding 10,000 ng THg/L (see Figure C-1).

Potential sublethal effects associated with benthic invertebrate exposure to THg in aqueous media were evaluated using studies reporting concentration-response relationships for growth endpoints (Azevedo-Pereira and Soares, 2010; Chibunda, 2009; Valenti et al., 2005). Growth endpoints from these studies were expressed on a relative basis given the varied, but biologically sensitive metrics used to measure growth in each study (e.g., total body length, dry weight). Relative growth was calculated as the ratio of the growth endpoint in the study treatment to the growth endpoint in the study control.

Figure C-2 presents the relative growth of *C. riparius* (8-day and 14-day exposures) and juvenile *V. iris* (21-day exposure) over a range of THg concentrations in aqueous exposure media; open symbols in Figure C-2 indicate growth endpoints that were statistically different than control treatments ($p < 0.05$), as reported in each respective study.

As illustrated in Figure C-2, the relative growth of benthic invertebrate test organisms decreased with exposure to increasing concentrations of THg. The minimum bounded NOEC of 4,000 ng THg/L was identified for the 21-day exposure of juvenile *V. iris* (Valenti et al., 2005); the LOEC of 8,000 ng THg/L was identified as the lowest concentration at which a statistically significant reduction in growth was reported. An ECOTOX query of growth endpoints for freshwater benthic invertebrate test organisms did not indicate a more sensitive growth endpoint for inorganic forms of mercury, indicating that these NOEC and LOEC values are adequately sensitive to evaluate adverse growth effects in AOC-4. Based on this analysis, 4,000 ng THg/L was selected as a NOEC and 8,000 ng THg/L was selected as a LOEC to evaluate potential sublethal growth effects to benthic macroinvertebrates exposed to pore water and surface water at the sediment-surface water interface.

Toxicological data on the effects of aqueous exposures of MeHg on benthic invertebrate test organisms are limited. However, water quality screening benchmarks have been derived for MeHg for the general protection of aquatic life as shown below.

Methylmercury Water Quality Screening Benchmark	NOEC (ng/L)	LOEC (ng/L)	Source
Canadian Water Quality Guideline (WQG)	4	40	CCME (2003)
Effect Concentration (EC20) Daphnids	--	870	Suter (1996)
EPA Tier II Secondary Chronic Value (SCV)	2.8	--	Suter and Tsao (1996)

The bounded NOEC and LOEC values presented in the Canadian Water Quality Guidelines (WQGs) were selected to evaluate potential benthic invertebrate exposure to MeHg in filtered pore water. These values represent conservative screening values derived for the broader protection of aquatic life. As such, these benchmark concentrations are not necessarily indicative of adverse effects to benthic invertebrate organisms, which may be substantially less sensitive to MeHg exposure than the aquatic test organisms (e.g., daphnids) used to derive the benchmarks.

2.1.3 Sediment Toxicity Testing

As discussed in Section 3.2.4 (in the main Report), site-specific toxicity testing (10-day survival and growth of *H. azteca* and *C. dilutus*) was performed as part of a SQT investigation conducted in the South River in 2010 to evaluate benthic macroinvertebrate exposure in the sediment-limited, cobble/gravel, and bedrock benthic habitats that are predominant in the river.

As summarized previously, survival and growth of test organisms in 10-day exposures were not adversely affected across THg and MeHg concentration gradients in sediments from AOC 4 sampling locations. Statistical analyses indicated that survival and growth of *H. azteca* and *C. dilutus* in AOC 4 sampling location treatments were not significantly lower than survival and growth in pooled reference treatments. As illustrated in Figure C-

3 a&b, *H. azteca* and *C. dilutus* survival and growth endpoints were not significantly lower in AOC 4 sampling location treatments with sediment THg concentrations ranging from 0.943 µg/g (RRM 0.1) to 18.9 µg/g (RRM 3.5). Survival and growth endpoints for both test organisms were not significantly lower in AOC 4 sampling location treatments with sediment MeHg concentrations ranging from 1.83 ng/g (RRM 0.1) to 102 ng/g (RRM 3.5; Figure C-3 c&d. The results of site-specific SQT toxicity testing indicate that thresholds for adverse effects on growth and survival of benthic macroinvertebrate test organisms occur at sediment THg and MeHg concentrations greater than 18.9 µg/g and 102 ng/g, respectively.

Above site-specific sediment toxicity test results were evaluated in the context of studies included in the freshwater Sediment Toxicity Database (SEDTOX) compiled by the National Oceanic and Atmospheric Administration (NOAA)¹. Toxicity test endpoints included in the analysis satisfied the control performance criteria for the 10-day *H. azteca* test that was required for acceptance in the SEDTOX database. The evaluation of SEDTOX studies focused on 10-day *H. azteca* survival results due to the availability of a robust dataset ($n = 118$ endpoints), consistency with an endpoint from site-specific toxicity testing, and the application of this 10-day survival endpoint in other assessments of potential injury to benthic macroinvertebrates (Field et al., 2002).

SEDTOX was queried to identify relevant survival endpoints from toxicity studies conducted in sediment environments where mercury was the primary COPEC. To control for the potentially confounding influences of non-mercury chemical stressors, threshold effects concentrations (TEC) and probable effect concentrations (PEC) reported by MacDonald et al. (2000) were used to censor endpoints where toxicity could potentially be the result of exposure to other constituents. Endpoints with sediment THg concentrations below the TEC of 0.18 µg/g were not included in the analysis to limit the confounding influence of toxic results that are not likely associated with mercury exposure. Likewise, endpoints with sediment samples containing non-mercury constituents (e.g., polycyclic aromatic hydrocarbons, pesticides, non-mercury metals) at concentrations exceeding PECs (i.e., PEC quotients (PEC-Q) greater than 1.0) were removed from the analysis. *H. azteca* survival for endpoints retained in the analysis was expressed as a function of control survival (i.e., control-adjusted survival²) to standardize the differences in control performance among the various studies.

As presented in Figure C-4, control-adjusted survival in select 10-day *H. azteca* endpoints from SEDTOX was consistent with control-adjusted survival in site-specific SQT toxicity tests. Survival was not statistically different than control survival in 85 percent of samples with THg concentrations ranging from 0.18 µg/g to 949 µg/g; control-adjusted survival in these samples was 80 percent or greater in 88 percent of samples.

¹ Although SEDTOX endpoints were derived based on bulk sediment samples and SQT endpoints were derived from interstitial sediment, the exposures are considered adequately similar to enable comparisons because interstitial sediment is comprised of approximately 70 percent silt and clay (Flanders et al., 2010).

² Control-adjusted survival was reported in SEDTOX and calculated for South River survival endpoints as the ratio of study treatment survival to reference treatment survival; study treatment survival exceeding reference treatment survival results in a control-adjusted survival value exceeding 100 percent.

The greatest variability in survival was observed at relatively low THg concentrations (0.18 µg/g – 1.0 µg/g), with control-adjusted survival ranging from 47 to 116 percent and 5 of the 18 (28 percent) significantly lower survival endpoints occurring in this concentration range. This variability at relatively low mercury concentrations may be indicative of other undefined stressors influencing survival in these samples. At THg concentrations between 1.0 µg/g and 18.9 µg/g, the maximum THg concentration associated with site-specific SQT endpoints, survival was not statistically lower than control survival in any samples and control-adjusted survival was 80 percent or greater in six of seven endpoints. At THg concentrations greater than 18.9 µg/g, survival in 54 of 67 study endpoints (81 percent) was not significantly lower than control survival. The findings of the SEDTOX data evaluation further validate the findings of site-specific toxicity testing, which indicated negligible effects on *H. azteca* survival at the maximum THg exposure concentration of 18.9 µg/g tested in the SQT investigation.

2.1.4 Summary of Effects Thresholds

Using the analyses presented in the preceding sections, NOECs were identified for sediment exposures for THg and MeHg, as summarized below. Corresponding LOECs were not estimated by simply applying an uncertainty factor (x10) to the NOECs because the estimated NOECs represent the highest tested site-specific sediment concentrations and it is unclear whether an uncertainty factor of 10 is justified.

Site-Specific SQT Sediment Benchmarks ^a	NOEC	LOEC	Basis
Total mercury (mg/kg dw)	18.9	NA	NOECs based on SQT investigations; LOECs not identified.
Methylmercury (mg/kg dw)	0.102	NA	

Notes:

a, To be consistent with the presentation of sediment concentration data, units were converted to mg/kg dw for total mercury (from µg/g dw) and methylmercury (from ng/g dw)

2.2 Critical Body Residues (CBRs)

Literature studies were evaluated to identify critical body residues (CBRs) for mercury in invertebrate tissue residues. These CBRs were used to evaluate potential effects associated with larval insects and crayfish tissue samples collected in AOC-4.

2.2.1 Larval Insects

Nine studies were evaluated that reported mercury concentrations in tissue residues associated with survival, growth, or reproductive success endpoints for aquatic invertebrates (see Table C-1). While most studies evaluated survival endpoints, growth and reproduction endpoints were the most sensitive endpoints.

Potential effects of mercury exposure on benthic invertebrate growth were not identified in a literature review (see Table C-1). Naimo et al. (2000) did not observe diminished growth of hexagenid mayfly nymphs with increasing tissue mercury concentrations up to

0.18 mg MeHg/kg dw (0.037 mg MeHg/kg ww³) or 10.8 mg THg/kg dw (2.16 mg THg/kg ww) during a series of four 21-day bioaccumulation tests (Naimo et al., 2000⁴). Growth was also not influenced in a 9-day experiment with hexagenid mayfly nymphs that accumulated up to 7.49 mg MeHg/kg ww and 3.77 mg THg/kg ww (Saouter et al., 1993). Biesinger et al. (1982) and Niimi and Cho (1983) identified reproductive THg LOECs for the water flea (*Daphnia magna*) of 2.33 and 4.66 mg THg/kg ww, respectively. Other LOECs identified for survival ranged from 9.73 to 18.40 mg THg/kg ww (see Table C-1).

A CBR_{NOEC} of 0.037 mg MeHg/kg ww was selected for MeHg based on effects of growth in hexagenid mayfly nymphs (Naimo et al., 2000). A corresponding CBR_{LOEC} was not identified. Nor was it estimated by simply applying an uncertainty factor of 10 on the CBR_{NOEC} because there is insufficient information to support this extrapolation. Bounded reproduction endpoints for daphnids reported by Biesinger et al., (1982) of 1.53 and 2.33 mg THg/kg ww were selected as the minimum CBR_{NOEC} and CBR_{LOEC} for THg, respectively.

The selected CBRs are comparable to (for THg) or more conservative than (for MeHg) the results of a field study of population-level benthic invertebrate impacts and measured invertebrate tissue residues. In a long-term study conducted near a mine site at Clear Lake, California, Suchanek et al. (2008) reported THg body burdens of 0.288 mg THg/kg dw (1.440 mg THg/kg ww) and MeHg body burden of 0.067 mg/kg dw (0.335 ng MeHg/g ww) in larval Chironomidae (chironomids). Chironomids did not experience any significant population-level effects and the littoral invertebrate community did not exhibit any significant response to the mercury exposures from surface water and sediment. The findings of Suchanek et al. (2008) indicate that the selected CBRs are adequately conservative to evaluate potential benthic invertebrate impacts in AOC-4.

CBRs were not identified for emergent adult invertebrates due to the lack of data available to evaluate adverse ecological effects based on tissue residue concentrations. However, it is assumed that CBRs protective of aquatic stages (i.e., larvae or nymphs) are protective of post-metamorphosis adult stages because organisms are generally more sensitive to adverse effects of contaminants during early life stages than during adulthood (UNEP, 2002).

2.2.2 Crayfish

Crayfish have been used as bioindicators for environmental mercury contamination (Simon and Boudou, 2001) and mercury bioaccumulation in crayfish has been documented in different systems (Parks and Hamilton, 1987; Pennuto et al., 2005; Gustin et al., 2005; Hothem et al., 2007). However, studies linking mercury concentrations in crayfish tissue at environmentally relevant exposures to adverse effects was not identified in the literature. Studies evaluating mercury bioaccumulation based on whole body

³ Conversions of dry weight values reported in literature studies assume a moisture content of 80 percent.

⁴ Note: Concentrations reported in literature studies reviewed for invertebrate critical body residues have been expressed as ng/g ww for consistency with the presentation of invertebrate tissue concentrations in this report.

residue have considered tissue concentrations < 0.100 mg/kg ww to be associated with background concentrations that are not indicative of adverse effects (Parks and Hamilton, 1987).

Based on available information regarding the relative toxicity of crayfish to mercury exposure, CBRs in whole body crayfish are not likely to be lower than the CBRs derived for invertebrates in the previous section. Effects of mercury on the survival or reproduction of crayfish are generally observed at aqueous concentrations much higher than the NRWQC of 770 ng/L (filtered) for THg. The NRWQC of 770 ng THg/L represents the Criterion Continuous Concentration (CCC) that is derived using acute toxicity of IHg on 29 genera of freshwater animals and estimated acute to chronic ratios. The supporting NRWQC database included crayfish species demonstrating species mean acute IHg toxicity at 20,000 ng THg/L (EPA, 1985; EPA, 1995). In more recent studies not included in the NRWQC database supporting derivation of the mercury NRWQC, *Astacus astacus* individuals exposed to HgCl_2 at 100,000 to 800,000 ng/L experienced cardiac arrhythmia and high levels of mortality (Styrishave et al., 1995; Styrishave and Depledge, 1996). As a result, potential effects associated with crayfish tissue mercury concentrations measured in AOC-4 were evaluated relative to the THg and MeHg CBRs derived in the preceding section.

2.3 Summary of Benthic Invertebrate Effects Benchmarks

Based on the rationale presented in the preceding sections, the following ecological effects benchmarks have been identified to evaluate benthic macroinvertebrate exposure in AOC-4.

Exposure Media	NOEC	LOEC	Basis
Sediment (mg/kg dw)			
Total mercury	18.9	NA	NOECs based on Sediment Quality Triad investigations; LOECs not identified.
Methylmercury	0.102	NA	
Surface/Pore Water (ng/L)			
Total mercury	4,000	7,000	Bounded NOEC and LOEC derived based on the relative growth of benthic macroinvertebrates evaluated in Chibunda (2009); Azevedo-Pereira and Soares (2010); Valenti et al. (2005).
Methylmercury	4	40	NOEC represents the CCME <i>Water Quality Guideline for the Protection of Aquatic Life</i> derived based on a LOEC of 40 ng/L for daphnid reproduction divided by a safety factor of 10 (CCME, 2003).
Critical Body Residue (mg/kg ww)			
Total mercury	1.53	2.33	Based on the lowest bounded endpoints for daphnid (Beisinger et al., 1982); See Table C-1.
Methylmercury	0.037	NA	CBR _{NOEC} based on growth of hexagenid mayfly nymphs (Naimo et al., 2000); See Table C-1; CBR _{LOEC} not identified.

Notes:

NA – Not Available; LOECs were not estimated based on extrapolation from corresponding NOECs because typical uncertainty factor (x10) is deemed inappropriate.

3.0 Aquatic Vegetation

Potential effects to submerged aquatic vegetation (SAV) in AOC-4 were evaluated based on direct contact exposure to sediment, and pore water/surface water concentrations. A community structure evaluation was also performed. The following subsections describe the selection of mercury benchmarks for SAV.

3.1 Sediment Benchmarks

Literature reviews did not identify toxicity data related to the exposure of aquatic plants to mercury in sediment. Therefore, SAV exposure to mercury was evaluated based on exposure to surface/pore water, as described below.

3.2 Surface Water/Pore Water Benchmarks

A review of aqueous toxicity endpoints indicated that sensitivity of freshwater aquatic vegetation to mercury exposure is highly variable. A summary of available literature on toxicity of mercury on aquatic plants is available in EPA (1985) and Boening (2000).

Available data indicate that freshwater plants are more sensitive to MeHg than IHg. EPA (1997) reported effect concentrations for IHg ranging from 53 to 3,400 ug/L for alga and SAV, whereas the reported effects concentrations for MeHg ranged from 0.8 to 6 ug/L for algal species. In rooted-submerged aquatic macrophytes (e.g., *Vallisneria spirallis*), Gupta and Chandra (1998) showed that IHg decreased chlorophyll contents at or above 100 ug/L. In a higher plant, the duckweed (*Lemna minor* L.), Naumann et al. (2007) reported a 10 percent effects concentration (EC₁₀) of 19 to 29 ug/L for various growth endpoints (frond number, weight, chlorophyll and carotenoid contents). In developing the *Canadian Water Quality Guideline for the Protection of Aquatic Life*, the CCME (2003) identified IHg and MeHg effect concentrations of 1 ug/L (i.e., 1,000 ng/L) or greater for freshwater aquatic plants. Based on these data, 1,000 ng/L was selected as an LOEC (for both THg and MeHg) to evaluate potential sublethal growth effects to SAV exposed to mercury in pore water and surface water. Comparisons of the available toxicity data indicate that general surface water quality criteria are protective of the varied effects concentrations for different aquatic plants. However, the available CCME MeHg criterion of 4 ng/L for the protection of general aquatic life is extremely conservative for the protection of the aquatic plants. Therefore, the following criteria are selected as conservative NOECs for THg and MeHg for plant exposure in surface water and pore water:

- THg: 770 ng THg/L (filtered) based on the chronic National Recommended Ambient Water Quality Criteria [NRWQC, EPA (2014)] and Virginia State Water Quality Criteria (VASWQC) for the protection of aquatic life
- MeHg: 100 ng MeHg/L based on applying a safety factor of 10 to the lowest chronic effects concentrations (of 1000 ng/L) identified for plants by CCME (2003).

It is important to note that these concentrations do not represent effect concentrations, but rather conservative benchmarks below which adverse effects to various aquatic plants are not likely.

3.3 Summary of Aquatic Vegetation Effects Benchmarks

Based on the rationale presented in the preceding sections, the following ecological effects benchmarks have been identified to evaluate submerged aquatic vegetation exposure in AOC-4.

Exposure Media	NOEC	LOEC	Basis
Surface/Pore Water (ng/L)			
Total mercury	770	1000	NRWQC/VASWQC of 770 ng/L represents a conservative benchmark for SAV exposure.
Methylmercury	100	1000	NOEC represents the lowest chronic effects concentrations of 1000 ng/L identified (CCME, 2003) for aquatic plants divided by a safety factor of 10.

4.0 Terrestrial Vegetation

Potential effects to terrestrial vegetation in AOC-4 were evaluated based on direct contact exposure to soil mercury concentrations. The following subsections describe the selection of soil benchmarks for terrestrial vegetation.

4.1 Soil Benchmarks from Literature Studies

Five mercury phytotoxicity studies involving seven species of terrestrial plants were identified for the derivation of a soil mercury benchmark (Table C-2). Only soil studies were included; hydroponic studies (plants grown in solution) were not included because they are not relevant toward deriving soil benchmarks (in terms of mercury concentrations in bulk soil). Among soil studies, only those studies were included for which sufficient details could be obtained (such as test species, test soil properties, test duration, effect endpoints, and benchmarks). Study by Environment Canada (1995) was included despite the lack of information on soil type and test duration, because it was deemed reliable as it is reported in several reliable documents including CCME (1999) and Tipping et al. (2010). The selected studies generally measured effects on germination, emergence, root elongation, shoot growth, and biomass growth. Soil mercury toxicities in the selected studies varied greatly for different measured effects, soil properties, and test species.

For wide-ranging endpoints (emergence, first bloom, plant height, etc.) for field mustard (*Brassica rapa*) grown in three different soils in Sheppard et al. (1993), no observed effects concentrations (NOECs) were estimated to be 10-100 mg Hg/kg dw and lowest observed effects concentrations (LOECs) were estimated to be 10-220 mg Hg/kg dw; *B. rapa* was more sensitive to mercury in sandy soils [with low pH and soil organic matter (SOM)] than in clayey and loamy soils (with pH > 7 and SOM > 2.5%). Similarly, Panda et al. (1992) reported different LOECs [103 (not shown in Table C-2) vs. 64 mg Hg/kg dw] for seed germination and seedling height for barley grown in primarily mercury-contaminated solid waste deposits of a chloralkali plant; a NOEC was 34.5 mg Hg/kg dw based on seedling height.

Toxicity differences for the same test species grown in different soils is evident in the Weaver et al. (1984) study; NOECs for Bermuda grass (*Cynodon dactylon*) grown in an alkaline soil with SOM = 1.3% and in an acidic soil with SOM = 0.4 % were 8 and 25 mg Hg/kg, respectively (about a three-fold difference).

Difference in species sensitivity is apparent in a study by Environment Canada (1995). Based on seed emergence for plants grown in the same soil (an acid soil with SOM = 5.6%), lettuce (*Lactuca sativus*, NOEC = 7 mg Hg/kg dw and LOEC = 11 mg Hg/kg dw) is about seven times more sensitive than radish (*Raphanus sativus*, NOEC = 51 mg Hg/kg dw and LOEC = 73 mg Hg/kg dw).

Studies in Table C-2 indicate that NOECs are generally greater than 7 mg Hg/kg dw, whereas LOECs are generally greater than 10 mg Hg/kg dw. Selected studies represent a wide range of soil types, endpoints, and species. Therefore, a geometric mean of NOECs (13 mg THg/kg dw) and LOECs (29 mg THg/kg dw) from all studies in Table C-2, except those estimated from figures in Sheppard et al. (1993), were selected as the soil

benchmarks for evaluating terrestrial vegetation exposed to THg in AOC-4. However, it should be noted that in the studies, soluble mercury salts were freshly added to the soils and are readily bioaccessible⁵. In historically contaminated AOC-4 soils, the “bioaccessible” fraction of the THg is likely to be limited. Therefore, the above benchmarks were adjusted to account for the site-specific bioaccessibility determined at AOC-4, as discussed below..

4.2 Site-Specific Considerations

A bioavailability factor of three was applied to the benchmarks identified in the previous section to account for the lower mercury bioaccessibility in the AOC-4 soils relative to HgCl₂-spiked soils in laboratory toxicity tests.

As indicated in the previous section the soil mercury toxicities were established based on the toxicity of mercuric chloride freshly added to the soils. However, mercuric chloride is a very soluble mercury species and in freshly spiked soils, it likely has not had the time to react with the soil matrices and surfaces, which potentially sequester a fraction of the mercury rendering it non-bioaccessible. For metals in general, the total metal concentrations in soil do not predict their toxicity, mainly because of differences in metal speciation and bioaccessibility (Thakali et al., 2006a; Thakali et al., 2006b). Several investigations (Revis et al., 1989; Barnett et al., 1995; Harris et al., 1996; Barnett et al., 1997) have suggested the mercury in floodplain soils may be less soluble and therefore potentially less bioaccessible than mercuric chloride, owing primarily to mercury speciation. For example, metacinnabar (mercuric sulfide, HgS) which is typically found in floodplain soils is orders of magnitude less water soluble than mercuric chloride.

Studies of mercury extractions in contaminated soils have also indicated limited mercury bioaccessibilities. Zagury et al. (2006) determined water-soluble (F1), exchangeable (F2), organic (F3), and residual (F4) fractions of mercury in three mercury contaminated soils from chlor-alkali plants; the bioaccessible fraction (sum of F1, F2, and F3) represented 4 to 10% of the total extractable (including F4). Similarly, Barnett and Turner (2001) determined mercury bioaccessibility in 20 soils from East Fork Poplar Creek (EFPC) floodplain in Oak Ridge, Tennessee, a mercury contaminated superfund site. They used a more stringent extraction (at pH 2.5 and four hours, to represent human stomach). The average bioaccessible mercury for the 20 soils was 5.3%, compared with 100% of the mercuric chloride subjected to the same conditions.

Site-specific plant toxicity testing was performed on a soil sample collected at RRM 11.8 in August 2013 as part of a potential remediation strategy. The soil was tested for toxicity to three plant species [wheat (*Triticum aestivum*), soybean (*Glycine max*), and radish (*Raphanus sativus*)] following protocols established by the Office of Economic Cooperation and Development (OECD) Test No. 208, Terrestrial Plant Test: Seedling Emergence and Seedling Growth Test (OECD, 2006). The test soil contained THg at a

⁵ Bioavailability and bioaccessibility are often used interchangeably, but here bioavailability refers to the systemic availability in an organism (e.g., in blood stream in higher organisms) and bioaccessibility refers to external availability (e.g., in a medium to which an organisms is exposed) that limits the uptake by and toxicity to plants and invertebrates.

concentration of 57.4 mg THg/kg and was paired with a control soil with THg concentrations of 0.05 mg THg/kg. There were no apparent mercury-related effects on plant seedling emergence or growth (height and biomass). Test soils also had concentrations of copper, manganese, and zinc above their respective EPA Ecological Soil Screening Level (Eco-SSL).

Bioaccessibility was determined in two soil samples (from river bank and floodplain in AOC-4) with mercury concentrations of 24 and 26 mg THg/kg. Sequential extractions were performed based on the protocol designed by Bloom et al. (2003): soil samples were extracted with fluids of increasing strength, designed to attack particular forms/species of mercury in soil. The extractants and the chemical species they are designed to target (in parentheses) are as follows:

- F1: Deionized (DI) water (HgCl₂, HgSO₄)
- F2: 0.01M HCl (HgSO₄, HgO, adsorbed Hg)
- F3: 1M KOH (organo-chelated Hg, Hg₂Cl₂)
- F4: 12M HNO₃ (Hg⁰, thiol-bound Hg)
- F5: Aqua regia (HgS, HgSe, HgAu)

Flanders et al. (2010) reported the results of the above investigation. The majority (>70%) of the THg was present in the F4 and F5 fractions, indicating that a small proportion of THg is present in soils as soluble species like HgCl₂, and that mercury is likely bound to reduced sulfur in soil. Subsequent speciation analysis at the University of Waterloo on floodplain soils confirmed the above finding using a Synchrotron radiation-based x-ray absorption spectroscopy technique (Ptacek et al., 2013). The speciation study confirmed that mercury is bound to reduced sulfur, either as cinnabar or metacinnabar (HgS) or soil organic matter.

Based on the above results, the soil benchmarks identified in the previous section are adjusted by a factor of 3, to reflect that readily bioaccessible mercury compounds (like HgCl₂, HgSO₄) constituting a maximum of 30% of the THg in the AOC-4 soils.

4.3 Summary of Terrestrial Vegetation Effects Benchmarks

Based on the information presented in the preceding sections, the following ecological effects benchmarks were identified to evaluate the exposure of terrestrial vegetation to soil mercury in AOC-4.

Exposure Media	NOEC	LOEC	Basis
Soil (mg THg/kg dw)			
Total mercury	54	87	Based on the geometric mean of select NOECs and LOECs from soil studies in Table C-2 and a site-specific bioaccessibility factor of 3.

5.0 Soil Invertebrates

Potential effects to soil invertebrates in AOC-4 were evaluated based on direct contact exposure to soil concentrations. The following subsections describe the selection of effects endpoints for soil invertebrates.

5.1 Soil Benchmarks from Literature Studies

Seven studies representing six invertebrate species were identified for the derivation of soil mercury benchmarks for soil invertebrates (Table C-3). Only studies on soil-burrowing oligochaetes and collembola were included as they best represent the direct contact exposure pathway for soil mercury.

Three species of earthworms have been studied (Table C-3). Abbasi and Soni (1983) reported that at 0.5 mg Hg/kg dw (the lowest concentration tested), HgCl₂ reduced *Octochaetus pattoni* survival by 65% and cocoon production by 40%; however, the number of juveniles produced was unaffected. Shepard et al. (1993) tested mercury toxicity to *Lumbricus terrestris* in three different soils. In a sandy soil (pH = 6.3 and SOM = 0%), survival was poor and the organisms were tested for 12 days compared to 30 days in a loamy garden soil (pH = 7.3 and SOM = 8.9%) and clayey soil (pH = 7.9 and SOM = 2.7%). The estimated LC₅₀ values varied widely in the three soils: 10-100, 100-1000, and > 1000 mg Hg/kg in the sandy, loamy, and clayey soils, respectively.

In a study of *Eisenia fetida* exposed to MeHg for 84 days in a commercial potting soil, 12.5 mg Hg/kg dw reduced survival and the ability to regenerate excised segments by 21% and 69%, respectively; the corresponding NOEC was 2.5 mg Hg/kg soil (Beyer et al., 1985). Lock and Jansen (2001) reported a 21-day NOEC of 10 mg Hg/kg dw for *E. fetida* reproduction; the corresponding LOEC was 18 mg Hg/kg dw. Survival was unaffected at the highest concentration tested (at 100 mg Hg/kg soil). Gudbrandsen et al. (2007) investigated the effects of pre-exposure to mercury on *E. fetida*. Effects on survival and reproduction (cocoon production) showed that pre-exposure to mercury (at 22 mg/kg dw) for one week strongly increased survival. The LC₅₀ for pre-exposed and not pre-exposed earthworms were 545 and 170 mg Hg/kg dw, respectively. The corresponding NOEC was 4.6 mg Hg/kg soil [as estimated by Tipping et al. (2010)]. Fischer and Koszorus (1992) reported 25% mortality in *E. fetida* exposed to 250 mg THg/kg ww but 0% mortality at 500 mg Hg/kg ww. Additionally, sublethal concentrations stimulated cocoon production. No explanations were provided for these peculiar effects.

Other test species include white worms (*Enchytraeus albidus*, NOEC = 18 mg THg/kg dw) and a collembola (*Folsomia candida*, NOEC = 1.8 mg THg/kg dw) in Lock and Jansen (2001) and another collembola (*Paronychiurus kimi*, NOEC = 0.25 mg Hg/kg dw) in Son et al. (2007).

Studies in Table C-3 represent a wide range of soil properties (pH = 6.0 to 7.9 and SOM = 0 to 10%) and the measured effects endpoints represent assessment endpoints targeted for soil invertebrates (survival and reproduction). Therefore, similar to soil benchmarks for terrestrial plants, the geometric mean of NOECs (6 mg THg/kg dw) and LOECs (12 mg THg/kg dw) from in Table C-3, except those estimated from figures in Sheppard et al.

(1993), were selected for the evaluation of the soil invertebrates in AOC-4. Similar to soil benchmarks for terrestrial plants, the soil benchmarks for soil invertebrates are also expected to be conservative because of the limited mercury bioaccessibility in historically contaminated soils compared to freshly spiked soils used in toxicity testing and also potential acclimation reported in Gudbrandsen et al. (2007). The benchmarks identified based on laboratory studies were, therefore, adjusted to account for site-specific bioaccessibility, as indicated below.

5.2 Site-Specific Considerations

Similar to terrestrial plants, the uptake by and toxicity to soil dwelling invertebrates are also similarly influenced by mercury bioaccessibility.

The RRM 11.8 and background soil that were tested for plant toxicities (see Section 4.2) were also tested for *E. fetida* toxicities following OECD Test No. 222, Earthworm Reproduction Test (OECD, 2004), with endpoints including survival, weight change (growth), and reproduction (number of cocoons or juveniles produced). In the RRM 11.8 soil (with 57 mg THg/kg), mortality was > 30%, but there was no effect on earthworm reproduction. However, it is unclear whether the observed mortality is due to mercury or other metals, such as copper, manganese, and zinc that were present above their respective EPA Eco-SSLs.

Based on the above results and the site-specific bioaccessibility and speciation studies (briefly discussed in Section 4.2), a site-specific mercury bioaccessibility factor of 3 is also reasonable for the evaluation of mercury effects on soil invertebrates. Therefore, the benchmarks identified in the previous section were adjusted upward using the same site-specific bioaccessibility factor of 3 to account for mercury bioaccessibility in the AOC-4 soils.

5.3 Summary of Soil Invertebrate Effects Benchmarks

Based on the rationale presented in the preceding sections, the following ecological effects benchmarks have been identified to evaluate soil invertebrate exposure in AOC-4.

Exposure Media	NOEC	LOEC	Basis
Soil (mg THg/kg dw)			
Total mercury	18	36	Based on the geometric mean of select NOECs and LOECs from soil studies in Table C-3 and a site-specific bioaccessibility factor of 3.

6.0 Fish

Potential effects to fish in AOC-4 were evaluated based on direct contact exposure to surface water and whole body CBRs. The following subsections describe the selection of corresponding benchmarks for fish.

6.1 Surface Water Benchmarks

A summary of aquatic toxicity of mercury on freshwater fish is provided in Table C-4. Acute toxicities (LC_{50} or median effect concentrations [EC_{50}]) for IHg range from 30,000 to 1,000,000 ng THg/L in fish (EPA, 1985 and 1996). The Canadian Council of Ministers for the Environment (CCME) also reported similar ranges, 150,000 to 900,000 ng THg/L for fish (CCME, 2003). Chronic values for THg range from < 230 to > 64,000 ng THg/L (EPA, 1985; Niimi and Kissoon 1994; CCME, 2003). Adverse effects reported commonly among studies include growth, reproduction and development, and mortality.

Current EPA NRWQC for the protection of aquatic life for IHg is based on EPA (1996) derivations. Acute Criterion Maximum Concentration (CMC) and chronic Criterion Continuous Concentration (CCC) protective of general aquatic life are 1,400 and 770 ng THg/L, respectively, based on the filtered (dissolved) water fraction. These criteria have been promulgated by VADEQ as VASWQC (9VAC25-260-140).

Acute toxicities of MeHg range from 24,000 to 84,000 ng MeHg/L in fish (EPA, 1985; McKim et al., 1976), while chronic values range from 290 to 63,000 ng MeHg/L for fish (McKim et al., 1976; CCME, 2003). McKim et al. (1976) exposed three generations of brook trout (*Salvelinus fontinalis*) to 30 to 290 ng MeHg/L as MeHg over a 144-week period. No significant effects on survival, growth, or reproduction were observed in second generation trout at < 930 ng MeHg/L and no toxic symptoms were found in the third generation at < 290 ng MeHg/L. EPA currently does not provide an NRWQC for MeHg for the protection of aquatic life due to its recognized bioaccumulation potential.

Based on a review of the available literature for aqueous toxicity of mercury to fish, the following surface-water mercury benchmarks were selected to evaluate fish exposed to mercury in AOC-4:

- THg: 770 ng THg/L (dissolved) for THg based on the current NRWQC (EPA, 2014) VASWQC.
- MeHg: 290 ng MeHg/L (dissolved) for MeHg based on the lowest chronic toxicity value observed in a multi-generational exposure for brook trout (McKim et al., 1976).

6.2 Critical Body Residues

Several studies have attempted to establish mercury CBRs for the protection of fish (Niimi and Kissoon, 1994; Wiener and Spry, 1996; Beckvar et al., 2005; and Dillon et al., 2010). Based on available literature at the time, Niimi and Kissoon (1994) concluded that lethal body burdens of mercury ranged from 10 to 20 mg THg/kg ww (whole body) and speculated that sublethal impacts would be associated with the 1 to 5 mg THg/kg ww (whole body) concentration range. Wiener and Spry (1996) conducted an exhaustive review of mercury residue-effects literature and identified a CBR of 5 mg/kg ww (whole body) as the probable toxic effects level and 3 mg/kg ww (whole body) as the no-observed-effects-level for freshwater fish.

Beckvar et al. (2005) summarized no effect residue (NER) and low effect residue (LER) body burden (whole body) thresholds for mercury (see Table C-5). Based on the geometric mean of paired NER and LER values for all species and life stages evaluated,

Beckvar et al. (2005) recommended a whole body threshold effect concentration of 0.21 mg THg/kg ww; this threshold effect concentration was considered protective of juvenile and adult fish due to the representation of multiple life stages in the supporting studies. This benchmark is considered a conservative, low end CBR_{NOEC} for evaluating small [Total Length (TL) < 130 mm] and larger fish (TL > 130 mm) tissue residues in AOC-4.

The endpoints summarized in Beckvar et al. (2005), were further evaluated to develop a more site-specific and relevant benchmark for fish tissue data collected at AOC-4 (see Table C-5). Species not applicable to or appropriate for the South River, including brackish (e.g., striped mullet, mummichog) and arctic species (grayling) were not considered in development of a site-specific CBR. In addition, comparisons of concentrations in early life stages (ELS), including eggs and larvae, were not appropriate for TL < 130 and TL > 130 fish tissue residues measured in AOC-4. Based on applicable and appropriate species and life stages, the geometric mean of NER and LER endpoints was calculated as 0.44 mg THg/kg ww (see Table C-5). This benchmark was established as a CBR_{LOEC} for comparisons whole body tissue residues from AOC-4. This benchmark is consistent with overall LER effects benchmarks for adult/juvenile and ELS endpoints; the geometric mean of LER concentrations for all life stages for species appropriate to the South River is 0.41 mg THg/kg ww (see Table C-5).

The CBR_{LOEC} of 0.44 ng THg/g ww is supported as a low effects benchmark by the evaluation of mercury fish tissue residues conducted by Dillon et al. (2010). Mercury dose-response relationships (D-Rs) were developed for early life stage (ELS) and juvenile or adult fish based on published tissue residue-toxicity data. The D-Rs relied primarily on lethality-equivalent test endpoints (i.e., endpoints that can be directly related to mortality, such as survival, reproductive success, and developmental abnormalities). The D-Rs for the juvenile and adult fish predicted 2.8 to 77.8 percent effects over a tissue residue range of 0.1 to 10 mg THg/kg ww; for the same range of tissue residues, the D-R for ELS fish predicted 19.8 to 96.1 percent effects. Consistent with the CBR_{LOEC}, Dillon et al. (2010) found an 11 percent probability of effects at ~0.40 mg THg/kg ww.

In summary, more recent literature-based whole body CBRs indicate a conservative (i.e., no effect) screening benchmark of 0.21 mg THg/kg ww for juvenile and adult fish. Multiple sources support the derivation of a low-effect level of 0.44 mg THg/kg ww for juvenile and adult fish exposure in AOC-4 (Beckvar et al., 2005; Dillon et al., 2010). As a result, CBR_{NOEC} and CBR_{LOEC} benchmarks for fish tissue were established as 0.21 mg THg/kg ww and 0.44 mg THg/kg ww, respectively. This range of CBRs was used to evaluate potential effects associated with mercury concentrations measured in juvenile and adult fish tissue sampled in AOC-4.

6.3 Summary of Fish Effects Benchmarks

Based on the rationale presented in the preceding sections, the following ecological effects benchmarks have been identified to evaluate fish exposure in AOC-4.

Exposure Media	NOEC	LOEC	Basis
Surface/Pore Water (ng/L)			
Total mercury	770	NA	NRWQC/VASWQS of 770 ng/L (filtered) represents a conservative benchmark for fish exposure at various life stages.
Methylmercury	290	NA	Lowest chronic toxicity value observed in a multi-generational exposure for brook trout (McKim et al., 1976)
Critical Body Residue (mg/kg ww)			
Total mercury	0.21	0.44	CBR _{NOEC} based on Beckvar et al. (2005); CBR _{LOEC} derived from data compiled in Beckvar et al. (2005).
Methylmercury	0.21	0.44	CBRs for MeHg are equivalent to THg based on assumption that nearly all mercury in fish is methylated.

7.0 Amphibians

Amphibians may be exposed to mercury through dietary ingestion pathways and direct contact with sediments/soils and surface/pore water. The following subsections summarize effects data that may be used to evaluate potential ecological effects to amphibians exposed to mercury within AOC-4.

7.1 Sediment and Soil Benchmarks

Literature reviews did not identify toxicity data related to amphibian exposure to mercury in sediment and soil. Therefore, their exposure to mercury was evaluated based on exposure to surface/pore water and critical body residues, as described below.

7.2 Surface Water and Pore Water Benchmarks

A review of aqueous toxicity endpoints indicated that amphibian sensitivity to mercury exposure is highly variable, particularly at different life stages. A summary of aqueous endpoints for various amphibians and life stages developed from literature reviews have previously been discussed in several studies (Schuytema and Nebeker, 1996; WHO, 1989; Boening, 2000; Linder and Grillitsch, 2000). Comparisons of compiled aqueous toxicity endpoints for amphibians indicate that general surface water quality criteria are more conservative than the varied effects concentrations at the different life stages evaluated, including sensitive life stages. Adverse effects concentrations for lethality, malformations, and reproductive changes are generally greater than 1,000 ng /L for THg. Based on this comparison, ambient surface water quality criteria that are protective of a broad range of aquatic life are selected as conservative NOECs for THg and MeHg exposure in surface water and pore water:

- THg: 770 ng THg/L (filtered) based on the chronic NRWQC/VASWQC for the protection of aquatic life
- MeHg: 4 ng MeHg/L based on the CCME WQG for the protection of aquatic life.

It is important to note that these concentrations do not represent effect concentrations, but rather conservative benchmarks below which adverse effects to sensitive life stages of amphibians are not likely.

7.3 Critical Body Residues

Mercury CBRs (in term of whole body tissue residues) for adverse effects on amphibians have not been established. Limited relevant studies are available and all of these studies are associated with the South River investigations (Todd et al., 2011a, 2011b, 2012; Bergeron et al., 2010; Bergeron et al., 2011), which will be evaluated as part of the risk characterization (see Section 6.0 in the main report).

In the absence of amphibian CBR information for mercury, investigators have compared whole body concentrations to fish CBRs (Todd et al., 2011a; Hothem et al., 2010; Burke et al., 2010; Bergeron et al., 2010). In the few studies where amphibian effects have been compared to fish benchmarks, effects-based body burdens in amphibians were greater than benchmarks for fish (Burke et al., 2010; Todd et al., 2011a). As a result, the fish CBRs derived in Section 6.2 were used to evaluate whole body adult amphibian tissue concentrations.

7.4 Summary of Amphibian Effects Benchmarks

Based on the rationale presented in the preceding sections, the following ecological effects benchmarks have been identified to evaluate amphibian exposure in AOC-4.

Exposure Media	NOEC	LOEC	Basis
Sediment (mg/kg dw)			
Total mercury	NA	NA	Sediment benchmarks for amphibian exposure to mercury were not identified in the literature review.
Methylmercury	NA	NA	
Surface/Pore Water (ng/L)			
Total mercury	770	NA	NRWQC/VASWQC of 770 ng/L represents a conservative benchmark for amphibian exposure at various life stages.
Methylmercury	4	40	CCME WQG for the protection of aquatic life represents a conservative benchmark for amphibian exposure at various life stages.
Critical Body Residue (mg/kg ww)			
Total mercury	0.21	0.44	Based on fish CBRs.
Methylmercury	0.21	0.44	

8.0 Wildlife

To evaluate mercury exposures to the focal avian and mammalian species representing the corresponding receptor categories (Table 3-8 in the main Report), toxicity reference values (TRVs) were derived that represent daily doses for each wildlife receptor that is equivalent to no observed adverse effects level (NOAEL) and lowest observed adverse effects level (LOAEL). To augment the wildlife risk characterizations, CBRs (based on blood) were also derived, where possible, to compare against the avian and mammalian blood mercury levels measured in AOC-4. The following subsections describe the TRVs and the CBRs that were derived for the representative avian and mammalian receptors for AOC-4.

8.1 Toxicity Reference Values

TRVs were derived to evaluate the potential for adverse ecological effects associated with the dietary doses estimated using the approach described in Chapter 5 (in the main Report). Reference doses to evaluate potential effects were derived from the following sources:

- Literature-derived TRVs: An evaluation of mercury toxicity to avian and mammalian wildlife was conducted to identify TRVs for comparisons with the daily doses calculated for IHg and MeHg. TRVs were derived from the review of toxicity studies from the literature as NOAELs or LOAELs. Selections of the appropriate TRVs to evaluate potential risks due to mercury at AOC-4 were based on their direct relevance to the assessment endpoints for the maintenance and sustainability of wildlife populations (survival, growth, and reproduction, see Section 3.6 of the main Report). Observations of physiological (e.g., immunotoxicity, endocrine effects), behavioral, or other sublethal endpoints were not included in the derivation of TRVs because their dose-dependence and population-level implications are unclear.
- Background doses: Daily doses estimated based on site-specific measurements of mercury in dietary items from the study-specific background (reference) areas were also considered in the evaluation of potential site-related ecological effects. Mercury is a global contaminant, with regional impacts within the United States (Driscoll et al., 2007); the bioaccumulation of mercury in aquatic ecosystems has resulted in state-wide fish consumption advisory in over a dozen states [U.S. Geological Survey (USGS), 2000]. Due to the regional impact of mercury on aquatic systems, it was necessary to quantify background doses to assess potential site-related exposures relative to exposure due to ambient conditions in Virginia.

In addition, for receptors with prey items having limited range, the background dose essentially represents a site-independent background dose. The site-independent dose from the background (reference) areas may be useful in evaluating the relevance of literature-derived TRVs with high uncertainty (due to limited toxicological data, inter-species extrapolation, etc.) in characterizing potential site-related risks to wildlife populations.

The following subsections describe the derivation of TRVs for comparisons to doses calculated for avian and mammalian wildlife receptors.

8.1.1 Avian Toxicity Reference Values

Avian TRVs for mercury were selected using data from various controlled studies, as summarized in Table C-6. These derivations generally used the critical study approach (CSA), as used in other studies deriving TRVs for the evaluation of dietary dose models [Canadian Council of Ministers of the Environment (CCME), 1998; EPA, 1995a; EPA, 1995b; Sample and Suter, 1993; USACHPPM, 2004)].

The CSA involves finding a technically defensible, definitive study (i.e., the critical study) in which a toxicity threshold is bracketed by experimental doses, expressed as a NOAEL or LOAEL (Blankenship et al., 2008; EPA, 2003). As appropriate, uncertainty factors (UFs) are then applied to the LOAEL or NOAEL from the critical study to derive generic or receptor-specific TRVs. The UFs may account for three potential sources of uncertainty: differences in species sensitivity between the test species and the species to be protected, sub-chronic to chronic extrapolations, and LOAEL-to-NOAEL extrapolations.

As shown below, separate avian TRVs were derived for MeHg and IHg. To account for the species sensitivity, MeHg TRVs were derived for each receptor groups represented by the focal species. Due to the lack of data and relatively low toxicity of IHg (compared to MeHg), only one set of IHg TRVs were derived for all avian receptors.

Methylmercury (MeHg) TRVs

Avian sensitivity to MeHg differs between species (Heinz et al., 2009; Heinz et al., 2011). In a study evaluating the sensitivities of embryonic exposure to MeHg, Heinz et al. (2009) injected MeHg into the air cell of eggs of 26 species of birds. Embryo survival (median lethal concentration, LC_{50}) varied between species, indicating relative differences in the sensitivities of birds to MeHg exposure. Based on the relative sensitivities described by Heinz et al. (2009), existing literature studies for dietary exposures were evaluated to identify TRVs representative of the potential variation in MeHg sensitivities between receptors. In addition, literature studies for small-bodied avian species (e.g., passerines) exposed to dietary MeHg were evaluated separately in the derivation of TRVs, given the higher mass-specific metabolic rates and higher food requirements per unit mass of passerines relative to larger bodied birds included in most toxicological studies. Dietary TRVs were developed for the following focal avian receptors and categories:

- Belted kingfisher (Piscivore): Specific data on belted kingfisher were not available. Therefore, belted kingfisher TRVs were estimated by identifying a high sensitivity piscivore as a surrogate. Although belted kingfisher were not included in the Heinz et al. (2009) study, because of their piscivory and relatively small size they were conservatively included in the high sensitivity category, defined as receptors or related taxa with egg survival LC_{50} values lower than 0.25 mg/kg (Heinz et al., 2009).
- Mallard (Omnivore): Specific data on mallard are available. Additionally, Heinz et al. (2009) reported that of the 26 species with eggs dosed with MeHg, only

double crested cormorant were less sensitive than mallard (LC_{50} values of 2.42 and 1.79 mg/kg, respectively). To derive TRVs for mallard, available data were reviewed on mallard and similarly moderate and low sensitivity piscivores/waterfowl, defined as receptors or related taxa with egg survival LC_{50} values greater than 0.25 and 1 mg/kg, respectively (Heinz et al., 2009).

- Eastern screech owl (Carnivore): Specific data on Eastern screen owl are not available. Information on the sensitivity of carnivores relative to other birds toward MeHg toxicity is also not available. However, because of their similar dietary habits Eastern screech owl (a raptor) is unlikely to be more sensitive than the two raptors (American kestrel and osprey) found to be in the high sensitivity group of birds tested in the Heinz et al. (2009) study. In the absence of more relevant data, sensitivity of the Eastern screech owl is assumed to be similar to the high sensitivity piscivores. The TRVs were derived accordingly.
- Tree swallow and American robin (Passerines): These are small-bodied receptors in the avian order Passeriformes. Tree swallow had a LC_{50} = 0.32 mg/kg in the Heinz et al (2009) study indicating moderate sensitivity (defined as having LC_{50} between 0.25 and 1.0 mg/kg). However, TRVs were derived based on field studies on tree swallows as these studies were considered more appropriate and adequate for evaluating passerines exposed to mercury.

The following sections detail the selection of TRVs for MeHg for the above avian receptors.

Belted Kingfisher: High Sensitivity Piscivore/Waterfowl

Dietary studies evaluating survival, growth, and reproduction endpoints for species or related taxa with high sensitivity to MeHg were available for American kestrel (*Falco sparverius*) and great egret (*Ardea alba*). Albers et al. (2007) exposed one-year old breeding pairs of American kestrel to dietary methylmercuric chloride concentrations of 0.3, 0.7, 1.2, 1.7, and 2.2 mg MeHg/kg ww for 13 weeks (see Table C-6). The number of fledglings and percent of nestlings fledged were reduced in the 0.3 mg MeHg/kg ww treatment, and total fledgling failure was observed at 1.7 mg MeHg/kg ww in the diet. Based on the reproductive effects observed in the 0.3 mg MeHg/kg ww treatment, a LOAEL of 0.055 mg MeHg/kg BW/day was calculated for American kestrel reproduction assuming a body weight of 0.119 kg and a food ingestion rate (FIR) of 0.022 kg ww/day (Zhang et. al., 2013). However, another study of American kestrel exposure to MeHg, did not find a reduction in clutch size in the treatment group fed an estimated dose of 0.085 mg MeHg/kg BW/day (French et al., 2010; see Table C-6).

Spalding et al. (2000) exposed nestlings of great egret, another highly sensitive species, to dietary methylmercuric chloride concentrations of 0.5 mg MeHg/kg ww and 5.0 mg MeHg/kg ww for 12 weeks (see Table C-6). Appetite and resultant growth metrics were reduced in nestlings exposed to the 0.5 mg/kg ww treatment, which was estimated as a growth LOAEL of 0.091 mg/kg BW/day based on an assumed body weight of 1.0 kg for great egret nestlings and a FIR of 0.181 kg ww/day (Zhang et al., 2013).

In another dietary study with a similarly sensitive species, behavioral, physiological, and potential reproductive effects associated with dietary MeHg exposure were observed in captive white ibis (*Eudocimus albus*); however, there is uncertainty regarding the implications of these observed effects on wild bird populations. Frederick and Jayasena (2010) observed an increase in male-male pairing and modifications to key male courtship behaviors in captive white ibis nestlings-adults fed dietary methylmercuric chloride concentrations of 0.05, 0.1, and 0.3 mg MeHg/kg ww over three years. While the modified mating behavior was associated with a significant decrease in nestling production, the total numbers fledged per female did not differ statistically from the control even though some reduction in the total numbers fledged was observed (Frederick and Jayasena, 2010). In a related study, Jayasena et al., (2011) reported endocrine disruption in the form of altered estradiol and testosterone concentrations in adult breeding kestrels of both sexes; however, the changes in hormone concentrations were not consistent over both years, and a clear-dose response relationship was not always present.

It is highly uncertain how the behavioral and physiological effects observed in the captive white ibis studies may be manifest in wild bird populations. In their study, Frederick and Jayasena (2010) indicated that male-male pairing was not observed in 134 breeding pairs of white ibis studied over four breeding seasons (greater than 15,000 pair-hours of observation) in a wild colony on Pumpkinseed Island located within Winyah Bay, South Carolina (Frederick, 1987). The wild colony observed in this study likely foraged in Winyah Bay and surrounding areas on dietary items containing concentrations equal to or greater than the 0.05 mg MeHg/kg effect concentration observed in the captivity studies (Frederick and Jayasena, 2010; Jayasena et al., 2011). Major tributaries to Winyah Bay⁶ are subject to South Carolina Department of Health and Environmental Control (SCDHEC) fish consumption advisories for mercury, which are based on adult fish filet concentrations of 0.25 mg MeHg/kg (SCDHEC, 2013; Glover et al., 2010). Limited tissue data available for Winyah Bay obtained from the National Listing of Fish Advisories (NLFA) Fish Tissue Search⁷ indicate that mercury concentrations in fish and crab samples, potential components of the white ibis diet, range from 0.09 to 0.25 mg THg/kg. These findings indicate that although dietary mercury concentrations in Winyah Bay were likely at least equivalent to or exceeded 0.05 mg MeHg/kg, male-male pairing and its potential reproductive effects were not observed over four breeding seasons in the wild colony of white ibis from Pumpkinseed Island. As a result of the uncertainty regarding the implications of the captivity study findings to wild bird populations, the dietary effects concentrations for mating behavior and potential reproductive success reported in Frederick and Jayasena (2010) were not considered in the selection of TRVs for piscivores and waterfowl with high sensitivity to MeHg.

Based on the review of dietary studies evaluating survival, growth, and reproduction endpoints for avian species with high sensitivity to MeHg (see Table C-6), the LOAEL of

⁶ Major tributaries with fish consumption advisories for mercury include the Pocomtucket River, Black River, Black Mingo Creek, Lynches River, Pee Dee River, Little Pee Dee River, Lumber River, and Waccamaw River.

⁷ Accessed on January 14, 2014 at: <http://map1.epa.gov/FishTissue.aspx>

0.055 mg MeHg/kg BW/day estimated based on the Albers et al. (2007) American kestrel study was used to evaluate MeHg exposure on piscivores and waterfowl with high sensitivity to MeHg. Applying the LOAEL-to-NOAEL UF of 3.25, a NOAEL of 0.017 mg MeHg/kg BW/day was estimated as the basis for a no observed adverse effect exposure to high sensitivity piscivores and waterfowl. The LOAEL-to-NOAEL UF was estimated based on the mean ratio of LOAEL to NOAEL doses reported for avian studies with survival, growth, and reproduction endpoints (see Table C-6; French et al., 2010; Heinz and Lock, 1976; Heinz et al., 2010; Scheuhammer, 1988). This UF is comparable to or more conservative than LOAEL-NOAEL UFs applied in the derivation of water quality criteria for the protection of wildlife, which ranged from 2 to 3 (EPA, 1995a; EPA, 1995b; EPA, 1997).

Mallard: Low-Moderate Sensitivity Omnivore/Waterfowl

Dietary studies evaluating survival, growth, and reproduction endpoints for species or related taxa with low-moderate sensitivity to MeHg, as classified by Heinz et al. (2009) were available for mallard, ring-necked pheasant (*Phasianus colchicus*), white leghorn chicken (*Gallus gallus*), common loon (*Gavia immer*), and Japanese quail (*Coturnix japonica*). Table C-6 presents a summary of the TRVs associated with dietary studies for birds with low-moderate sensitivity to MeHg; key studies are discussed in detail below.

Heinz (1974, 1976a, 1976b, and 1979) exposed mallard duck to MeHg dicyandiamide at dietary concentrations ranging from 0.5 to 3.0 mg MeHg/kg dw for two generations, with the third generation exposed to 0.5 mg MeHg/kg dw. No behavioral or reproductive effects were observed in the initial (P1) test birds. A 30 percent reduction in 1-week survival rates was observed in the first generation (F1) at 0.5 mg/kg dw; however, the second generation birds (F2) showed no effects at 0.5 mg MeHg/kg dw. Based on the 0.5 mg MeHg/kg dietary treatment, a LOAEL of 0.078 mg MeHg/kg BW/day was estimated based on a food ingestion rate (FIR) of 0.156 kg dw/kg BW/day for the P1 female.

LOAELs estimated from other dietary studies with taxa with low-moderate sensitivity to MeHg were greater than the LOAEL of 0.078 mg MeHg/kg BW/day derived from Heinz (1974, 1976a, 1976b, and 1979). As summarized in Table C-6, LOAEL doses estimated for survival, growth, and reproduction endpoints from other studies ranged from 0.093 to 0.857 mg MeHg/kg BW/day.

Based on the review of dietary studies evaluating survival, growth, and reproduction endpoints for avian species with low-moderate sensitivity to MeHg, the LOAEL of 0.078 mg MeHg/kg BW/day was estimated from studies by Heinz (1974, 1976a, 1976b, and 1979). The LOAEL is intended to be protective of avian receptor categories represented by mallard. Applying the LOAEL-to-NOAEL UF of 3.25, a NOAEL of 0.024 mg MeHg/kg BW/day was estimated as the basis for a no observed adverse effect exposure to low-moderate sensitivity piscivores and waterfowl.

Eastern Screech Owl: Carnivores

As indicated previously, in the absence of more relevant data, carnivores are conservatively assumed to be as sensitive as the high sensitivity piscivores. Therefore,

the TRVs derived based on the Albers et al. (2007) study on American kestrel, are used to evaluate MeHg exposures to Eastern screech owl at AOC-4.

Tree Swallow and American Robin: Passerine Birds

Available toxicity literature evaluating passerine birds exposed to mercury was reviewed independent of toxicity literature for piscivores and waterfowl. Taxa studied to evaluate piscivores and waterfowl exposed to mercury are relatively large bodied (e.g., mallard and loon) with lower mass-specific metabolic rates and lower mass-specific food ingestion rates in comparison with passerine birds (Bennett and Harvey, 1987). As a result, TRVs based on larger birds (and of different feeding guild) may not be sufficiently conservative for the protection of passerine species. To address the uncertainty in identifying adequately protective dietary TRVs for comparison with modeled doses for tree swallow and American robin, studies specifically evaluating the toxicity to passerines were evaluated.

A review of avian toxicological literature identified only one laboratory dosing study evaluating the effects of mercury exposure on passerine birds. Scheuhammer (1988) reported no effects on a captive breeding colony of zebra finch (*Taeniopygia guttata*) exposed to chloromethylmercury in the diet for 76 days at a concentration of 0.5 mg MeHg/kg; however, behavioral signs of intoxication and increased mortality were observed in zebra finch exposed to 5.0 mg MeHg/kg for the same period. Based on these endpoints, Scheuhammer (1988) estimated a NOAEL dose of 0.88 mg MeHg/kg BW/day and a LOAEL dose of 1.75 mg MeHg/kg BW/day for zebra finch based on the low and high dose treatment groups, respectively. No other dietary studies evaluating the potential effects of mercury on passerine birds were identified.

In the absence of additional laboratory dosing studies to evaluate potential sublethal responses (e.g., growth and reproduction) of passerine birds exposed to dietary MeHg, available field studies were identified that concurrently measured dietary MeHg concentrations (e.g., bolus measurements) and sublethal endpoints (e.g., reproductive success metrics). Based on the field-measured endpoints and associated dietary MeHg concentrations, dietary TRVs were estimated using assumptions of representative body weights and FIRs estimated based on allometric relationships developed for passerine birds (Nagy, 2001). As summarized below, several field studies were identified that provide a basis for estimating dietary TRVs for passerine birds exposed to MeHg (see Table C-6).

Gerrard and St. Louis (2001) conducted a six-year study to evaluate the impact of reservoir flooding and MeHg bioaccumulation on the reproductive success and growth of tree swallow nestlings. Measures of reproductive success included clutch initiation date, egg size, eggs per clutch, total volume in the clutch, incubation length, hatching success, growth rate of fledglings, and fledgling success; growth metrics included wing, tail, bill, and tarsus lengths, bill width, and weight. In addition to measuring reproductive success and growth metrics, MeHg concentrations in emergent dipterans, the primary dietary component of tree swallow, were measured three times per week. A fundamental assumption of the study design was that the dietary intake and resultant MeHg exposure for tree swallow nestlings would be delivered to nestlings by adults foraging on emergent insects (primarily dipterans) within localized areas surrounding the nesting sites. The

average pre-flood concentration of MeHg in emergent dipterans was 0.0438 ± 0.0158 mg/kg dw. Following flooding of the reservoir, MeHg concentration measured in dipterans increased to an average concentration of 0.111 ± 0.0024 mg MeHg/kg dw (range 0.063 to 0.202 mg MeHg/kg dw). The average MeHg concentration in emergent dipterans remained consistently elevated at 0.119 ± 0.0216 mg/kg dw six years after the initial flood. Despite the increase in dietary MeHg exposure associated with reservoir flooding, measures of reproductive success in tree swallow nestlings evaluated over the six-year period following flooding were no different than reproductive success metrics measured prior to flooding. In addition, there were no differences in growth metrics measured during the post-flood conditions relative to the same metrics measured in a tree swallow population at reference lakes. Based on this long-term field investigation, a no effect dietary concentration of 0.111 mg MeHg/kg dw was estimated for tree swallow growth and reproductive success.

Longcore et al. (2007) monitored tree swallow nest boxes at six study areas in Acadia National Park, Maine and an EPA Superfund Site in Ayer, Massachusetts. Mean hatchability of tree swallow eggs was 88.6 to 94.3 percent and mean fledging success was 88.9 to 100 percent. Mean THg concentrations in boli obtained from nestlings monitored within the study areas ranged from 0.128 to 0.291 mg THg/kg ww. Reproductive metrics did not differ statistically between sites with varying exposure concentrations in boli. Furthermore, mean hatchability and mean fledgling success in the study were greater than estimates for the eastern part of the tree swallow breeding range. The findings of this field study indicate that mercury concentrations reported in boli sampled from monitored nestlings were not associated with adverse reproductive effects. Based on these findings, a dietary no effect concentration of 0.128 mg THg/kg ww was estimated based on the lowest average boli concentrations. A dietary no effect concentration of 0.0448 mg MeHg/kg ww, was estimated based on the THg concentration measured in boli and an assumed MeHg:THg ratio of 0.35 for bolus samples based on a conservative estimate of the range of MeHg proportions reported for emergent insects (Tremblay et al., 1996).

Custer et al. (2008) studied the effects of mercury exposure on reproductive success and survival in tree swallows eggs and nestlings at Lostwood National Wildlife Refuge in North Dakota. As a part of the study, boli were collected from the throats of 8 to 12-day-old nestlings to determine dietary composition and THg concentrations. The geometric mean concentration of THg in boli was 0.047 mg/kg dw, with concentrations ranging from below detection to 0.091 mg/kg dw. Tree swallow hatching success was 77 to 99 percent and was comparable to the nationwide average of 87 percent, indicating that mercury exposure did not adversely affect hatching success. Mean nestling survival to 12 days-of-age ranged from 94 to 100 percent, indicating that nestling survival was not depressed. Based on the lack of reproductive or survival effects on tree swallow nestlings, a dietary no effect concentration of 0.047 mg THg/kg dw was estimated based on the geometric mean concentration measured in boli. A dietary no effect concentration for MeHg of 0.016 mg MeHg/kg dw, was estimated based on the THg concentration measured in boli from reference areas and an assumed MeHg:THg ratio of 0.35 for bolus samples (Tremblay et al., 1996).

Using the dietary no effect concentrations derived from the tree swallow field studies described above, NOAEL doses were estimated based on a mean BW of 0.0202 kg and

FIRs of 0.0116 kg dw/day or 0.0352 kg ww/day derived by Nagy (2001) for passerine birds. As summarized in Table C-6, the estimated NOAELs for tree swallow ranged from 0.009 to 0.078 mg/kg BW/day based on Longcore et al. (2007). This NOAEL of 0.078 mg/kg BW/day based on Longcore et al. (2007) is very similar to the NOAEL of 0.067 mg/kg BW/day estimated based on Gerrard and St. Louis (2001), which provides the most comprehensive evaluation of exposure. Although the NOAEL derived from Gerrard and St. Louis (2001) has a robust basis and corresponds well with the NOAEL derived based on Longcore et al. (2007), a geometric mean of 0.036 mg/kg BW/day calculated from the three NOAELs derived from the field studies described above was used as the basis to evaluate modeled exposure on passerines. The geometric mean of the three NOAELs based on Gerrard and St. Louis (2001), Longcore et al. (2007), and Custer et al. (2008) studies was conservatively used to account for potential uncertainty in deriving TRVs from field studies.⁸ Although corresponding LOAELs were not derived based on these field studies, the maximum NOAEL from the field studies (0.078 mg/kg BW/day) was conservatively identified to represent a potential upper bound of the no effect dataset.

Inorganic Mercury (IHg) TRVs

Relatively fewer studies were available to evaluate chronic avian toxicity to IHg (Table C-7). Hill and Schaffner (1976) exposed Japanese quail chicks to dietary mercuric chloride at concentrations of 2, 4, 8, 16, or 32 mg THg/kg dw. No effects were observed on growth, maintenance, hatchability, and egg shell thickness at any dietary treatment; however, egg fertilization was suppressed at 4 mg THg/kg dw. A study by Scott et al. (1975) found no effects on egg production, hatchability, shell quality, morbidity, and mortality in Japanese quail or chicken at dietary concentrations of mercury sulfate or mercury chloride up to 200 mg/kg.

Avian TRVs for IHg were estimated based on the endpoints for Japanese quail presented in Hill and Schaffner (1976). Based on the suppression of egg fertilization at 4 mg THg/kg dw in diet, a LOAEL was estimated as 0.9 mg IHg/kg BW/day assuming a body weight of 0.15 kg and a FIR of 0.0169 kg dw/day (Sample et al., 1996). A NOAEL for IHg was estimated based on the no effect treatment of 2 mg THg/kg dw from Hill and Schaffner (1976), which is equivalent to 0.45 mg IHg/kg BW/day based on the above assumptions for body weight and FIR. TRVs derived for IHg were used for comparisons to IHg doses calculated for each representative avian receptor.

8.1.2 Summary of Avian Toxicity Reference Values

A summary of the TRVs used to evaluate potential risks associated with modeled dietary doses of IHg and MeHg to avian receptors within AOC-4 is provided in the table below.

⁸ A similar field study is available for the South River (Brasso and Cristol, 2008) that results in an estimated NOAEL of 0.008 mg/kg BW/day, similar to that based on Custer et al. (2008) study but likely overly conservative compared to 0.067 mg/kg BW/day based on Gerrard and St. Louis (2001). Only the three independent studies (Gerrard and St. Louis, 2001; Longcore et al., 2007; Custer et al., 2008) are included for the current derivation of NOAELs for tree swallows. However, Brasso and Cristol (2008) will be considered specifically in the risk characterizations.

Receptors	NOAEL (mg/kg BW/day)	LOAEL (mg/kg BW/day)	Basis
Methylmercury			
Piscivores/Waterfowl High Sensitivity	0.017	0.055	Reproductive effects on American kestrel (Albers et al., 2007)
Piscivores/Waterfowl Low-Moderate Sensitivity	0.024	0.078	Reproductive effects on mallard duck (Heinz, 1974; 1975; 1976a; 1976b; and 1979)
Carnivores	0.017	0.055	Reproductive effects on American kestrel (Albers et al., 2007)
Passerines	0.036/0.078 ^a	ND	Based on geometric mean of NOAELs derived from field studies (Gerrard and St. Louis, 2001; Longcore et al., 2007; Custer et al., 2008)
Inorganic Mercury	0.45	0.90	Reproductive effects on Japanese quail (Hill and Schaffner, 1976)

Notes:

a - Dose represents a potential upper bound of the NOAEL dataset.

ND - A dose was not derived due to limited dietary studies indicating adverse ecological effects.

8.1.3 Mammalian Toxicity Reference Values

Mammalian TRVs for MeHg and IHg were identified using a similar CSA process as described in the preceding section for birds. Similar to birds, different sets of MeHg TRVs were derived for different categories of mammals whereas only a single set of IHg TRVs were derived for all mammals. The following subsections describe the derivation of MeHg and IHg TRVs.

Methylmercury (MeHg) TRVs

EPA (1995b) derived MeHg TRVs for mammals based on a compilation of mammalian toxicity studies. These data were reviewed, and additional mammalian effects data from studies conducted since 1995 were also included in the review. Table C-8 summarizes mammalian studies and associated TRVs and the underlying assumptions regarding their derivation. Three studies [Verschuuren et al. (1976), O'Connor and Neilsen (1981), and Dansereau et al. (1999)] that were not included in the EPA (1995b) evaluations are briefly discussed below.

Verschuuren et al. (1976) conducted a growth, physiological, and reproduction study over three generations of rats exposed to dietary methylmercuric chloride (MeHgCl). Study endpoints included growth, food intake, hematology, serum and urinalysis, organ weights and reproductive performance. The most sensitive endpoint was relative weights of internal organs (kidneys, heart, spleen, brain, and thyroid), which increased at 0.08 mg/kg MeHgCl. Other notable effects thresholds included 0.4 mg MeHg/kg for increase in neutrophils and a decrease in lymphocytes and 2.0 mg MeHg/kg for impairment in viability index, reductions in weight gain and leucocyte counts. Based on NOEC of 0.5 and LOEC of 2.5 (0.4 and 2mg Hg/kg, respectively, at 79.9% purity of the test

compound) for survival and reproduction, a food ingestion rate of 0.074 kg/day (Nagy, 2001) and a BW of 0.35 kg (Sample et al., 1996), a NOAEL of 0.090 mg THg/kg BW/day and a LOAEL of 0.420 mg THg/kg BW/day were derived.

O'Connor and Neilsen (1981) fed rations with 2, 4, or 8 mg/kg MeHg to 11 adult male river otters (3 per dose level and 2 for control) for six months. Actual doses were 0.09, 0.17, and 0.37 mg THg/kg BW/day. At the LOAEL of 0.09 mg THg/kg/day two of three otter developed anorexia and ataxia between day 168 and 199.

Dansereau et al. (1999) fed semi-domesticated minks for two generations with a diet consisting of 20 percent mink feed, 40 percent eviscerated chicken carcasses (contaminant free), and 40 percent field-collected fish. Estimated dietary doses included 0.1, 0.5, and 1.0 mg THg/kg ww; however, it was assumed that THg concentrations of fish were in the form of MeHg. Whelping percentages of female mink were significantly lower in the 0.5 and 1.0 mg THg/kg treatment groups when compared to the 0.1 mg THg/kg group. In addition, survival of female mink from both generations was negatively affected in the 1.0 mg THg/kg ww treatment group. Effects concentrations reported in Dansereau et al. (1999) involved some uncertainty because the field-collected fish contained other organic chemicals that may have contributed to the reported reproductive toxicity. Therefore, this study was not considered suitable for the derivation of mercury-specific TRVs. However, it is summarized to support the selected TRVs as discussed further below.

Based on the available data summarized in Table C-8 and other considerations, mammalian TRVs were derived for four groups of the mammalian receptors: river otter (a piscivore), white-tailed deer (an herbivore), short-tailed shrew (a terrestrial insectivore) and big brown bat (an aerial insectivore).

River Otter: Piscivore

As part of the Great Lakes Initiative (EPA, 1995b), EPA based its derivation of water quality criteria for the protection of piscivorous mammals on two subchronic studies of mink conducted by Wobeser et al. (1976a and 1976b). Wobeser et al. (1976a) exposed ranch mink for 145 days at dietary methylmercuric chloride concentrations of 0.22 and 0.33 mg MeHg/kg ww. No clinical or pathological evidence of intoxication was observed in either treatment. As a result, a no effect dietary concentration of 0.33 mg/kg ww was identified for mink.

Wobeser et al. (1976b) fed adult female mink diets containing methylmercuric chloride at concentrations of 1.1, 1.8, 4.8, 8.3, and 15.0 mg MeHg/kg ww for up to 93 days. Female mink exposed to dietary concentrations of 1.8 mg/kg ww and greater developed clinical signs of mercury intoxication, including anorexia and ataxia; two of the five female mink exposed at 1.8 mg/kg ww died. Based on the combined results of these studies, a dietary effect concentration for anorexia, ataxia, and mortality in mink fed MeHg is identified as 1.8 mg/kg ww, and a corresponding no effect concentration is identified as 1.1 mg/kg. Assuming a mink BW of 1.0 kg and FIR of 0.015 kg/day ww (EPA, 1995b), the subchronic LOAEL and NOAEL doses associated with these studies are 0.27 mg/kg BW/day and 0.16 mg/kg BW/day, respectively (see Table C-8).

Wobeser et al. (1976b) was used as the basis for the derivation of MeHg TRVs for piscivorous mammals. This study was selected as the critical study for deriving TRVs for piscivorous mammals because it was a controlled, 93-day study of a piscivorous receptor exposed to MeHg that identifies no effect and effect endpoints that are relevant for population-level implications. Because the study was considered to be subchronic, UFs were applied to the estimated NOAEL and LOAEL doses to represent a chronic exposure. The subchronic NOAEL (0.16 mg/kg BW-day) and LOAEL (0.27 mg/kg BW/day) doses derived from Wobeser et al. (1976b) were divided by a UF of three based on EPA (1997) to estimate chronic TRVs. The resulting chronic NOAEL for mammalian piscivores was estimated as 0.053 mg/kg BW/day and the chronic LOAEL was estimated as 0.09 mg/kg BW/day. The estimated NOAEL corresponds well with : 1) a NOAEL of 0.050 mg/kg BW/day⁹ estimated from the 145-day study in which ranch mink were exposed to mercury-contaminated fish diet (Wobeser et al., 1976a), 2) a LOAEL of 0.09 mg/kg BW/day estimated based on a study in which multiple generations of mink were exposed to mercury-contaminated fish as part of their diet, and 3) a LOAEL observed in a 6 month study on adult male river otters exposed to MeHg via diet (O'Connor and Neilsen, 1981). Because mink and river otter are in the same family (*Mustelidae*), the chronic NOAEL and LOAEL derived based on Wobeser et al. (1976b) were used to evaluate potential risks to river otters in AOC-4.

White-Tailed Deer: Herbivore

Due to lack of MeHg toxicity data, derivations of screening level MeHg TRVs for white-tailed deer have generally relied on either the mink study by Wobeser et al. (1976a and b) or the rat study by Verschuuren et al. (1976) and application of scaling factors. For example, Sample et al. (1996) derived screening level NOAEL = 0.009 mg/kg BW/day and LOAEL = 0.045 mg/kg BW/day for white-tailed deer based on the Verschuuren et al. (1996) study and applying a body weight scaling factor (Travis and White, 1988; Travis et al., 1990, EPA 1992). Ford (2004) has used more appropriate data to derive a TRV of 0.09 mg/kg BW/day as a part of the *Risk Management Criteria for Metals at Bureau of Land Management Mining Sites*. Ford (2004) used the Maximum Mineral Tolerance Levels for mercury to ruminants (cows) that National Research Council (NRC, 1980) determined and applied an uncertainty factor of 6. This TRV of 0.090 mg/kg BW/day is the same as the NOAEL from the rat study by Verschuuren et al. (1976).

In the absence of more relevant data for mercury toxicity on white-tailed deer, the MeHg TRVs derived from the rat study by Verschuuren et al., (1976) is used to evaluate white-tailed deer exposed to mercury in AOC-4. An additional uncertainty factor is deemed unnecessary based on the Ford (2004) evaluation.

Short-Tailed Shrew: Terrestrial Insectivore

Similar to herbivores, insectivores also lack data on MeHg toxicity. Sample et al. (1996) derived screening level NOAEL = 0.070 mg/kg BW/day and LOAEL = 0.352 mg/kg

⁹ Assuming a dietary concentration of 0.33 mg MeHg/kg ww, a mink body weight of 1.0 kg, and an FIR of 0.015 kg/day ww.

BW/day for short-tailed shrew based on the rat study by Verschuuren et al. (1996) and applying a body weight scaling factor. The body weight scaling factor assumes that smaller animals have higher metabolic rates and usually are more resistant to toxic chemicals because of more rapid detoxification rates (Travis and White, 1988; Travis et al., 1990, EPA 1992). Limited acute toxicity data for mercury toxicity to mammals indicate otherwise: acute toxicities of organic mercury for a harp seal (average BW = 180 kg), a mule deer (average BW = 54.5 kg), and mink (average BW = 1 kg) occur at 25 mg/kg BW/day, 18 mg/kg BW/day (based on single dose of 18 mg/kg), and 0.15 mg/kg BW/day, respectively [data from EPA (1995)]. Available chronic toxicity data on mink and rat corroborate that mink (the larger of the two mammals) is generally more sensitive than rats to MeHg and IHg (Tables C-7 and C-8). However, among other characteristics, the mink and rat differ in their diet. Both the rat and short-tailed shrew are insectivores whereas the mink is a piscivore. It is also unclear whether body weight scaling factors are applicable for MeHg toxicity toward mammals. Therefore, the NOAEL = 0.090 mg/kg BW/day and LOAEL = 0.420 mg/kg BW/day for rats based on survival and reproductive endpoints from Verschuuren et al. (1976) were selected, without further extrapolation, for evaluation of short-tailed shrew exposed to MeHg in AOC-4.

Big Brown Bat: Aerial Insectivore

Available data are limited to evaluate the effects of mercury exposure on aerial insectivorous mammals (e.g., bats). A review of available literature did not identify dietary dosing studies or field studies (similar to those used for passerines) that could be used to derive a receptor-specific NOAEL or LOAEL to evaluate potential risks associated with dietary exposure to bats.

Bats feed on emergent insects and have relatively high metabolic rates associated with flight and small size. As a result, bats have greater relative food intake rates than other mammals that are less active or larger. Due to these factors and general differences in species sensitivities to MeHg exposure, bats may have different sensitivities to MeHg exposure relative to other mammals. Studies of rat exposures to MeHg indicate that mink are generally more sensitive to dietary MeHg exposure than other mammals (see Table C-8). In the absence of mercury toxicity information for bats, an interspecies UF of 2 was applied to the MeHg TRVs derived from mink studies (Wobeser et al., 1976b). The application of a UF may be conservative given that rat studies indicate less sensitive endpoints relative to mink studies; however, given the lack of toxicity data for taxa directly related to bats and potential vulnerability due to their exposure pathway linked to the aquatic system (i.e., feeding on emergent invertebrates), the application of a UF is warranted. Applying a UF of 2 to the TRVs derived for mammalian piscivores, the chronic NOAEL and LOAEL for aerial insectivores were estimated as 0.027 mg/kg BW/day and 0.045 mg/kg BW/day, respectively.

As previously stated, the evaluation of mammalian aerial insectivores exposed to mercury within AOC-4 will be evaluated based on comparisons of modeled doses to literature-derived TRVs and background doses. The dietary doses estimated for bats foraging in Reference Reaches will represent a site-independent dose that may be used to assess the relative exposure on bats in AOC-4, as well as to evaluate the uncertainty associated with the literature-derived TRVs described above.

Inorganic Mercury (IHg) TRVs

TRVs for mammalian exposure to IHg were selected based on a compilation of dietary exposure studies (see Table C-7). A NOAEL TRV for IHg was selected based on a chronic no effect dietary concentration for reproductive effects of mercuric chloride on mink (Aulerich et al., 1974). In this study, the adult minks were fed diets at 10 mg/kg dw mercuric chloride (at 73.9% purity) for five months. No effects were observed on growth, mortality, and reproductive success relative to controls. Based on a dietary IHg concentration of 10 mg/kg dw, a BW of 1.0 kg and FIR of 0.137 kg dw/day, Sample et al. (1996) derived a NOAEL of 1.01 mg/kg BW/day for IHg. This NOAEL is selected to evaluate IHg risks associated with dietary exposure to IHg in AOC-4. No LOAEL-based TRV was derived for mammalian exposure to IHg; however, Table C-7 provides a summary of LOAEL values reported in various studies.

8.1.4 Summary of Mammalian Toxicity Reference Values

A summary of the TRVs used to evaluate potential risks associated with modeled doses of IHg and MeHg to mammalian receptors within AOC-4 is provided in the table below.

Receptors	NOAEL (mg/kg BW/day)	LOAEL (mg/kg BW/day)	Basis
Methylmercury			
Mammalian Piscivores	0.053	0.09	Based on intoxication and mortality in mink (Wobeser et al., 1976b) and subchronic to chronic extrapolation factor of 2.
Mammalian Herbivores	0.090	0.420	Based on effects on survival and reproduction in rat (Verschuuren et al., 1976) and maximum tolerance level for cows (NRC, 1980).
Terrestrial Mammalian Insectivores	0.090	0.420	Based on effects on survival and reproduction in rat (Verschuuren et al., 1976).
Aerial Mammalian Insectivores	0.027	0.045	Based on an interspecies uncertainty factor of 2 applied to the TRVs for piscivores (above).
Inorganic mercury			
All mammals	1.01	NA	NOAEL derived by Sample et al. (1996) using mink reproductive endpoints reported by Aulerich et al. (1974).

9.0 References

- Abbasi, S.A., and Soni, R. 1983. *Stress-induced enhancement of reproduction in earthworm *Octochaetus Pattoni* exposed to chromium (VI) and mercury (II) – Implications in environmental management*. International Journal of Environmental Studies. 22: 43-47.
- Albers, P.H., Koterba, M.T., Rossmann, R., Link, W.A., French, J.B., Bennett, R.S., Bauer, W.C. 2007. *Effects of methylmercury on reproduction in American kestrels*. Environmental Toxicology and Chemistry. 26(9): 1856–1866.
- Aulerich, R.J., Ringer, R.K., Iwamoto, S. 1974. *Effects of dietary mercury on mink*. Archives of Environmental Contamination and Toxicology. 2: 43-51.
- Azevedo-Pereira, H, and AM, Soares. 2010. *Effects of mercury on growth, emergence, and behavior of *Chironomus riparius* Meigen (Diptera: Chironomidae)*. Archives of Environmental Contamination and Toxicology. 59:216-224.
- Barnett, M.O., Harris, L.A., Turner, R.R., Henson, T.J., Melton, R.E., and Stevenson, R.J. 1995. *Characterization of mercury species in contaminated floodplain soils*. Water Air Soil Pollution. 80: 1105–1108.
- Barnett, M.O., Harris, L.A., Turner, R.R., Stevenson, R.J., Henson, T.J., Melton, R.C., and Hoffman, D.P. 1997. *Formation of mercuric sulfide in soil*. Environmental Science & Technology. 31: 3037-3043.
- Barnett, M.O., and Turner, R.R. 2001. *Bioavailability of mercury in soils*. Soil and Sediment Contamination. 10(3): 301-316.
- Beckvar, N., et al. 2005. *Approaches for linking whole-body fish tissue residues of mercury or DDT to biological effects thresholds*. Environmental Toxicology and Chemistry. 24: 2094-2105.
- Bennett, P.M., Harvey, P.H. 1987. *Active and resting metabolism in birds: allometry, phylogeny and ecology*. Journal of Zoology. 213: 327-363.
- Bergeron, C.M., C.M. Bodniof, J.M. Urine and W.A. Hopkins. 2010. *Bioaccumulation and maternal transfer of mercury and selenium in amphibians*. Environmental Toxicology and Chemistry 29:989-997.
- Bergeron, C. M., Hopkins, W. A., Todd, B. D., Hepner, M. J., & Unrine, J. M. 2011. *Interactive effects of maternal and dietary mercury exposure have latent and lethal consequences for amphibian larvae*. Environmental Science and Technology. 45(8):3781-3787.
- Beyer, W.N., Cromartie, E., and Moment, G.B. 1985. *Accumulation of methylmercury in the earthworm *Eisenia foetida*, and its effect on regeneration*. Bulletin of Environmental Contamination and Toxicology. 35: 157-162.
- Biesinger, K. E., L. E. Anderson, and J. G. Eaton 1982. *Chronic effects of inorganic and organic mercury on *Daphnia magna*: toxicity, accumulation, and loss*. Archives of Environmental Contamination and Toxicology. 11:769-774.

- Birge, W.J., Black, J.A., Westerman, A.G., Hudson, J.E. 1979. *The effects of mercury on reproduction of fish and amphibians*. In Nriagu, J.O., ed, *The Biogeochemistry of Mercury in the Environment*. Elsevier/North-Holland Biomedical, New York, NY, USA, pp 629–655.
- Blankenship, A.L., Kay, D.P., Zwiernik, M.J., Holem, R.R., Newsted, J.L., Hecker, M., Giesy, J.P. 2008. *Toxicity reference values for mink exposed to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) equivalents (TEQs)*. *Ecotoxicology and Environmental Safety*. 69(3): 325–349.
- Bloom, N.S., Preus, E., Katon, J., Hiltner, M. 2003. *Selective extractions to assess the biogeochemically relevant fractionation of inorganic mercury in sediments and soils*. *Analytica Chimica Acta*. 479: 233-248.
- Boening, D.W. 2000. *Ecological effects, transport, and fate of mercury: a general review*. *Chemosphere*, 40: 1335-1351.
- Brasso, R.L., Cristol, D.A. 2008. *Effects of Mercury Exposure on the Reproductive Success of Tree Swallows (Tachycineta bicolor)*. *Ecotoxicology* 17:133-141.
- Borgmann, U., Norwood, W.P., and Clarke, C. 1993. *Accumulation, regulation and toxicity of copper, zinc, lead and mercury in Hyalella Azteca*. *Hydrobiologia* 259:78-89.
- Brasso, R.L., Cristol, D.A. 2008. *Effects of Mercury Exposure on the Reproductive Success of Tree Swallows (Tachycineta bicolor)*. *Ecotoxicology* 17:133-141.
- Burke, J.N., C.M. Bergeron, B.D. Todd and W.A. Hopkins. 2010. *Effects of mercury on behavior and performance of northern tow-lined salamanders (Eurycea bislineata)*. *Environmental Pollution* 158:3546-3551.
- Charbonneau, S.M., Munro, I.C., Nera, E.A., Willes, R.F., Kuiper-Goodman, T., Iverson, F., Moodie, C.A., Stoltz, D.R., Armstrong, F.A.J., Uthe, J.F., Grice, H.C. 1974. *Subacute toxicities of methylmercury in the adult cat*. *Toxicology and Applied Pharmacology*. 27: 569-581.
- CCME. 1998. *Protocol for derivation of Canadian tissue residue guidelines for the protection of wildlife that consume aquatic biota*. Canadian Council of Ministers of the Environment, Winnipeg.
- CCME. 2003. *Canadian water quality guidelines for the protection of aquatic life. Mercury: inorganic and methylmercury*. Canadian Environmental Quality Guidelines, Canadian Council of Ministers of the Environment.
- Chibunda, R.T. 2009. *Chronic toxicity of mercury (HgCl₂) to the benthic midge Chironomus riparius*. *International Journal of Environmental Research*. 3: 455-462.
- Custer, T.W., Custer, C.M., Johnson, K.M., Hoffman, D.J. 2008. *Mercury and other element exposure to tree swallows (Tachycineta bicolor) nesting on Lostwood National Wildlife Refuge, North Dakota*. *Environmental Pollution*. 155: 217-226.

- Dansereau, M., Lariviere, N., Du Tremblay, D., Belanger, D. 1999. *Reproductive performance of two generations of female semidomesticated mink fed diets containing organic mercury contaminated freshwater fish*. Archives of Environmental Contamination and Toxicology. 36: 221-226.
- Dillon, T., Beckvar, N., Kern, J. 2010. *Residue-based mercury dose-response in fish: An analysis using lethality-equivalent test endpoints*. Environmental Toxicology and Chemistry 29: 2559-2565.
- Drevnick, P.E., Sandheinrich, M.B. 2003. *Effects of dietary methylmercury on reproductive endocrinology of fathead minnows*. Environmental Science and Technology. 37: 4390–4396.
- Driscoll, C.T., Han, Y.J., Chen, C.Y., Evers, D.C., Lambert, K.F., Holsen, T.M., Kamman, N.C., Munson, R.K. 2007. *Mercury Contamination in Forest and Freshwater Ecosystems in the Northeastern United States*. Bio. Science. 57(1): 17-28.
- Duncan, D.A., and Klaverkamp, J.F. 1983. *Tolerance and resistance to cadmium in white suckers (Catastomus commersoni) previously exposed to cadmium, mercury, zinc or selenium*. Canadian Journal of Fisheries Aquatic Science. 40: 128-138.
- Environment Canada. 1995. *Toxicity testing of National Contaminated Sites Remediation Program priority substances for the development of soil quality guidelines for contaminated sites*. Evaluation and Interpretation Branch, Guidelines Division, Ottawa.
- EPA. 1985. *Ambient water quality criteria for mercury - 1984*. U.S. Environmental Protection Agency, Office of Water. Washington, DC 20460. EPA 440/5-84-026.
- EPA. 1992a. *Draft Report: A cross-species scaling factor for carcinogen risk assessment based on equivalence of mg/kg^{3/4}/day*. Notice. Federal Register. 57(109): 24152–24173.
- EPA. 1995a. *Final water quality guidance for the great lakes*. Fed Regist 60(56): 15366–15425
- EPA. 1995b. *Great Lakes Water Quality Initiative Criteria Documents for the Protection of Wildlife: DDT; Mercury; 2,3,7,8-TCDD; and PCBs*. Office of Water, Office of Science and Technology, Washington, DC 20460. EPA/820/B-95/008, March 1995.
- EPA. 1996. *1995 Updates: Water quality criteria documents for the protection of aquatic life in ambient water*. EPA, Office of Water, 4301. EPA-820-B-96-001.
- EPA. 1997. *Mercury Study Report to Congress; Volume VI: An Ecological Assessment for Anthropogenic Mercury Emissions in the United States*. Office of Air Quality Planning & Standards and Office of Research and Development, EPA-452/R-97-008.
- EPA. 2003. *Attachment 4–5. Ecological Soil Screening Levels (Eco-SSLs) standard operating procedure SOP No.6: Derivation of wildlife toxicity reference value (TRV)*. OWSER directive 92857–55, US EPA, Washington DC.

- EPA. 2014. *National Recommended Water Quality Criteria*. U.S. Environmental Protection Agency, Office of Water. Accessed February 21, 2014. Research and Development, Washington, DC. Available at: <http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm>
- ESI (EVS Solutions, Inc.). 1999. *Review of tissue residue effects data for tributyltin, mercury, and polychlorinated biphenyls: Literature review*. Prepared for The Port of Seattle, Lockheed Martin Corporation, Todd Shipyards, for submittal to U.S. Environmental Protection Agency Region 10. ESI Project No. 8/203-16.1.
- Eskeland, B., and I. Nafstad. 1978. *The modifying effect of multiple generation selection and dietary cadmium on methyl mercury toxicity in Japanese quail*. Archives of Toxicology. 40: 303-314.
- Field, J.L., D.D. MacDonald, S.B. Norton, C.G. Ingersoll, C.G. Severn, D. Smorong, and R. Lindscoog. 2002. *Predicting amphipod toxicity from sediment chemistry using logistic regression models*. Environmental Toxicology and Chemistry. 21(9): 1993-2005.
- Fimreite, N. 1970. *Effects of methyl mercury treated feed on the mortality and growth of leghorn cockerels*. Canadian Journal of Animal Science. 50(2): 387-389.
- Fimreite, N. 1971. *Effects of dietary methylmercury on ring-necked pheasants, with special reference to reproduction*. Canadian Wildlife Service, Ottawa, Occasional paper, no. 9. Department of the Environment.
- Fischer, E., and Koszorus, L. 1992. *Sublethal effects, accumulation capacities and elimination rates of As, Hg, and Se in the manure worm, Eisenia fetida (Oligochaeta, Lumbricidae)*. Pedobiologia. 36: 172-178.
- Fitzhugh, O.G., Nelson, A.A., Laug, E.P., Kunze, F.M. 1950. *Chronic oral toxicities of mercuri-phenyl and mercuric salts*. Archives of Industrial Hygiene and Occupational Medicine. 2: 433-442.
- Fjeld, E., Haugen, T.O., Vøllestad, L.A. 1998. *Permanent impairment in the feeding behavior of grayling (Thymallus thymallus) exposed to methylmercury during embryogenesis*. Science of the Total Environment. 213: 247-254.
- Flanders, J.R., Turner, R.R., Morrison, T., Jensen, R., Pizzuto, J., Skalak, K., Stahl, R. 2010. *Distribution, Behavior, and Transport of Inorganic and Methylmercury in a High Gradient Stream*. Applied Geochemistry, 25: 1756-1769.
- Ford, K.L. 2004. *Risk Management Criteria for Metals at Bureau of Land Management Mining Sites*. United States Department of the Interior, Bureau of Land Management, National Science and Technology Center, Denver, CO. BLM/RS/ST-97/001+1703.
- Frederick, P. C. 1987. *Extra pair copulations in the mating system of white ibis (Eudocimus Albus)*. Behaviour 100: 170-201.

- Frederick, P., Jayasena, N. 2010. *Altered pairing behavior and reproductive success in white ibises exposed to environmentally relevant concentrations of methylmercury*. Proceedings of the Royal Society B: Biological Sciences. 278: 1851–1857.
- French, J. B., Bennett, R.S., Rossmann, R. 2010. *Mercury in the blood and eggs of American kestrels fed methylmercury chloride*. Environmental Toxicology and Chemistry, 29(10), 2206–2210.
- Friedmann, A.S., Watzin, M.C., Brinck-Johnsen, T., Leiter, J.C. 1996. *Low levels of dietary methylmercury inhibit growth and gonadal development in juvenile walleye (Stizostedion vitreum)*. Aquatic Toxicology. 35: 265–278.
- Fuchsman, P.C., Barber, T.R., Lawton, J.C., Leigh, K.B. 2006. *An evaluation of cause-effect relationships between polychlorinated biphenyl concentrations and sediment toxicity to benthic invertebrates*. Environmental Toxicology and Chemistry. 25:2601–2612.
- Fuyuta, M., Fujimoto, T., Hirata, S. 1978. *Embryotoxic effects of methylmercuric chloride administered to mice and rats during organogenesis*. Teratology. 18:353–366.
- Gerrard, P.M., and St. Louis, V.L. 2001. *The effects of experimental reservoir creation on the bioaccumulation of MeHg and reproductive success of tree swallows (Tachycineta bicolor)*. Environmental Science & Technology. 35:1329–1338.
- Geyer, M.A., Butcher, R.E., Fite, K. 1985. *A study of startle and locomotor activity in rats exposed prenatally to methylmercury*. Neurobehavioral Toxicology & Teratology. 7:759–765.
- Glover, J.B., Domino, M.E., Altman, K.C., Dillman, J.W., Castleberry, W.S., Eidson, J.P., Mattocks, M. 2010. *Mercury in South Carolina Fishes, USA*. Ecotoxicology 19:781–797.
- Gudbrandsen, M., Sverdrup, L.E., Aamodt, S. and Stenersen, J. 2007. *Short-term exposure increases earthworm tolerance to mercury*. European Journal of Soil Biology. 43 (Supp. 1): S261–S267.
- Gupta, M., and Chandra, P. 1998. *Bioaccumulation and toxicity of mercury in rooted-submerged macrophyte Vallisneria spiralis*. Environmental Pollution. 103: 327–332.
- Gustin, M.S., L.Saito and M. Peacock. 2005. *Anthropogenic impacts on mercury concentrations and nitrogen and carbon isotope ratios in fish muscle tissue of the Truckee River watershed, Nevada, USA*. Science of the Total Environment 347:282–294.
- Hammerschmidt, C.R., Sandheinrich, M.B., Wiener, J.G., Rada, R.G. 2002. *Effects of dietary methylmercury on reproduction of fathead minnows*. Environmental Science and Technology. 36: 877–883.

- Harris, L.A., Henson, T.J., Combs, D., Melton, R.E., Steele, R.R., and Marsh, G.C. 1996. *Imaging and microanalyses of mercury in flood plain soils of East Fork Poplar Creek*. Water Air Soil Pollution. 86: 51-69.
- Heinz, G. 1974. *Effects of low dietary levels of methyl mercury on mallard reproduction*. Bulletin of Environmental Contamination and Toxicology. 11(4): 386–392.
- Heinz, G. 1975. *Effects of methylmercury on approach and avoidance behavior of mallard ducklings*. Bulletin of Environmental Contamination and Toxicology. 13(5):554–564.
- Heinz, G.H. 1976a. *Methylmercury: second-generation reproductive and behavioral effects on mallard ducks*. Journal of Wildlife Management. 40(4): 710–715
- Heinz, G.H. 1976b. *Methylmercury: second-year feeding effects on mallard reproduction and duckling behavior*. Journal of Wildlife Management. 40: 82–90
- Heinz, G.H. 1979. *Methylmercury: reproductive and behavioral effects on three generations of mallard ducks*. Journal of Wildlife Management. 43: 394–401
- Heinz, G., and Locke, L.N. 1976. *Brain lesions in mallard ducklings from parents fed methylmercury*. Avian Diseases. 20(1): 9–17
- Heinz, G., Hoffman, D., Klimstra, J., Stebbins, K., Kondrad, S., Erwin, C. 2009. *Species differences in the sensitivity of avian embryos to methylmercury*. Archives of Environmental Contamination and Toxicology. 56(1): 129–138.
- Heinz, G., Hoffman, D., Klimstra, J., Stebbins, K. 2010. *Reproduction in mallards exposed to dietary concentrations of methylmercury*. Ecotoxicology. 19(5): 977–982.
- Heinz, G., Hoffman, D., Klimstra, J., Stebbins, K., Kondrad, S., Erwin, C. 2011. *Hormesis associated with a low dose of methylmercury injected into mallard eggs*. Archives of Environmental Contamination and Toxicology. 62(1): 141–144.
- Hill, E.F., Schaffner, C.S. 1976. *Sexual maturation and productivity of Japanese Quail fed graded concentrations of mercuric chloride*. Poultry Science 55: 1449-1459.
- Hothem, R.L., D.R. Bergen, M.L. Bauer, J.J. Crayon and A.M. Meckstroth. 2007. *Mercury and Trace Elements in Crayfish from Northern California*. Bulletin of Environmental Contamination and Toxicology. 79:628-632.
- Hothem, R.L., Jennings, M.R., Crayton, J.J. 2010. *Mercury contamination in three species of anuran amphibians from the Cache Creek Watershed, California, USA*. Environmental Monitoring and Assessment. 163: 433-448.
- Jayasena, N., Frederick, P.C., Larkin, L.V. 2011. *Endocrine disruption in white ibises (Eudocimus albus) caused by exposure to environmentally relevant levels of methylmercury*. Aquatic Toxicology. 105(3–4): 321–327.
- Kenow, K.P., Gutreuter, S., Hines, R.K., Meyer, M.W., Fournier, F., Karasov, W.H. 2003. *Effects of methyl mercury exposure on the growth of juvenile common loons*. Ecotoxicology. 12(1): 171–181.

- Khera, K.S., Tabacova, S.A. 1973. *Effects of methylmercuric chloride on the progeny of mice and rats treated before or during gestation*. Food and Cosmetics Toxicology. 11:245-254.
- Linder, G., and Grillitsch, B. 2000. *Ecotoxicology of metals. Ecotoxicology of Amphibians and Reptiles*. SETAC, Pensacola, FL, USA, 325-459.
- Lock, K. and Janssen, C.R., 2001. *Ecotoxicity of mercury to Eisenia fetida, Enchytraeus albidus and Folsomia candida*. Biology and Fertility of Soils 34, 219–221.
- Longcore, J.R., Haines, T.A., Halteman, W.A. 2007. *Mercury in tree swallow food, bodies, and feathers at Acadia National Park, Maine, and an EPA Superfund Site, Ayer, Massachusetts*. Environmental Monitoring and Assessment. 126: 129-143.
- Long, E.R., Field, L.J., MacDonald, D.D. 1998. *Predicting toxicity in marine sediments with numerical sediment quality guidelines*. Environmental Toxicology and Chemistry. 17: 714-727.
- Lorz, H.W., et al. 1978. *Effects of several metals on smolting of coho salmon*. EPA-600/3-78-090. National Technical Information Service, Springfield, Virginia.
- Matta, M.B., Linse, J., Cairncross, C., Francendese, L., Kocan, R.M. 2001. *Reproductive and transgenerational effects of methylmercury or Aroclor 1268 on F. heteroclitus*. Environmental Toxicology and Chemistry. 20: 327–335.
- MacDonald, D.D., Ingersoll, C.G., and T.A. Berger. 2000. *Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems*. Arch. Environmental Toxicology and Chemistry. 39:20-31.
- Mallatt, J., Barron, M.G., and McDonough, C. 1986. *Acute toxicity of methyl mercury to the larval lamprey, Petromyzon marinus*. Bulletin of Environmental Contamination and Toxicology. 37: 281-288.
- McKim, J. M., Olson, G. F., Holcombe, G.W., Hunt, E.P. 1976. *Long-term effects of methylmercuric chloride on three generations of brook trout (Salvelinus fontinalis): toxicity, accumulation, distribution, and elimination*. J. Fish. Res. Board Can. 33: 2726-2739.
- Nagy, K.A. 2001. *Food requirements of wild animals: predictive equations for free-living mammals, reptiles, and birds*. Nutrition Abstracts and Reviews Series B: Livestock Feeds and Feeding. 71(10): 21R-31R.
- Naimo, T.J., Wiener, J.F., Cope, W.G., Bloom, N.S. 2000. *Bioavailability of sediment-associated mercury to Hexagenia mayflies in a contaminated floodplain river*. Canadian Journal of Fish and Aquatic Science. 57: 1092-1102.
- National Research Council (NRC). 1980. *Mineral Tolerance of Domestic Animals*. National Academy of Sciences, Washington, DC.
- Naumann, B., Eberius, M., Appenroth, K.J. 2007. *Growth rate based dose-response relationships and EC-values of ten heavy metals using the duckweed growth inhibition test (ISO 20079) with Lemna minor L. clone St*. Journal of Plant Physiology. 164: 1656-1664.

- Niimi, A.J., and Cho, C.Y. 1983. *Laboratory and field analysis of pentachlorophenol (PCP) accumulation by salmonids*. Water Research. 17(12): 1791-1795.
- Niimi, A.J. and Kisson, G.P. 1994. *Evaluation of the critical body burden concept based on inorganic and organic mercury toxicity to rainbow trout (Oncorhynchus mykiss)*. Archives of Environmental Contamination and Toxicology. 26:169-178.
- O'Connor, D.J., and S.W. Nielsen. 1980. *Environmental survey of methylmercury levels in wild mink (Mustela vison) and otter (Lutra canadensis) from the northeastern United States and experimental pathology of methylmercurialism in the otter*. Worldwide Furbearer Conference Proceedings, pp. 1728-1745.
- Odin, M., Ferutet-Mazel, A., Ribeyre, F., Boudou, A. 1994. *Actions and interactions of temperature, pH and photoperiod on mercury bioaccumulation by nymphs of the burrowing mayfly Hexagenia rigida, from the sediment contamination source*. Environmental Toxicology & Chemistry. 13(8): 1291-1302.
- Office of Economic Cooperation and Development (OECD). 2004. *Test 222: OECD Guideline for the Testing of Chemicals. Earthworm Reproduction Test (Eisenia fetida/Eisenia andrei)*. Adopted 23, November, 2004.
- Office of Economic Cooperation and Development (OECD). 2006. *Test 208: OECD Guideline for the Testing of Chemicals. Terrestrial Plant Test: Seedling Emergence and Seedling Growth Test*. Adopted 19, July, 2006.
- Panda, K.K., Lenka, M., and Panda B.B. 1992. *Monitoring and assessment of mercury pollution in the vicinity of a chlorakali plant. II. Plant-availability, tissue-concentration and genotoxicity of mercury from agricultural soil contaminated with solid waste assessed in barley (Hordeum vulgare L.)*. Environmental Pollution. 76: 33-42.
- Parks, J. W. and A.L. Hamilton. 1987. *Accelerating Recovery of the Mercury-Contaminated Wabigoon/English River System*. Hydrobiologia. 149: 159-188.
- Pennuto, C.M., O.P. Lane, D.C. Evers, R.J. Taylor and J. Loukmas. 2005. *Mercury in the Northern Crayfish, orconectes virilis (Hagen), in New England, USA*. Ecotoxicology 14:149-162.
- Persaud, D., Jaagumagi, R., and A. Hayton, 1992. *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario*. Ontario Ministry of the Environment, Queen's Printer for Ontario.
- Ptacek, C., Blowes, D., Desrochers, K., Gibson, B., Paulson, K. 2013. *Geochemical characterization of mercury-bearing riverbank sediments and soils from the South River, Virginia (USA)*. Department of Earth and Environmental Sciences, University of Waterloo, Waterloo, Ontario, Canada. Available at: https://s3.amazonaws.com/abi_web_files/southriverscienceteam.org/document-library/2013/10-2013/Briefing_Paper-Geochemical_Characterization.pdf
- Qureshi, S.A., and Saksena, A.B. 1980. *The acute toxicity of some heavy metals to Tilapia mossambica (Peters)*. Aqua 1:19.

- Revis, N., Holdsworth, G., Bingham, G., King, A., Elmore, J. 1989. *An assessment of health risk associated with mercury in soil and sediment from East Fork Poplar Creek, Oak Ridge, Tennessee*. Oak Ridge Research Institute, Final Report, 58 pp.
- Revis, N.W., Osborne, T.R., Holdsworth, G. and Hadden, C. 1989b. *Distribution of mercury species in soil from a mercury-contaminated site*. Water Air Soil Pollution. 45: 105–113.
- Rizzo, A. M., Furst, A. 1972. *Mercury teratogenesis in the rat*. Proceedings of the Western Pharmacology Society. Vol. 15, pp. 52-54.
- Rossaro, B., Gaggino, G.F., and Marchetti, R. 1986. *Accumulation of mercury in larvae and adults, Chionomus riparius (Meigen)*. Bulletin of Environmental Contamination and Toxicology. 37:402-406.
- Sample B.E, Suter, D. 1993. *Toxicological benchmarks for wildlife*. ORNL Oak Ridge National Laboratory (US), Oak Ridge.
- Sample, B.E., Suter, G.W. 1994. *Estimating Exposure of Terrestrial Wildlife to Contaminants*. September 1994, Prepared by the Risk Assessment Program Health Sciences Research Division Oak Ridge, Tennessee 37831 ES/ER/TM-125.
- Sample, B.E., Opersko, D.M., Suter, G.W. 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision*. June 1996, Prepared by the Risk Assessment Program Health Sciences Research Division Oak Ridge, Tennessee 37831, ES/ER/TM-86/R3.
- Saouter, E., Hare, L., Campbell, P., Boudou, A., and F. Ribeyre. 1993. *Mercury accumulation in the burrowing mayfly Hexagenia rigida (Ephemeroptera) exposed to CH₃HgCl or HgCl₂ in water and sediment*. Water Resources. 27: 1041-1048.
- Scheuhammer, A. 1988. *Chronic dietary toxicity of methylmercury in the zebra finch, Poephila guttata*. Bulletin of Environmental Contamination and Toxicology. 40(1):123–130
- Schuytema, G.S. and A.V. Nebeker. 1996. *Amphibian toxicity data for water quality criteria chemicals*. EPA/600/R-96/124. U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Western Ecology Division, Corvallis, Oregon.
- Scott, M.L., Zimmermann, J.R., Marinsky, S., Mullenhoff, P.A., Rumsey, G.L., Rice, R.W. 1975. *Effects of PCBs, DDT, and mercury compounds upon egg production, hatchability and shell quality in chickens and Japanese quail*. Poultry Science. 54(2), 350-368.
- Scott, M. 1977. *Effects of PCBs, DDT, and mercury compounds in chickens and Japanese quail*. Federation Proceedings. 36: 1888–1893
- SCDHEC (South Carolina Department of Health and Environmental Control). 2013. *South Carolina Fish Consumption Advisory*. Accessed on January 17, 2013 at: <https://www.scdhec.gov/environment/water/fish/map.htm>

- Semu, E., Singh, B.R., Selmerolsen, A.R. and Steenberg, K. 1985. *Uptake of Hg from Hg²⁰³-labeled mercury compounds by wheat and beans grown on an oxisol*. Plant and Soil. 87: 347–355.
- Sheppard, S.C., Evenden, W.G., Abboud, S.A., Stephenson, M. 1993. *A plant life-cycle bioassay for contaminated soil, with comparison to other bioassays: Mercury and zinc*. Archives of Environmental Contamination and Toxicology. 25: 27-35.
- Simon, O. and A. Boudou. 2001. *Simultaneous Experimental Study of Direct and Indirect Plus Trophic Contamination of the Crayfish *Astacus astacus* by Inorganic Mercury and Methylmercury*. Environmental Toxicology and Chemistry 20:1206-1215.
- Smith DW and SM Jones. 2006. *It's time to abandon co-occurrence sediment quality benchmarks (SQBs)*. SETAC Globe, March-April 2006, pp. 27-29.
- Snarski, V.M., Olson, G.F. 1982. *Chronic toxicity and bioaccumulation of mercuric chloride in the fathead minnow (*Pimephales promelas*)*. Aquatic Toxicology. 2: 143–156.
- Son, J., Ryoo, M.I., Jung, J., and Cho, K. 2007. *Effects of cadmium, mercury and lead on the survival and instantaneous rate of increase of *Paronychiurus kimi**. Applied Soil Ecology. 35: 404–411.
- Spalding, M.G., Frederick, P.C., McGill, H.C., Bouton, S.N., McDowell, L.R. 2000. *Methylmercury accumulation in tissues and its effects on growth and appetite in captive great egrets*. Journal of Wildlife Diseases. 36(3): 411-422.
- Spann, J., Heath, R., Kreitzer, J., Locke, L. 1972. *Ethyl mercury p-toluene sulfonamide: lethal and reproductive effects on pheasants*. Science. 175(4019): 328-331.
- Styrishave, B., Rasmussen, A.D. and Depledge, M.H. 1995. *The influence of bulk and trace metals on the circadian rhythm in fresh water crayfish (*Astacus astacus*)*. Marine Pollution Bulletin 31: 87–92.
- Styrishave, B., and Depledge, M. H. 1996. *Evaluation of mercury-induced changes in circadian heart rate rhythms in the freshwater crab, *Potamon potamios* and the crayfish, *Astacus astacus* as an early predictor of mortality*. Comparative Biochemistry and Physiology Part A: Physiology, 115: 349-356.
- Suchanek, T.H., C.A. Eacles-Smith, D.G. Slotton, E.J. Harner, D.P. Adam, A.E. Colwell, H.L. Anderson and D.L. Woodward. 2008. *Mine-Derived Mercury: Effects on Lower Trophic Species in Clear Lake, California*. Ecological Applications 18:A158-A176.
- Suter, G.W., II. 1996. *Toxicological benchmarks for screening contaminants of potential concern for effects on freshwater biota*. Environmental Toxicology and Chemistry 15:1232-1241.
- Suter, G.W. II, and C.L. Tsao. 1996. *Toxicological Benchmarks for Screening of Potential Contaminants of Concern for Effects on Aquatic Biota on Oak Ridge Reservation: 1996 Revision*. Oak Ridge National Laboratory, Oak Ridge, TN. 104pp. [ES/ER/TM-96/R2](#).

- Suter, K.E., Schon, H. 1986. *Testing strategies in behavioral teratology: I. Testing battery approach*. Neurobehavioral Toxicology & Teratology. 8: 561-566.
- Tessier L, G Vaillancourt, L Pazdernik. 1996. *Laboratory study of Cd and Hg uptake by two freshwater molluscs in relation to concentration, age and exposure time*. Water Air Soil Pollution. 86: 347-357.
- Thakali, S., Allen, H.E., Di Toro, D.M., Ponizovsky, A.A., Rooney, C.P., Zhao, F.J., McGrath, S.P., Criel, P., Van Eeckhout, H., Janssen, C.R., Oorts and K. Smolders, E. 2006a. *A terrestrial biotic ligand model. 1. Development and application to Cu and Ni toxicities to barley root elongation in soils*. Environmental Science and Technology. 40: 7094-7100.
- Thakali, S; Allen, HE; Di Toro, DM; Ponizovsky, AA; Rooney, CP; Zhao, FJ; McGrath, SP; Criel, P; Van Eckout, H; Janssen, C; Oorts, K; Smolders, E. 2006b. *Terrestrial biotic ligand model. 2. Application to Ni and Cu toxicities to plants, invertebrates, and microbes in soil*. Environmental Science and Technology. 40:7094-7100.
- Tipping, E., Loftis, S., Hooper, H., Frey, B., Spurgeon, D., Svendsen, C. 2010. *Critical limits for Hg(II) in soils, derived from chronic toxicity data*. Environmental Pollution. 158: 2465-2471.
- Todd, B.D., C.M. Bergeron, M.J. Hepner, J.N. Burke and W.A. Hopkins. 2011a. *Does maternal exposure to an environmental stressor affect offspring response to predators?* Oecologia 166:283-290.
- Todd, B.D., C.M. Bergeron, M.J. Hepner and W.A. Hopkins. 2011b. *Aquatic and Terrestrial stressors in amphibians: A test of the double jeopardy hypothesis based on maternally and trophically derived contaminants*. Environmental Toxicology and Chemistry 30: 2277-2284.
- Todd, B.D., J.D. Willson, C.M. Bergeron and W.A. Hopkins. 2012. *Do effects of mercury in larval amphibians persist after metamorphosis?* Ecotoxicology 21:87-95.
- Travis, C.C., and White, R.K. 1988. *Interspecific scaling of toxicity data*. Risk Analysis 8:119-125.
- Travis, C.C., White, R.K., and Wards, R.C. 1990. *Interspecies extrapolation of pharmacokinetics*. Journal of Theoretical Biology. 142: 285-304.
- Tremblay, A., Lucotte, M., Meili, M., Cloutier, L., and Pichet, P. 1996. *Total mercury and methylmercury contents of insects from boreal lakes: ecological, spatial, and temporal patterns*. Water Quality Research Journal of Canada. 31: 851-873.
- Tsui, M.T.K., and Wang, W.X. 2006. *Acute toxicity of mercury to Daphnia magna under different conditions*. Environmental Science & Technology. 40: 4025-4030.
- UNEP (United Nations Environment Program). 2002. Global mercury assessment. Issued by UNEP Chemicals Geneva, Switzerland, December 2002, accessed on April 8, 2014 at: <http://www.unep.org/gc/gc22/Document/UNEP-GC22-INF3.pdf>
- USACE (U.S. Army Corps of Engineers). 2014. *Environmental Residue Effects Database (ERED)*. Accessed in February, 2014 at: <http://el.erdc.usace.army.mil/ered/>

- USACHPPM (U.S. Army Center for Health Promotion and Preventive Medicine). 2004. *Development of Terrestrial Exposure and Bioaccumulation Information for the Army Risk Assessment Modeling System (ARAMS)*. USACHPPM Contract Number DAAD050-00-P-8365, Aberdeen Proving Ground, Maryland, 2004.
- USGS. 2000. *Mercury in the Environment*. Fact Sheet 146-00. October. Available from: <http://www.usgs.gov/themes/factsheet/146-00/#fish>.
- Valenti, T.W., Cherry, D.S., Neves, R.J., and J. Schmerfeld. 2005. *Acute and chronic toxicity of mercury to early life stages of the rainbow mussel, Villosa iris (Bivalvia: Unionidae)*. Environmental Toxicology and Chemistry. 24: 1242-1246.
- Verschuuren, H.G., Kroes, R., Den Tonkelaar, E.M., Berkvens, J.M., Helleman, P.W., Rauws, A.G., Schuller, P.L., Van Esch, G.J. 1976. *Toxicity of methylmercury chloride in rats. II. Reproduction study*. Toxicology. 6: 97-106.
- Vorhees, C. 1985. *Behavioral effects of prenatal methylmercury in rats: a parallel trial to the collaborative behavioral teratology study*. Neurobehavioral Toxicology & Teratology. 7: 717-725.
- Weaver, R.W., Melton, J.R., Wang, D.S. and Duble, R.L. 1984. *Uptake of arsenic and mercury from soil by Bermuda grass Cynodon dactylon*. Environmental Pollution. 33: 133-142.
- Webber, H.M., Haines, T.A. 2003. *Mercury effects on predator avoidance behavior of a forage fish, golden shiner (Notemigonus crysoleucas)*. Environmental Toxicology and Chemistry. 22: 1556-1561.
- Weis, P., and Weis, J.S. 1978. *Methylmercury inhibition of fin regeneration in fishes and its interaction with salinity and cadmium*. Estuar Coast Mar Sci 6:327-334.
- Wiener, J. G. and D. J. Spry. 1996. *Toxicological significance of mercury in freshwater fish*. In: Beyer, W.N., G.H. Heinz, and A.W. Redmon-Norwood (eds.). Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations. Special Publication of the Society of Environmental Toxicology and Chemistry. Boca Raton, Florida: Lewis Publishers. 494 pp.
- Wobeser, G., Nielsen, N.D., Schiefer, B. 1976a. *Mercury and Mink I: The use of mercury contaminated fish as a food for ranch mink*. Canadian Journal of Comparative Medicine. 40:30-33.
- Wobeser, G., Nielsen, N.D., Schiefer, B. 1976b. *Mercury and Mink II: Experimental methyl mercury intoxication*. Canadian Journal of Comparative Medicine. 40: 34-45.
- World Health Organization (WHO). 1989. *Mercury — Environmental Aspects*. International Programme on Chemical Safety (IPCS). Geneva, Switzerland. 115 pp.
- Zagury, G.J., Neculita, C.M., Bastien, C., Deschenes, L. 2006. *Mercury fractionation, bioavailability, and ecotoxicity in highly contaminated soils from chlor-alkali plants*. Environmental Toxicology and Chemistry. 24(4): 1138-1147.

Zhang, R., Wu, F., Li, H., Guo, G., Feng, C., Giesy, J.P., Chang, H. 2013. *Toxicity reference values and tissue residue criteria for protecting avian wildlife exposed to methylmercury in China*. Reviews of Environmental Contamination and Toxicology. 223: 53-80.

Tables

Table C-1
Summary of Invertebrate Critical Body Residues
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Test Species	Life Stage	Exposure Route	Effect Type	Tissue Type	Mercury Form	NOEC (mg Hg/kg ww)	LOEC (mg Hg/kg ww)	References ^a
Mayfly (<i>Hexagenia</i>)	Nymph	Absorption	Growth	Whole Body	MeHg	0.037	NA	Naimo et al. (2000) ^c
Mayfly (<i>Hexagenia</i>)	Nymph	Absorption	Growth	Whole Body	THg	2.16	NA	Naimo et al. (2000) ^d
Mayfly-Burrowing (<i>Hexagenia rigida</i>)	Nymph	Combined	Growth	Whole Body	THg	2.70	NA	Odin et al. (1994)
Mayfly-Burrowing (<i>Hexagenia rigida</i>)	Nymph	Combined	Growth	Whole Body	MeHg	7.49	NA	Saouter et al. (1993)
Mayfly-Burrowing (<i>Hexagenia rigida</i>)	Nymph	Combined	Growth	Whole Body	THg	3.77	NA	Saouter et al. (1993)
Water flea (<i>Daphnia magna</i>)	Immature	Absorption	Reproduction	Whole Body	THg	1.53	2.33	Biesinger et al. (1982)
Water flea (<i>Daphnia magna</i>)	Juvenile	Water	Reproduction	Whole Body	THg	3.05	4.66	Niimi and Cho (1983)
Grass shrimp (<i>Palaemonetes pugio</i>)	Adult	Absorption	Survival	Whole Body	THg	1.64	NA	Barthalmus (1977)
Water flea (<i>Daphnia magna</i>)	Immature	Absorption	Survival	Whole Body	THg	2.60	NA	Biesinger et al. (1982) ^b
Mayfly-Burrowing (<i>Hexagenia rigida</i>)	Nymph	Combined	Survival	Whole Body	THg	2.70	NA	Odin et al. (1994)
Eastern elliptio (<i>Elliptio complanata</i>)	NS	Water	Survival	Soft Tissue	THg	3.40	NA	Tessier et al. (1996)
Water flea (<i>Daphnia magna</i>)	Juvenile	Water	Survival	Whole Body	THg	4.66	NA	Niimi and Cho (1983)
Banded mystery snail (<i>Viviparus georgianus</i>)	NS	Water	Survival	Soft Tissue	THg	6.00	NA	Tessier et al. (1996)
Water flea (<i>Daphnia magna</i>)	Juvenile	Water	Survival	Whole Body	THg	NA	9.73	Tsui and Wang (2006)
Water flea (<i>Daphnia magna</i>)	Immature	Absorption	Survival	Whole Body	THg	7.57	18.40	Biesinger et al. (1982)
Amphipod (<i>Hyalella azteca</i>)	Juvenile	Water	Survival	Whole Body	THg	11.20	18.00	Borgmann et al. (1993)
Non-biting Midge (<i>Chironomus riparius</i>)	Larval	Absorption	Survival	Whole Body	THg	107.6	NA	Rossaro et al. (1986)

Notes:

NA, Endpoint not available from study; NS, Life stage not stated; ww, wet weight; dw, dry weight; NOEC, No observed effects concentration; LOEC, Lowest observed effects concentration. Concentrations reported in literature studies reviewed for invertebrate critical body residues have been expressed as mg/kg ww for consistency with the presentation of invertebrate tissue concentrations in the 2014 Ecological Risk Assessment Report.

a, All studies from Environmental Effects Residue Database [(ERED), USACE (2014)], unless noted otherwise; Accessed in February, 2014 at: <http://el.erdc.usace.army.mil/ered/>

b, From ESI (1999); Involved MeHg exposure and no effects on survival.

c, Based on mean concentration (0.1837 mg MeHg/kg dw) from the highest no effect treatment and an assumed moisture content of 80 percent for benthic invertebrates.

d, Based on mean concentration (10.819 mg THg/kg dw) from the highest no effect treatment and an assumed moisture content of 80 percent for benthic invertebrates.

Table C-2
Summary of Studies on Mercury Toxicity toward Terrestrial Plants
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Species	Soil Type	Duration	Endpoint	Soil pH	SOM (%)	NOEC (mg Hg/kg soil)	LOEC (mg Hg/kg soil)	Reference
Bermuda grass (<i>Cyndon dactyldon</i>)	Houston Black Clay	42-d	Biomass	7.6	3.9	50	NA	Weaver et al. (1984)
Bermuda grass (<i>Cyndon dactyldon</i>)	Westwood Silt	42-d	Biomass	7.7	1.29	8	25	Weaver et al. (1984)
Bermuda grass (<i>Cyndon dactyldon</i>)	Arenosa Fine Sand	42-d	Biomass	4.7	0.39	25	50	Weaver et al. (1984)
Lettuce (<i>Lactuca sativa</i>)	NA	NA	Emergence	4	5.6	7	11 (25)	Environment Canada (1995)
Radish (<i>Raphanus sativus</i>)	NA	NA	Emergence	4	5.6	51	73 (25)	Environment Canada (1995)
Kidney bean (<i>Phaseolus vulgaris</i>)	Natural Soil (oxisol)	43-d	Biomass Emergence	5.7	2.9	1	5	Semu et al. (1985) ^a
Wheat (<i>Triticum aestivum</i> L.)	Natural Soil (oxisol)	43-d	Biomass Emergence	5.7	2.9	5	50	Semu et al. (1985) ^a
Field mustard (<i>Brassica rapa</i>)	Artificial Silty-Clay Soil	60-d	Various	7.9	2.7	100 ^b	220 ^b	Sheppard et al. (1993)
Field mustard (<i>Brassica rapa</i>)	Artificial Garden Soil	60-d	Various	7.3	8.9	100 ^b	220 ^b	Sheppard et al. (1993)
Field mustard (<i>Brassica rapa</i>)	Artificial Sandy Soil	60-d	Various	6.3	0	10 ^b	10-22 ^b	Sheppard et al. (1993)
Barley	Contaminated Soil	NA	Growth Germination	7.4	0.7	34.5	64 (19)	Panda et al. (1992) ^c

Notes:

Unless stated otherwise, all studies tested inorganic mercury (mercuric chloride).

NOEC, No observed effects concentration; LOEC, Lowest observed effects concentration (available associated %Effect shown in parenthesis); SOM, Soil organic matter.

NA, Not available.

NA for NOEC or LOEC because either effects were observed at the lowest tested concentration or no effects were observed at the highest tested concentrations.

a, Tested mercuric chloride and 2-methoxyethylmercuric chloride.

b, Estimated from Figure 3 in Sheppard et al. (1993), not used in calculating the geometric mean of NOECs and LOECs.

c, Soil substrate was waste (from a chloralkali plant) containing 2550 mg THg/kg soil.

Table C-3
Summary of Studies on Mercury Toxicity toward Soil Burrowing Invertebrates
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Species	Soil Type	Duration	Soil pH	SOM (%)	Endpoint	NOEC mg THg/kg dw soil	LOEC mg THg/kg dw soil	Reference
Earthworm (<i>Eisenia fetida</i>)	Artificial Soil	21-d	6.4	10	Survival Reproduction	10	18	Lock and Janssen (2001)
Earthworm (<i>Eisenia fetida</i>)	Natural Soil	28-d	6.2	3.2	Reproduction	4.6 ^b	545 ^b 170 ^b	Gudbrandsen et al. (2007)
Earthworm (<i>Eisenia fetida</i>)	Peaty Marshland Soil	56-d	NA	NA	Survival Reproduction	231 ^c	577 ^c	Fischer and Koszorus (1992)
Earthworm (<i>Eisenia fetida</i>)	Potting Soil	84-d	NA	NA	Survival Segment Regeneration	2.5	12.5	Beyer et al. (1985) ^d
Earthworm (<i>Octochaetus pattoni</i>)	Natural Soil	60-d	NA	NA	Survival Reproduction	NA	0.5	Abbasi and Soni (1983)
Earthworm (<i>Lumbricus terrestris</i>)	Artificial Silty-Clay Soil	30-d	7.9	2.7	Survival	NA	1000	Sheppard et al. (1993)
Earthworm (<i>Lumbricus terrestris</i>)	Artificial Garden Soil	30-d	7.3	8.9	Survival	100 ^a	100-1000 ^a	Sheppard et al. (1993)
Earthworm (<i>Lumbricus terrestris</i>)	Artificial Sandy Soil	12-d	6.3	0	Survival	10 ^a	10-100 ^a	Sheppard et al. (1993)
White worm (<i>Enchytraeus albidus</i>)	Artificial Soil	42-d	6.4	10	Survival Reproduction	18	22	Lock and Janssen (2001)
Collembola (<i>Folsomia candida</i>)	Artificial Soil	28-d	6.4	10	Survival Reproduction	1.8	3.2	Lock and Janssen (2001)
Collembola (<i>Paronychiurus kimi</i>)	Artificial Soil	42-d	6	10	Reproduction Population Growth	0.25	0.5	Son et al. (2007)

Notes:

Unless stated otherwise, all studies tested inorganic mercury (mercuric chloride).

SOM, Soil organic matter content.

dw, Dry weight.

NOEC, No observed effects concentration; LOEC, Lowest observed effects concentration.

NA, Not available; NA for NOEC because effects were observed at the lowest tested concentration.

a, Estimated from Figure 3 in Sheppard et al. (1993) and not used in calculating the geometric mean of NOECs and LOECs.

b, NOEC = 4.6 as estimated in Tipping et al. (2010); LOEC = 545 mg THg/kg dw for organisms pre-exposed to 22 mg THg/kg dw and LOEC = 170 mg THg/kg dw for organism not pre-exposed to THg.

c, NOEC (100 mg HgCl₂/kg soil ww) and LOECs (250 mg HgCl₂/kg soil ww) were converted to mg Hg/kg soil dw based on the reported moisture content (68%) of the substrate.

d, Test compound was methylmercury (MeHg).

Table C-4
Summary of Aqueous Toxicity Endpoints for Fish
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Toxicity	Species			Toxicity Endpoint	References	Total Mercury Concentration (ng/L)
ACUTE	IHg	Fathead minnow	<i>Pimephales promelas</i>	96-h LC ₅₀	EPA (1985, 1996)	150,000 - 172,000
		Rainbow trout	<i>Oncorhynchus mykiss</i>	96-h LC ₅₀	EPA (1985)	155,000 - 420,000
		Coho salmon	<i>Oncorhynchus kisutch</i>	96-h LC ₅₀	Lortz et al. (1978)	240,000
		White Sucker	<i>Catostomus commersoni</i>	96-h LC ₅₀	Duncan and Klaverkamp (1983)	900,000
		Tilapia	<i>Talapia mossambica</i>	96-h LC ₅₀	Qureshi and Saksena (1980)	1,000,000
	MeHg	Rainbow trout	<i>Oncorhynchus mykiss</i>	96-h LC ₅₀	EPA (1985)	24,000 - 42,000
		Lamprey	<i>Petromyzon sp.</i>	96-h LC ₅₀ @12C	Mallat et al. (1986)	48,000
		Brook trout	<i>Salvelinus fontinalis</i>	96-h LC ₅₀	McKim et al. (1976)	65,000 - 84,000
CHRONIC	IHg	Fathead minnow	<i>Pimephales promelas</i>	60-d Reproduction, Growth	Snarski and Olson (1982)	260
		Channel catfish	<i>Ictalurus punctatus</i>	10-d Survival	Birge et al. (1979)	300
		Largemouth bass	<i>Microptes salmoides</i>	8-d Survival	Birge et al. (1979)	4,300
	MeHg	Brook trout	<i>Salvelinus fontinalis</i>	3rd Generation	McKim et al. (1976)	290
		Brook trout	<i>Salvelinus fontinalis</i>	2nd Generation	McKim et al. (1976)	930
		Coho salmon	<i>Oncorhynchus kisutch</i>	48-d Survival	CCME (2003)	63,000

Notes:

LC₅₀, Median lethal concentration.

IHg, Inorganic mercury.

MeHg, Methylmercury.

Table C-5
Summary of No Effect Residue (NER) and Low Effect Residue (LER) Body Burden Thresholds for Mercury
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Species	Life Stage	THg NER (mg/kg, ww)	THg LER (mg/kg, ww)	THg Control (mg/kg, ww)	Tissue Type	Effect Endpoint	Form and Route of Exposure	Reference	Include	Justification for Removal
Juvenile/Adult Endpoints										
Walleye	Juvenile (6 month old)	0.06	0.25	0.06	Whole body	Reproduction	MeHg, food	Friedmann et al. 1996	Yes	
Fathead Minnow	Juvenile to Adult	0.10	0.39	0.10	Whole body	Reproduction	MeHg, food	Hammerschmidt et al. 2002	Yes	
Golden Shiner	Adult	0.23	0.52	0.04	Whole body	Behavior	MeHg, food	Webber and Haines 2003	Yes	
Fathead Minnow	Larvae to Adult	0.62	1.20	0.22	Whole body	Growth	HgCl, aqueous	Snarski and Olsen 1982	Yes	
Fathead Minnow	Juvenile to Adult	0.08	0.86	0.08	Whole body	Reproduction	MeHg, food	Drevnick and Sandheinrich 2003	Yes	
Brook Trout	Three Generations	2.70	5.00	0.10	Whole body	Lethality	MeHg, aqueous	McKim et al. 1976	Yes	
Geometric mean of juvenile/adult NER and LERs:		0.44								
Early Life Stage (ELS) Endpoints										
Rainbow Trout	Eggs	0.02	0.07	0.02	Eggs	Lethality	HgCl, aqueous	Birge et al. 1979	Yes	
Rainbow Trout	Larvae	0.02	0.04	0.02	Whole body	Lethality	HgCl, aqueous + sediment	Birge et al. 1979	Yes	
Geometric mean of applicable juvenile/adult and ELS LERs:			0.41							
Excluded Endpoints - Brackish/Arctic Species										
Striped Mullet		0.10	0.30	<0.1	Whole body	Development	MeHg, aqueous	Weis and Weis 1978	No	Estuarine/Marine
Mummichog		0.21	0.44	0.08	Whole body	Lethality	MeHg, food	Matta et al. 2001	No	Estuarine/Marine
Grayling	Fry	0.06	0.27	0.06	Whole body	Behavior	MeHg, aqueous	Fjeld et al. 1998	No	Arctic

Notes:

Studies include compilation of whole body residue endpoints for mercury compiled by Beckvar et al. (2005).

ww - Wet weight

MeHg - Methylmercury.

HgCl - Mercury chloride.

THg - Total mercury.

NER - No effect residue; LER - Low effect residue.

ELS - Early life stages.

Table C-6
Summary of Avian Toxicity Reference Values (TRVs) for Methylmercury
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Species	Order	Exposure Duration	Test Compound	Life Stage	Effects Endpoints	NOAEL (mg/kg BW/day)	Basis	LOAEL (mg/kg BW/day)	Basis	Study References
Piscivores/Waterfowl - High Sensitivity										
<i>American kestrel</i>	<i>Falconiformes</i>	13 weeks	<i>Methylmercuric chloride</i>	<i>Adult (1 year old breeding pairs)</i>	<i>Reproduction</i>	0.017	<i>Applied LOAEL-to-NOAEL uncertainty factor of 3.25 based on the mean LOAEL:NOAEL ratios for avian studies included in the review.</i>	0.055	<i>Based on dietary LOEC of 0.30 mg Hg/kg ww (0.7 mg/kg dw), average body weight of 0.119 kg and FIR 0.022 kg ww/day using assumptions by Zhang et al. (2013)</i>	<i>Albers et al. (2007)</i>
Great egret	Pelecaniformes	12 weeks	Methylmercuric chloride	Juvenile	Growth	0.028	Applied LOAEL-to-NOAEL uncertainty factor of 3.25 based on the mean LOAEL:NOAEL ratios for avian studies included in the review.	0.091	Based on LOEC of 0.5 mg Hg/kg food ww in daily diet, average body weight of 1.0 kg, food intake rate 0.181 kg ww/day (Zhang et al., 2013)	Spalding et al. (2000)
American kestrel	Falconiformes	12-14 weeks	Methylmercuric chloride	Adult (1 year old breeding pairs)	Reproduction	0.081	Based on dietary NOEC of 1.04 mg Hg/kg ww (2.8 mg/kg dw) for clutch size, average body weight of 0.119 kg and FIR 0.022 kg ww/day using assumptions by Zhang et al. (2013)	0.264	Based on dietary LOEC of 1.43 mg Hg/kg ww (3.9 mg/kg dw) for reduced clutch size, average body weight of 0.119 kg and FIR 0.022 kg ww/day using assumptions by Zhang et al. (2013)	French et al. (2010)
White ibis	Pelecaniformes	3 years	Methylmercuric chloride	Juvenile	Mating behavior, endocrine function, and possible reproductive effects	0.003	Applied LOAEL-to-NOAEL uncertainty factor of 3.25 based on the mean LOAEL:NOAEL ratios for avian studies included in the review.	0.010	Based on LOEC of 0.05 mg MeHg/kg food ww in daily diet, average body weight of 0.869 kg (geometric mean), and food intake rate 0.182 kg ww/day based on Kushlan (1977) (Zhang et al., 2013)	Frederick and Jayasena (2010); Jayasena et al. (2011)
Non-Piscivores/Waterfowl - Low-Moderate Sensitivity										
<i>Mallard</i>	<i>Anseriformes</i>	3 years	<i>Methylmercury dicyandiamide</i>	<i>3 generations</i>	<i>Reproduction</i>	0.024	<i>Applied LOAEL-to-NOAEL uncertainty factor of 3.25 based on the mean LOAEL:NOAEL ratios for avian studies included in the review.</i>	0.078	<i>Based on LOEC of 0.5 mg Hg/kg food dw in daily diet and a food ingestion rate of 0.156 kg dw/kg BW/day for the dosing group (EPA, 1995)</i>	<i>Heinz (1974, 1975, 1976a,b, 1979)</i>
Mallard	Anseriformes	1.5 years	Methylmercury dicyandiamide	Adult	Offspring Neurotoxicity	0.029	Based on NOEC of 0.5 mg Hg/kg food dw in daily diet and a food ingestion rate of 0.057 kg dw/kg BW (assuming 1 kg BW, 0.051 kg food dw/kg BW, and 10% moisture in food) (Zhang et al., 2013)	0.171	Based on LOEC of 3.0 mg Hg/kg food dw in daily diet and a food ingestion rate of 0.057 kg dw/kg BW/day (assuming 1 kg BW, 0.051 kg food dw/kg BW, and 10% moisture in food) (Zhang et al., 2013)	Heinz and Lock (1976)
Ring-necked pheasant	Galliformes	12 weeks	Methylmercury dicyandiamide	Adult	Reproduction	0.029	Applied LOAEL-to-NOAEL uncertainty factor of 3.25 based on the mean LOAEL:NOAEL ratios for avian studies included in the review.	0.093	Actual dose	Fimreite (1971)
Non-Piscivores/Waterfowl - Low-Moderate Sensitivity (continued)										
Ring-necked pheasant	Galliformes	350 days	Methylmercury p-toluene sulfonanilide	Adult	Reproduction	0.077	Applied LOAEL-to-NOAEL uncertainty factor of 3.25 based on the mean LOAEL:NOAEL ratios for avian studies included in the review.	0.250	Based on LOEC of 4.2 mg Hg/kg, average BW of 1.1 kg, food ingestion rate of 0.053 kg dw/kg BW/day, and 10% water in food.	Spann et al. (1972)
White leghorn chicken	Galliformes	21 days	Methylmercury dicyandiamide	Juvenile	Growth	0.089	Applied LOAEL-to-NOAEL uncertainty factor of 3.25 based on the mean LOAEL:NOAEL ratios for avian studies included in the review.	0.289	Based on LOEC of 6 mg Hg/kg food ww in daily diet; Average body weight of 0.28 kg, mercury intake rate 0.081 mg Hg/chick/day (EPA, 1995)	Fimreite (1970)
Mallard	Anseriformes	26 days	Methylmercury chloride	Adult	Reproduction/ Duckling Survival	0.114	Based on NOEC of 2 mg Hg/kg food dw in daily diet and a food ingestion rate of 0.057 kg dw/kg BW (Zhang et al., 2013)	0.228	Based on LOEC of 4 mg Hg/kg food dw in daily diet and a food ingestion rate of 0.057 kg dw/kg BW/day (Zhang et al., 2013)	Heinz et al. (2010)
Piscivores/Waterfowl - Low/Moderate Sensitivity										
White leghorn chicken	Galliformes	21 days	Methylmercury chloride	Adult	Reproduction	0.206	Applied LOAEL-to-NOAEL uncertainty factor of 3.25 based on the mean LOAEL:NOAEL ratios for avian studies included in the review.	0.67	Based on LOEC of 10 mg Hg/kg food in daily diet and food ingestion rate 0.067 kg food/kg BW/day (EPA, 1995)	Scott (1977)
Ring-necked pheasant	Galliformes	350 days	Methylmercury p-toluene sulfonanilide	Adult	Mortality	0.25	Based on NOEC of 4.2 mg Hg/kg, average BW of 1.1 kg, food ingestion rate of 0.053 kg dw/kg BW/day, and 10% water in food.	0.75	Based on LOEC of 12.5 mg Hg/kg, average BW of 1.1 kg, food ingestion rate of 0.053 kg dw/kg BW/day, and 10% water in food.	Spann et al. (1972)
Japanese quail	Galliformes	6 weeks	Methylmercuric chloride	Multigenerational	Offspring Mortality	0.26	Based on NOEC of 2 mg Hg/kg and food ingestion rate of 0.13 kg/kg BW/day.	0.52	Based on LOEC of 4 mg Hg/kg and food ingestion rate of 0.13 kg/kg BW/day.	Eskeland and Nafstad (1978)
Common loon	Gaviiformes	15 weeks	Methylmercury chloride	Juvenile	Growth	0.27	Based on NOEC of 1.5 mg MeHg/kg food ww in daily diet, average body weight of 4.67 kg common loon adults, and food intake rate 0.839 kg ww/day (Zhang et al., 2013)	NA	No effect was observed on growth or food consumption in the study.	Kenow et al. (2003)
White leghorn chicken	Galliformes	21 days	Methylmercury dicyandiamide	Juvenile	Mortality	0.57	Based on NOEC of 6 mg Hg/kg food ww in daily diet; Average body weight of 0.28 kg, mercury intake rate 0.081 mg Hg/chick/day (EPA, 1995)	0.857	Based on LOEC of 18 mg Hg/kg food ww in daily diet; Average body weight of 0.28 kg, mercury intake rate 0.24 mg Hg/chick/day (EPA, 1995)	Fimreite (1970)
Passerines ^a										
<i>Tree swallow</i>	<i>Passeriformes</i>	<i>Multi-Year (2 seasons)</i>	<i>Total mercury measured in diet</i>	<i>Juvenile</i>	<i>Reproduction</i>	0.078	<i>Based on NOEC of 0.128 mg THg/kg ww measured in boli (concentration range 0.128 -0.291 mg THg/kg ww) and the minimum assumed MeHg:THg ratio of 0.35 (i.e., NOEC of 0.0448 mg MeHg/kg ww); average body weight of 0.0202 kg, and FIR of 0.0352 kg dw/day (Nagy, 2001)</i>	NA	<i>An effect dose was not estimated for the study.</i>	<i>Longcore et al. (2007)</i>
<i>Tree swallow</i>	<i>Passeriformes</i>	<i>Multi-Year (6 seasons)</i>	<i>Methylmercury measured in diet</i>	<i>Juvenile</i>	<i>Growth Reproduction</i>	0.067	<i>Based on NOEC of 0.111 mg MeHg/kg dw field-measured in diet, average body weight of 0.0202 kg, and FIR of 0.0116 kg dw/day (Nagy, 2001)</i>	NA	<i>An effect dose was not estimated for the study.</i>	<i>Gerrard and St. Louis (2001)</i>
<i>Tree swallow</i>	<i>Passeriformes</i>	<i>Multi-Year (2 seasons)</i>	<i>Total mercury measured in diet</i>	<i>Juvenile</i>	<i>Reproduction</i>	0.009	<i>Based on NOEC of 0.047 mg THg/kg dw measured in boli (maximum concentration 0.091 mg THg/kg) and an assumed MeHg:THg ratio of 0.35 (i.e., a NOEC of 0.016 mg MeHg/kg dw); average body weight of 0.0202 kg, and FIR of 0.0116 kg dw/day (Nagy, 2001)</i>	NA	<i>An effect dose was not estimated for the study.</i>	<i>Custer et al. (2008)</i>
Zebra finch	Passeriformes	76 days	Methylmercury chloride	Adult	Neurotoxicity and mortality	0.880	Based on NOEC of 0.5 mg/kg Hg [Scheuhammer (1988) as cited in EPA (1995)]	1.750	Based on LOEC of 5 mg/kg [Scheuhammer (1988) as cited in EPA (1995)]	Scheuhammer (1988)

Notes:
Bolded and italicized study represents the critical study used for the derivation of the TRVs.
NA, Not available either because not reported, not calculated, or not necessary.
NOEC, No observed effect concentration.
LOEC, Lowest observed effect concentration.
NOAEL, No observed adverse effect level.
LOAEL, Lowest observed adverse effect level.
dw, Dry weight.
ww, Wet weight.
Hg, Mercury.
MeHg, Methylmercury.
BW, Body weight.
a, A field study by Brasso and Cristol (2008) also allows derivation of a NOEC, but it is excluded because the study area forms the site-specific reference (background) area for the Study Area (AOC-4).

Table C-7
Summary of Toxicity Reference Values (TRVs) for Inorganic Mercury
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Species	Life Stage	Exposure Duration	Test Compound	Effects Endpoints	NOAEL (mg/kg BW/day)	Basis	LOAEL (mg/kg BW/day)	Basis	Reference
Birds									
<i>Japanese quail</i>	<i>Adult during reproduction</i>	<i>1 year</i>	<i>Inorganic (mercuric chloride)</i>	<i>Reproduction</i>	<i>0.45</i>	<i>Based on NOEC of 4 mg Hg/kg, BW of 0.15, and food ingestion rate of 0.0169 kg/day (Sample et al., 1996)</i>	<i>0.9</i>	<i>Based on LOEC of 8 mg Hg/kg, BW of 0.15, and food ingestion rate of 0.0169 kg/day (Sample et al., 1996)</i>	<i>Hill and Schaffner (1976)</i>
Mammals									
<i>Mink</i>	<i>Adult (critical life stage)</i>	<i>6 Months</i>	<i>Inorganic (mercuric chloride, 73.9% Hg)</i>	<i>Reproduction, Growth, Survival</i>	<i>1.01</i>	<i>Based on NOEC = 10 mg Hg/kg (73.9% purity), BW = 1 kg and food ingestion rate of 0.137 kg food/day (Sample et al. 1996)</i>	<i>NA</i>	<i>No effect was observed on reproduction, growth, or survival at the highest dietary treatment in the study</i>	<i>Aulerich et al. (1974)</i>
Rat	Weanling	2 years	Inorganic	Growth	14	Based on NOEC of 160 mg Hg/kg; Intake rate of 2.4 mg Hg/day and average BW of 0.175 kg for the exposed group (EPA, 1995)	56	Applied conservative NOAEL to LOAEL factor of 4.0 based on growth data for organic mercury from the same study (URS)	Fitzhugh et al. (1950)
Rat	Gestation	Days 5, 12, 19	Inorganic (HgO)	Development	NA	Effects were observed on development at the lowest oral ingestion treatment in the study	7	2 mg Hg oral ingestion and a BW of 0.29 kg (Unit here is mg/kg)	Rizzo and Furst (1972) [as cited in EPA (1995)]
Mouse	Adult	20 Months	Inorganic (Mercuric sulfide)	Mortality, Histology, Reproduction	13.2	Actual dose	NA	No effect was observed on mortality, histology, and reproduction at the highest tested dose in the study	Revis et al. (1989)

Notes:

Bolded and italicized study represents the critical study used for the derivation of the TRVs.

NA, Not Available either because not reported, not calculated, or not necessary.

NOEC, No observed effect concentration.

LOEC, Lowest observed effect concentration.

NOAEL, No observed adverse effect level.

LOAEL, Lowest observed adverse effect level.

Hg, Mercury.

MeHg, Methylmercury.

BW, Body weight.

Table C-8
Summary of Mammalian Toxicity Reference Values (TRVs) for Methylmercury
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Former DuPont Waynesboro Plant, Waynesboro, Virginia

Species	Life Stage	Exposure Duration	Test Compound	Effects Endpoints	NOAEL (mg/kg BW/day)	Basis	LOAEL (mg/kg BW/day)	Basis	Reference
Piscivorous Mammals									
Mink	Adult	145 days	Assumed Methylmercury (in fish) ^a	Reproduction, Development	0.05	Based on NOEC of 0.33 mg/kg, food ingestion rate of 0.15 kg/day and a BW of 1 kg (EPA, 1995)	NA	No effect was observed on reproduction or development at the highest dietary treatment in the study	Wobeser et al., 1976a
<i>Mink</i>	<i>Adult</i>	<i>93 days</i>	<i>Organic (methylmercuric chloride)</i>	<i>Intoxication (anorexia and ataxia) and mortality</i>	<i>0.16</i>	<i>Based on NOEC of 1.1 mg/kg, food ingestion rate of 0.15 kg/day and a BW of 1 kg (EPA, 1995)</i>	<i>0.27</i>	<i>Based on NOEC of 1.8 mg/kg, food ingestion rate of 0.15 kg/day and a BW of 1 kg (EPA, 1995)</i>	<i>Wobeser et al., 1976b</i>
Mink	Multiple generations	400 days	Assumed to be methylmercury (in contaminated fish)	Reproduction	0.02 ^b	Based on NOEC of 0.12 mg/kg ww; a BW of 1.35 kg (EPA, 1993) and food ingestion rate of 0.21 kg ww/day [Equation 1 from Nagy (2001)]	0.09 ^b	Based on LOEC of 0.56 mg/kg ww; a BW of 1.35 kg (EPA, 1993) and food ingestion rate of 0.21 kg ww/day [Equation 1 from Nagy (2001)]	Dansereau et al. (1999)
Mink	Multiple generations	400 days	Assumed to be methylmercury (in contaminated fish)	Survival	0.09 ^b	Based on NOEC of 0.56 mg/kg ww; a BW of 1.35 kg (EPA, 1993) and food ingestion rate of 0.21 kg ww/day [Equation 1 from Nagy (2001)]	0.14 ^b	Based on LOEC of 0.9 mg/kg ww; a BW of 1.35 kg (EPA, 1993) and food ingestion rate of 0.21 kg ww/day [Equation 1 from Nagy (2001)]	Dansereau et al. (1999)
Mink	Adult	2 months	Organic (methylmercuric chloride)	Growth and Survival	NA	Effects were observed on growth and survival at the lowest dietary treatment in the study	0.64	Based on LOEC of 5 mg/kg; food ingestion rate of 0.15 kg/day and a BW of 1.2 kg	Aulerich et al. (1974)
River otter	Adult	6 months	Organic (methylmercuric chloride)	Intoxication (anorexia and ataxia)	NA	Effects observed at the lowest dose in the study	0.09	Actual dose	O'Connor and Nielson (1981)
Non-piscivorous Mammals									
Rat	Three generations	> 1 year	Organic (methyl mercury chloride; 79.9% Hg)	Growth (Internal Organs)	NA	Effects were observed on growth of internal organs at the lowest dietary treatment in the study	0.02	Based on LOEC of 0.08 mg/kg ww; a BW of 0.35 kg (from Sample et al., 1996) and a food ingestion rate of 0.074 kg ww/day (based on Equation 2 in Nagy, 2001)	Verschuuren et al. (1976)
<i>Rat</i>	<i>Three generations</i>	<i>> 1 year</i>	<i>Organic (methyl mercury chloride; 79.9% Hg)</i>	<i>Survival and Reproduction</i>	<i>0.09</i>	<i>Based on NOEC of 0.5 (0.399 mg Hg/kg); food ingestion rate of 0.074 kg/day (Nagy, 2001) and a BW of 0.35 kg (Sample et al., 1996)</i>	<i>0.42</i>	<i>Based on LOEC of 2.5 mg/kg (1.997 mg Hg/kg); food ingestion rate of 0.074 kg/day (Nagy, 2001) and a BW of 0.35 kg (Sample et al., 1996)</i>	<i>Verschuuren et al. (1976)</i>
Rat	Weanling	2 years	Organic (phenyl mercuric acetate)	Growth	0.56	Based on NOEC of 10 mg Hg/kg; Intake rate of 0.15 mg Hg/day and average BW of 0.275 kg for the control group (EPA, 1995)	2.2	Based on LOEC of 40 mg Hg/kg; Intake rate of 0.6 mg Hg/day and average BW of 0.275 kg for the control group (EPA, 1995)	Fitzhugh et al. (1950)
Rat	Weanling	2 years	Organic (phenyl mercuric acetate)	Mortality	2.2	Based on NOEC of 40 mg Hg/kg; Intake rate of 0.6 mg Hg/day and average BW of 0.275 kg for the control group (EPA, 1995)	14	Based on LOEC of 160 mg Hg/kg; Intake rate of 2.4 mg Hg/day and average BW of 0.175 kg for the exposed group (EPA, 1995)	Fitzhugh et al. (1950)
Rat	Weanling	122 days	Organic (methylmercuric chloride)	Reproduction and Development	0.25	Actual dose	1	Applied conservative NOAEL to LOAEL factor of 4.0 based on growth data for organic mercury from Fitzhugh et al. (1950) (URS)	Khera and Tabacova (1973)
Rat	Gestation	Days 7-14	Organic (methylmercuric chloride)	Growth and Neurotoxicity	4	Actual dose	6	Actual dose	Fuyuta et al. (1978)

Table C-8
Summary of Mammalian Toxicity Reference Values (TRVs) for Methylmercury
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Species	Life Stage	Exposure Duration	Test Compound	Effects Endpoints	NOAEL (mg/kg BW/day)	Basis	LOAEL (mg/kg BW/day)	Basis	Reference
Non-piscivorous Mammals (continued)									
Rat (Wistar)	Gestation	Days 7-14	Organic (methylmercuric chloride)	Development	2	Actual dose	4	Actual dose	Fuyuta et al. (1978)
Rat (Sprague-Dawley albino)	Gestation	Days 6-15	Organic (methylmercuric chloride)	Development	1	Actual dose	2	Actual dose	Geyer et al. (1985)
Rat (Sprague-Dawley)	Gestation	Days 6-9	Organic (methylmercuric chloride)	Offspring Mortality and Development	1.6	Actual dose	4.8	Actual dose	Vorhees (1985)
Rat (HAN-Wistar)	Adult	8 weeks	Organic (methylmercuric chloride)	Development	NA	Effects were observed on development at the lowest dose tested in the study	0.21	Actual dose	Suter and Schon (1986)
Domestic Cats (<i>Felis domesticus</i>)	Adult	2 years	Organic (methylmercuric chloride)	Neurotoxicity	0.02	Actual dose	0.05	Actual dose	Charbonneau et al. (1974)

Notes:

Bolded and Italicized study represents the critical study used for the derivation of the TRVs.

NA, Not available either because not reported, not calculated, or not necessary.

NOEC, No observed effect concentration.

LOEC, Lowest observed effect concentration.

NOAEL, No observed adverse effect level.

LOAEL, Lowest observed adverse effect level.

a, Assumes Hg form in fish is MeHg.

b, There is uncertainty associated with these TRVs because the field-collected fish (making up 40% of the prepared diet) may have contained other, uncharacterized organic chemicals that could have contributed to the reproductive toxicity reported in mink.

dw, Dry weight.

ww, Wet weight.

Hg, mercury

MeHg, Methylmercury.

BW, Body weight.

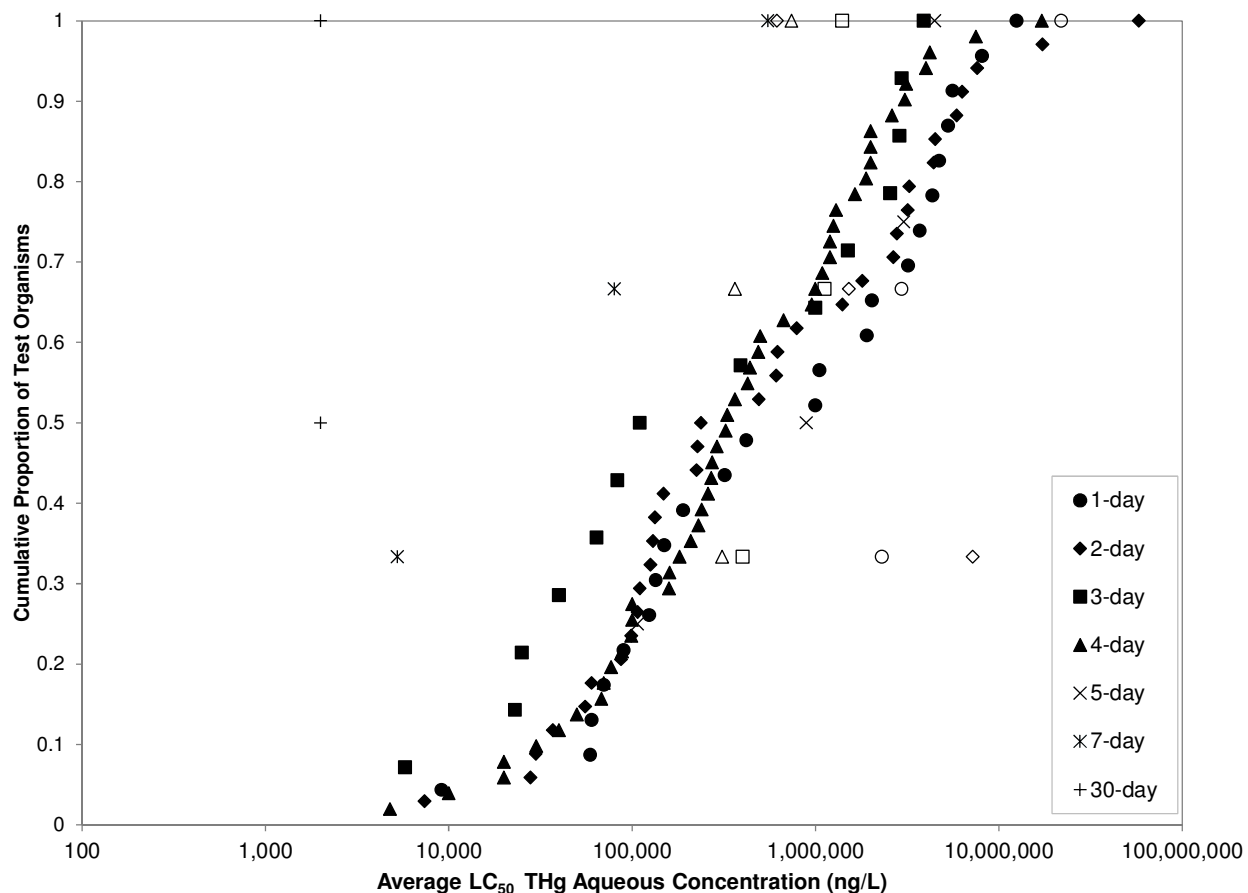
Figures

Figure C-1

Cumulative Frequency Distribution of Median Lethal Concentrations (LC50) for Aqueous THg Averaged by Benthic Macroinvertebrate Test Species

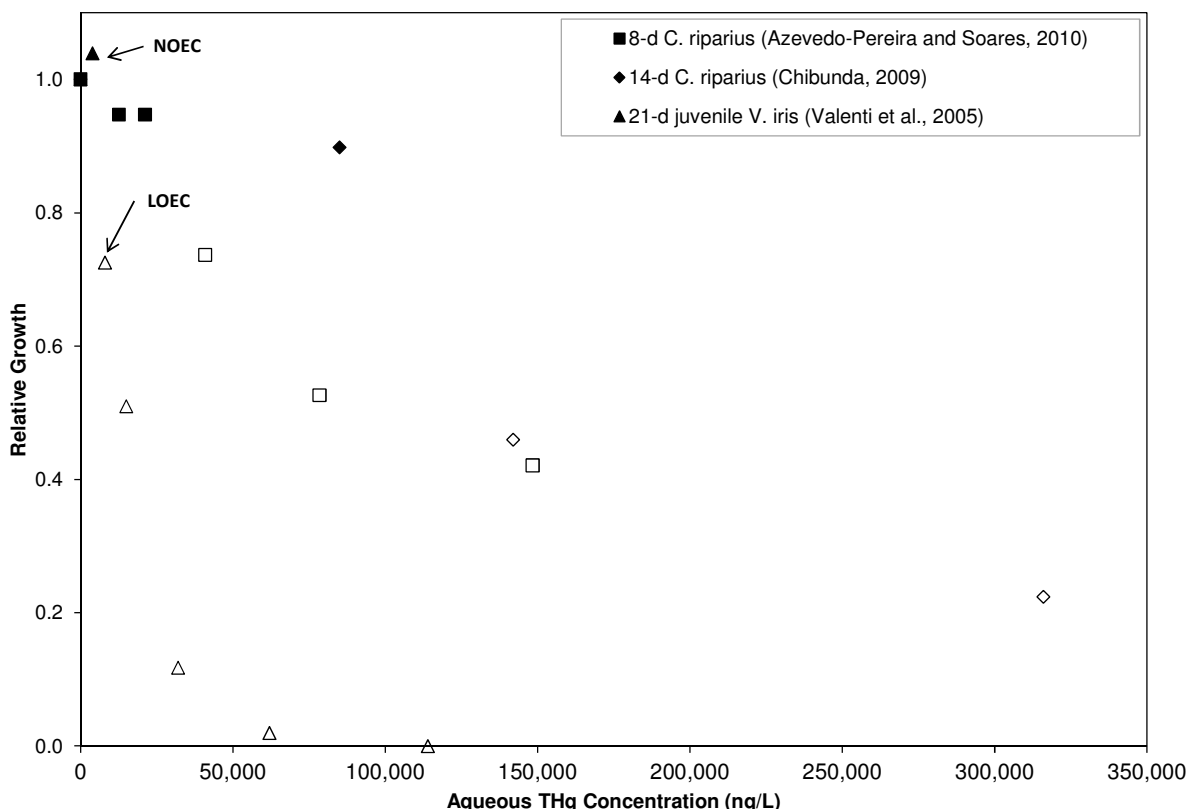
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Waynesboro, Virginia**



Notes: Data shown are the cumulative frequencies of median lethal concentrations (LC50) averaged by test species for various durations of exposure (in days) to aqueous concentrations of total mercury (THg). Open symbols indicate aqueous concentration was based on filtered results and closed symbols indicate aqueous concentration was based on unfiltered results; concentrations representing exposures of 5 days or more were based on unfiltered sample results. Data were obtained from the EPA ECOTOX (ECOTOXicology) database. Test organisms associated with benthic environments were preferentially selected for inclusion in the cumulative frequency distribution plot.

Figure C-2
Relative Growth of Benthic Test Organisms Exposed to Total Mercury in Aqueous Media
Ecological Risk Assessment Report
Area of Concern (AOC-4), Former DuPont Waynesboro Plant
Waynesboro, Virginia



Notes: Data shown are the relative growth of benthic macroinvertebrate test organisms exposed to aqueous total mercury concentrations (THg). Relative growth was calculated as the ratio of the growth endpoint in the study treatment (e.g., total body length, dry weight) to the growth endpoint in the study control. Open symbols represent growth endpoints that were statistically different than control treatments ($p < 0.05$), as reported in each respective study. The minimum bounded no observed effect concentration (NOEC) was identified as 4,000 ng/L from the 21-day exposure of juvenile *Villosa iris* (Valenti et al., 2005); the lowest observed effect concentration (LOEC) of 8,000 ng THg/L was identified as the lowest concentration in Valenti et al. (2005) at which a statistically significant reduction in growth was reported. Relative growth calculations for endpoints reported by Azevedo-Pereira and Soares (2010) were estimated from Figure 2 presented in the study; the raw data recorded for these growth endpoints were requested from the authors, but were not received as of the date of this report.

Figure C-3
Summary of Sediment Toxicity Studies
Ecological Risk Assessment Report
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Waynesboro, Virginia

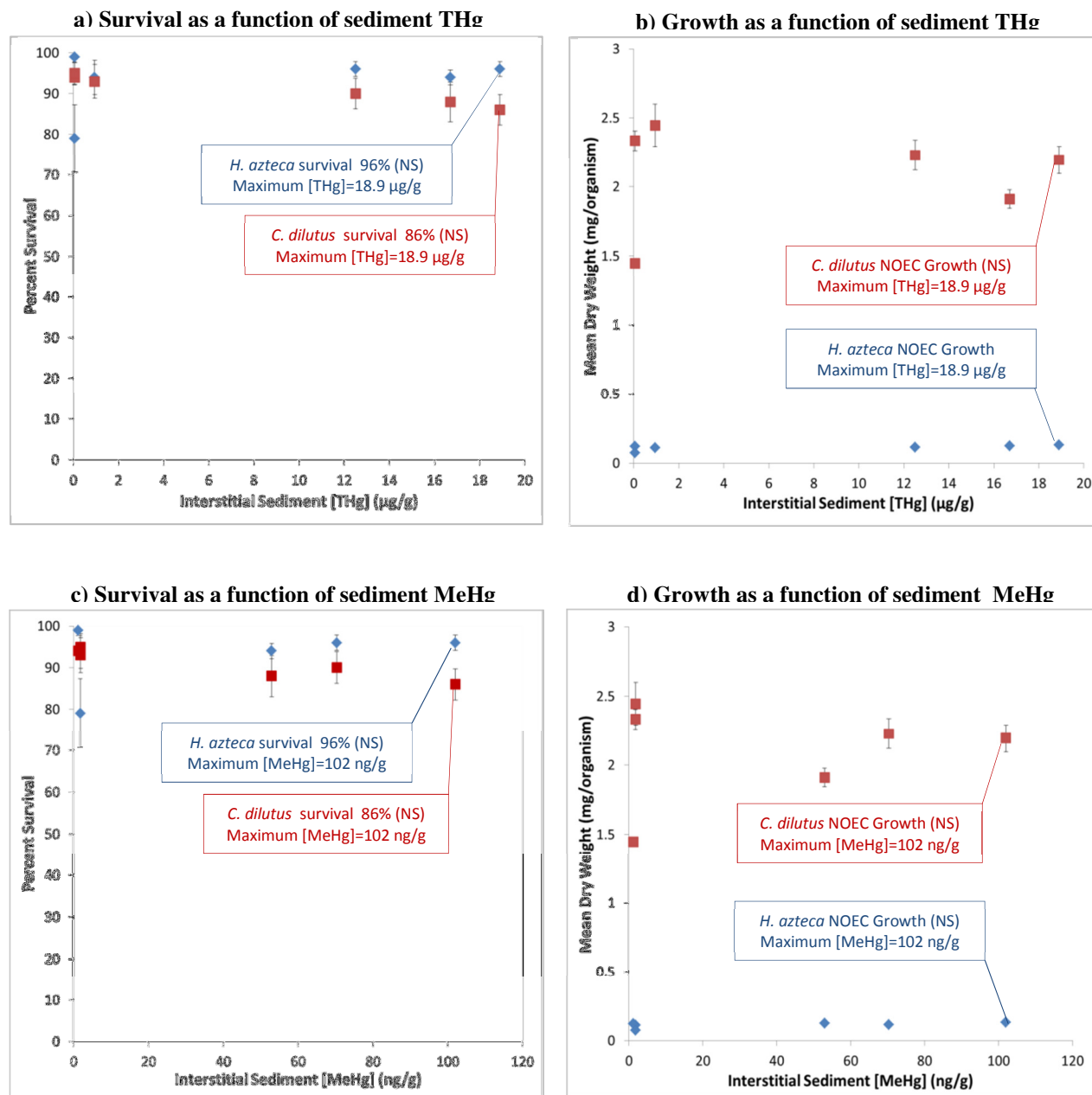


Figure C-4
Control-adjusted 10-day *Hyalella azteca* Survival Relative to Sediment THg Concentrations in
South River SQT and Select SEDTOX Toxicity Tests
Ecological Risk Assessment Report
Area of Concern (AOC-4), Former DuPont Waynesboro Plant
Waynesboro, Virginia

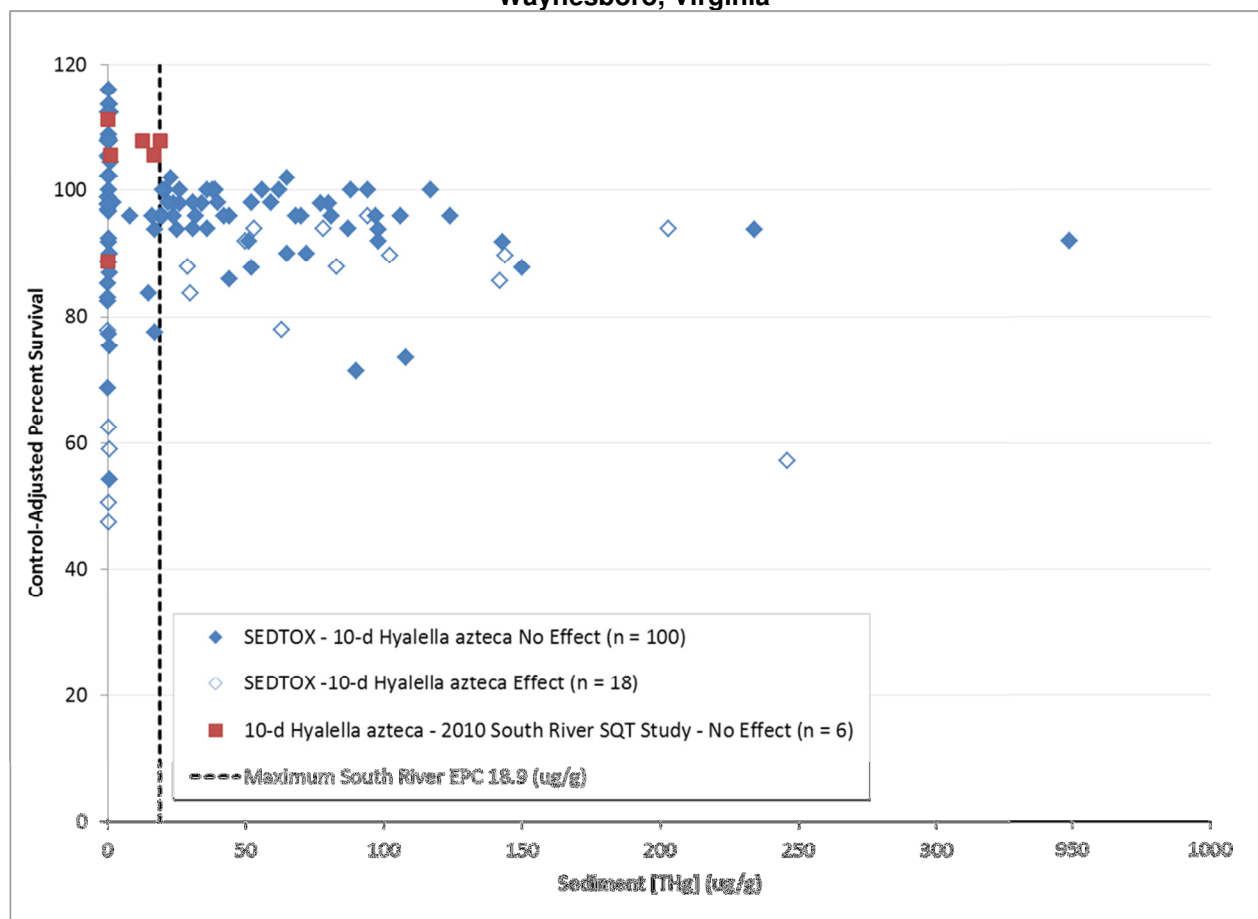
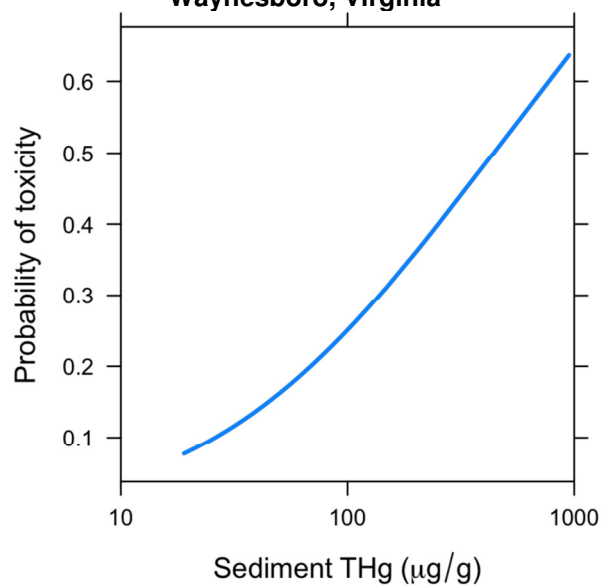


Figure C-5
Logistic Regression Model Indicating a Weak Association between the Probability of Toxicity and
Sediment THg Concentrations $>18.9 \mu\text{g/g}$ ($p = 0.07$)
Ecological Risk Assessment Report
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Waynesboro, Virginia



Appendix D

Wildlife Exposure Factors for Dose Rate Modeling

Wildlife Exposure Factors for Dose Rate Modeling

AOC 4 Ecological Risk Assessment

Former DuPont Waynesboro Plant

1.0 Introduction

This appendix presents the wildlife exposure factors for dose rate models (DRM) used to evaluate dietary exposures to mercury for the nine focal wildlife species identified in the Conceptual Site Model (CSM) in Section 3.5 (in the main Report).

The primary data source of exposure factors for the focal wildlife species was the EPA *Wildlife Exposure Factors Handbook* [“the Handbook” (EPA, 1993)]. Additional receptor-specific literature sources were also used to supplement exposure data compiled in the Handbook.

Exposure factors that are representative of typical or average (e.g., mean parameter) exposure conditions were used (see Table D-1). Receptor profiles (Tables D-2a through D-2i) provides the basis for exposure factors included in the evaluation and discussed below.

2.0 Body Weight (BW, g wet weight)

Representative body weights were estimated as arithmetic mean values of adult body weights (male and female) reported in the literature or midpoints of the range of body weights when arithmetic mean values were not available (see Table D-1).

3.0 Food Ingestion Rate (FIR, g ww/day)

Value for food ingestion rates (FIR_{ww}) were estimated based on receptor-specific BW values using appropriate empirical allometric (scaling) relationships developed by Nagy (2001).

Nagy (2001) derived allometric relationships for various avian and mammalian feeding groups based on taxon, habitat, and diet. For each of the wildlife receptors, evaluated in dietary exposure models for AOC-4, the most appropriate allometric equation from Nagy (2001) based on fresh (wet) weight was used to estimate FIR_{ww} using the following relationship to BW:

$$FIR_{ww} = a \times BW^b \quad (2)$$

where,

FIR_{ww} = Wet weight (or fresh weight) food ingestion rate (g ww/d)

BW = Receptor-specific body weight (g)

a and b = Parameters whose values are specific to an allometric equation (see Table D-1)

4.0 Sediment or Soil Ingestion Rate (SIR, g dw/day)

Exposure models account for the dietary intake of sediment or soil that may be ingested incidentally as a result of the feeding behavior of select receptors or indirectly through the ingestion of prey. Following sections provide the basis for sediment and/or soil ingestion rates assumed for the focal wildlife species.

4.1 Sediment Ingestion

Sediment ingestion was estimated as a percentage of dry food intake for the following receptors based on feeding behaviors (see Tables D-1 and D-2a to i):

- Belted kingfisher: Receptor-specific data regarding incidental sediment ingestion in belted kingfisher were not identified. Belted kingfishers are predominantly piscivores that dive into the water to capture fish near the surface. In addition to fish, belted kingfisher may also consume crayfish and amphibians as part of their diet. While negligible sediment ingestion is likely associated with capturing fish within the water column, the exposure models assumed that incidental sediment ingestion represents one percent of dry food intake as a result of foraging on crayfish and amphibians.
- Mallard: Mallard are omnivorous waterfowl that may have a large component of benthic invertebrates in their diets during certain times of the year. Mallard may incidentally ingest sediment while foraging for benthic invertebrates in sediment. The exposure models estimated that incidental sediment ingestion represents 3.3 percent of dry food intake based on species-specific estimates from Beyer et al. (1994).
- River otter: Receptor-specific data regarding incidental sediment ingestion in piscivorous mammals were not identified. Mink and river otter diets consist primarily of fish; however, both receptors may be opportunistic and forage on other available food sources including amphibians and crustaceans (e.g., crayfish). While the incidental ingestion of sediment is typically considered to be negligible for piscivores (Sample and Suter, 1994), the exposure models assumed that incidental sediment ingestion represents one percent of dry food intake for river otter as a result of foraging on amphibians and crayfish.

4.2 Soil Ingestion

Soil ingestion was also estimated as a percentage of dry food intake for the following receptors based on feeding behaviors (see Tables D-1 and D-2a to i):

- American Robin: Soil ingestion rates for American robins are not available in the literature. But estimates are available based on birds with similar diet [U.S. Army Center for Health Promotion & Preventative Medicine (USACHPPM), 2004]. Both robins and woodcocks consume earthworms; however, earthworms comprise more than 60 percent to 99 percent of the American woodcock diet (Sperry, 1940; Krohn, 1970, Stribling and Doerr, 1985) compared to less than 20 percent of the American robin diet (Howell, 1942). Therefore, the SIR of 10.4 percent of the diet reported for American woodcocks by Beyer et al. (1994) is

likely to be an extreme upper bound for the robin. If the SIR is proportioned to the percent of earthworms in the diet, then soil would only make up 2.1 percent (dw) of the robin diet. Sample and Suter (1994) also used the same estimate. Therefore, the exposure model assumed that incidental soil ingestion represents 2.1 percent of dry food intake for American robin as a result of foraging on soil invertebrates (such as earthworm).

- Short-tailed shrew: USACHPPM (2004) indicated that data concerning soil ingestion by short-tailed shrews was not located in the literature; therefore, an incidental soil ingestion rate of 2.4 percent of dry food intake was assumed based on soil ingestion by meadow voles in Beyer et al. (1994). The same was assumed for the current exposure model for short-tailed shrew.
- White-tailed deer: USACHPPM (2004) indicates that diets of many herbivores are deficient in sodium and other trace nutrients. Ungulates, such as white-tailed deer have been observed to consume soils with elevated sodium levels, presumably to meet sodium needs (Weeks, 1978). Beyer et al. (1994) reported a soil ingestion rate of less than two percent of the dry food intake. Therefore, the exposure model assumed that incidental soil ingestion represents two percent of dry food intake for white-tailed deer as a result of foraging on terrestrial plants.

4.3 Soil and Sediment Ingestion

Soil and sediment ingestion was estimated as a percentage of dry food intake for the following receptor based on feeding behaviors (see Tables D-1 and D-2a to i):

- Eastern screech owl: Information on incidental soil or sediment ingestion rates is not available for Eastern screech owl. However, its dietary preference (see Table D-2c) indicates that it may consume approximately 15 percent each of soil invertebrates (e.g., earthworms and spiders) and aquatic invertebrates (crayfish). Therefore, the exposure model conservatively assumed that the incidental sediment and soil ingestion represents one percent each of dry food intake for eastern screech owl as a result of foraging on terrestrial and aquatic invertebrates.

4.4 SIR Estimation

In the exposure models, the receptor-specific SIR was estimated based on the assumed percentage of dry food intake as incidental sediment and/or soil ingestion (discussed in the preceding sections) and the appropriate allometric relationship for dry food ingestion rates (FIR_{dw}) derived by Nagy (2001). SIRs were expressed as a proportion of the dry food ingestion rate, as follows:

$$SIR = FIR_{dw} \times \left(\frac{Ps}{100} \right)$$

$$SIR = a \times BW^b \times \left(\frac{Ps}{100} \right) \quad (3)$$

where,

SIR = Sediment or soil ingestion rate (g dw/d)

FIR_{dw} = Dry weight food ingestion rate (g dw/d)

BW = Receptor-specific body weight (g)

a and b = Parameters whose values are specific to an allometric equation

P_s = Percentage of dry food intake ingested as sediment

FIR_{dw} values were obtained from Nagy (2001) using dry weight intake equations that correspond to the fresh weight FIR_{ww} equations described in the preceding section. For the deterministic exposure model, the receptor-specific SIR was estimated as a single point estimate based on the appropriate dry weight allometric relationship derived by Nagy (2001) and the assumed percentage of dry food intake as incidental sediment or soil ingestion.

The feeding behaviors of tree swallows and big brown bat are expected to result in negligible incidental sediment or soil ingestion ($SIR = 0$). Both forage almost exclusively on flying insects captured during flight. As a result of this feeding behavior, there is no complete pathway with sediments or soils; therefore, incidental sediment or soil ingestion for these representative aerial insectivores is assumed to be negligible.

5.0 Drinking-Water Ingestion Rate (WIR, L/day)

Drinking-water ingestion rates (WIRs) were also derived based on an allometric relationship to body weight, when empirical data were not available. For birds, Calder and Braun (1983) developed an equation for drinking-water ingestion based on a dataset representing 21 bird species with body weights ranging from 0.011 to 3.15 kg, which encompasses the range of avian body weights included in the exposure modeling for AOC-4. WIRs for avian receptors were estimated based on body weight as follows:

$$WIR_{avian} = 0.059 \times BW^{0.67} \quad (4)$$

where,

WIR_{avian} = Avian drinking water ingestion rate (L/d)

BW = Receptor-specific body weight (kg)

Drinking-water ingestion rates for mammalian receptors ($WIR_{mammalian}$) were also estimated based on an allometric relationship to body weight using a parallel equation from Calder and Braun (1983):

$$WIR_{mammalian} = 0.099 \times BW^{0.90} \quad (5)$$

where,

$WIR_{mammalian}$ = Mammalian drinking-water ingestion rate (L/d)

BW = Receptor body weight (kg)

Similar to other rates based on allometric relationships (e.g., FIR_{ww} and SIR), estimates of WIR in deterministic exposure models were based on arithmetic mean values of adult body weights (male and female) (see Table D-1).

6.0 Dietary Preference/Composition

Dietary models were developed to evaluate exposure to various trophic categories of wildlife based on typical feeding behaviors. Receptors select dietary items based on species-specific foraging strategies and behaviors, which are also influenced by the availability and abundance of dietary items within an exposure area. Because it is impractical to sample each possible dietary item within an exposure area, only representative dietary items historically sampled in AOC-4 were used in exposure modeling. Dietary items were selected based on their dietary significance in AOC-4 and also to represent different trophic positions of prey items. As indicated previously, analyses of THg and MeHg in the dietary items from AOC-4 provide site-specific data. Site-specific dietary items historically sampled in AOC-4 and the focal wildlife receptors are summarized below. For Assessment Reaches where representative dietary items were not sampled, their mercury concentrations were conservatively estimated based on extrapolations from adjacent or appropriate Assessment Reaches.

Historical Sampling Data For Representative Dietary Items	Focal Wildlife Species								
	Belted kingfisher	Mallard	Eastern screech owl	Tree swallow	American robin	River otter	Short-tailed shrew	White-tailed deer	Big brown bat
Aquatic vegetation		●							
Aquatic larval insects (<i>Chironomidae</i>)		●							
Emergent adult insects (<i>Chironomidae</i>)				●					●
Crayfish	●	●	●			●			
Amphibians	●					●			
Small fish (< 130 mm total length [TL])	●	●				●			
Large fish (> 130 mm TL)						●			
Earthworms			●		●		●		
Spiders			●	●	●		●		
Small birds			●						
Small mammals			●						
Terrestrial vegetation							●	●	

The relative composition of prey items in the diets of focal wildlife species were estimated based on dietary studies obtained from the literature and summarized in the Handbook and other compilations (USACHPPM, 2004; Sample and Suter, 1994). Literature data were evaluated for dietary composition in the context of exposure conditions in AOC-4. For example, the dietary composition of the omnivorous mallard duck was conservatively assumed to include mostly animal tissue, which is typical of the shift that occurs from a largely herbivorous diet in winter to a high protein of mainly animal tissue during spring molt and spring/summer egg production (Swanson and Meyer, 1973; Swanson et al., 1979; Swanson et al., 1985; Heitmeyer, 1988). This dietary

composition for mallard likely represents the most sensitive dietary exposure to mercury during a likely period of high foraging activity within AOC-4.

The estimation of dietary composition also considered receptor-specific prey size preferences for piscivores. Smaller fish [less than 130 millimeters (mm) total length (TL)] were used to estimate the dietary dose to belted kingfisher, which typically forage on fish that are generally less than 130 mm TL (Alexander, 1977; Hamilton, 1940; and Gilbert and Nancekivell, 1982). Larger fish (greater than 130 mm TL size classes) were also used to estimate the dietary exposures to other piscivorous receptors that may consume a broader range of size classes. However, no fish greater than 350 mm TL were included in dietary exposure modeling due to the limited ability of piscivores to capture and consume fish larger than 350 mm TL.

Relative composition of each dietary item sampled historically in AOC-4 was estimated for each focal wildlife species based on a review of the available literature for each receptor. Because sampling all possible dietary items reported in the literature was impractical, professional judgment was used to estimate the relative compositions of the major dietary components for which site-specific THg and MeHg concentration data were available. Table D-1 presents the assumed relative compositions of dietary items in the total diets of selected receptors; receptor-specific information obtained from the literature to support the estimation of dietary composition is summarized in Tables D-2a to i.

7.0 References

- ADW (Animal Diversity Web). 2014. *Otus asio* (Eastern screech owl). Accessed on March 24, 2004 at: http://animaldiversity.ummz.umich.edu/accounts/Otus_asio/
- Alexander, G.R. 1977. *Food of vertebrate predators on trout waters in north central lower Michigan*. Michigan Academician. 10: 181-195.
- Anderson, E.A., and Woolf, A. 1987. *River otter food habits in northwestern Illinois*. Trans. Illinois Acad. Sci. 80: 115-118.
- Barber, H.L. 1984. *Eastern mixed forest*. pp. 345-354. In: Halls, L.K., ed. *White-tailed Deer: Ecology and Management*. Harrisburg, PA: Stackpole Books.
- Barrett, G.W., and Stueck, K.L. 1976. *Caloric ingestion rate and assimilation efficiency of the short tailed shrew, Blarina brevicauda*. Ohio J. Sci. 76: 25-26.
- Beal, F.E.L. 1918. *Food habits of swallows, a family of valuable native birds*. USDA Bull. 619.
- Beck, M. L., Hopkins, W. A., Jackson, B. P. 2013. *Spatial and Temporal Variation in the Diet of Tree Swallows: Implications for Trace-Element Exposure After Habitat Remediation*. Archives of Environmental Contamination and Toxicology, 1-13.
- Bellrose, F.C. 1976. *Ducks, geese, and swans of North America*. Harrisburg, PA: The Stackpole Co.
- Bent, A.C. 1938. *Life histories of North American birds of prey*. U.S. Nat. Mus. Bull. 170 (Repr. by Dover Publ. Co., N.Y. 1961). 482 pp.

- Bent, A.C. 1940. *Life histories of North American cuckoos, goat suckers, hummingbirds, and their allies*. Washington, DC: U.S. Government Printing Office; Smithsonian Inst. US Nat. Mus., Bull. 176.
- Beyer, W., Nelson, E.E., Gerould, C., Gerould, S. 1994. *Estimates of soil ingestion by wildlife*. Journal of Wildlife Management. 58(2): 375-382.
- Blair, W.F. 1940. *Notes on home ranges and populations of the short-tailed shrew*. Ecology 21: 284-288.
- Blancher, P. J., and McNicol, D. K. 1991. *Trees swallow diet in relation to wetland acidity*. Canadian Journal of Zoology. 69(10): 2629-2637.
- Brasso, R.L., Cristol, D.A. 2008. *Effects of Mercury Exposure on the Reproductive Success of Tree Swallows (Tachycineta bicolor)*. Ecotoxicology 17:133-141.
- Brooks, R.P., and Davis, W.J. 1987. *Habitat selection by breeding belted kingfishers (Ceryle alcyon)*. Am. Midl. Nat. 117: 63-70.
- Buckner, C.H. 1964. *Metabolism, food capacity, and feeding behavior in four species of shrews*. Canadian Journal of Zoology. 42: 259-279.
- Buckner, C.H. 1966. *Populations and ecological relationships of shrews in Tamarack bogs of southeastern Manitoba*. J. Mammal. 47: 181-194.
- Burleigh, T.D. 1958. *Georgia birds*. Univ. Oklahoma Press, Norman
- Calder, W.A., and Braun, E.J. 1983. *Scaling of osmotic regulation in mammals and birds*. American Journal of Physiology. 244(13): R601-R606.
- Chew, R.M. 1951. *The water exchanges of some small mammals*. Ecol. Monogr. 1: 215-224.
- CLO. 2014a. *Tree swallow: Life History*. Cornell Lab of Ornithology. Accessed on 24 March, 2014 at: http://www.allaboutbirds.org/guide/Tree_swallow/lifehistory
- CLO. 2014b. *Eastern screech owl: Life History*. Cornell Lab of Ornithology. Accessed on 24 March, 2014 at: http://www.allaboutbirds.org/guide/eastern_screech-owl/lifehistory
- Coutts, R.A., Fenton, M.B., Glen, E. 1973. *Food intake by captive Myotis lucifugus and Eptesicus fuscus (Chiroptera: Vespertilionidae)*. J. Mammal. 54(4): 985-990.
- Davis, W.J. 1982. *Territory size in Megaceryle alcyon along a stream habitat*. Auk 99: 353-362.
- DeGraaf, R.M., and Rudis, D.D. 1986. *New England Wildlife: Habitat, Natural History and Distribution*. USDA Forest Serv. GTR NE-108. 491 p.
- DeGraaf, R.M., Witman, G.M., Lanier, J.W., Hill, B.J., Keniston, J.M. 1981. *Forest habitat for birds of the northeast*. U.S.D.A. Forest Service. Northeast Forest Experiment Station and Eastern Region.
- Del Hoyo, J., Elliot, A., Sargatal, J. (eds.). 1999. *Handbook of birds of the world volume 5. Barn owls to humming birds*. Lynx Edicions, Barcelona, Spain.
- Delnicki, D., and Reinecke, K. J. 1986. *Mid-winter food use and body weights of mallards and wood ducks in Mississippi*. Journal of Wildlife Management. 50: 43-51.

- Dunn, P.O., and Hannon, S.J. 1992. *Effects of food abundance and male parental care on reproductive success and monogamy in tree swallows*. Auk 109: 488–499
- Dunning, J.B. 1984. *Body weights of 686 species of North American birds*. Western Bird Banding Association Monograph No. 1. 38pp.
- Dunning, J.B. 1993. *CRC Handbook of Avian Body Masses*. CRC Press, Boca Raton, Florida.
- EPA. 1993. *Wildlife Exposure Factors Handbook. Volumes I and II*. EPA/600/R-93/187. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment and Office of Research and Development, Washington, DC. December.
- EPA. 2003. *Multimedia, Multipathway, and Multireceptor Risk Assessment (3MRA) Modeling System, Volume I: Modeling System and Science*. EPA530-D-03-001a, July 2003, SAB Review Draft, Chapter 15 Ecological Exposure Module. Available at: http://www.epa.gov/osw/hazard/wastetypes/wasteid/hwirwste/sab03/vol1/1_15_eco-exp.pdf
- Erickson, D.W., McCullough, C.R., Porath, W.R. 1984. *River otter investigations in Missouri*. Missouri Dept. Conserv.; Pittman-Robertson Proj. W-13-R-38, Final Report.
- Feusier, S. 1989. *Distribution and behavior of western screech-owls (Otus kennicottii) of the Starr Ranch Audubon Sanctuary, Orange County, California*. M.S. Thesis, Humboldt State Univ., Arcata, CA.
- Fredrickson, L.H., and Heitmeyer, M.E. 1988. *Waterfowl use of forested wetlands of the southern United States: an overview*. In: Weller, M. W., ed. *Waterfowl in winter*. Minneapolis, MN: University of Minnesota Press; pp. 307-323.
- French, T.W. 1984. *Reproduction and age structure of three Indiana shrews*. Proc. Indiana Acad. Sci. 94: 641-644.
- FWS (Fish and Wildlife Services). 1975. *The screech owl: Its life history and population ecology in northern Ohio*. North American Fauna, Number 71. U.S. Department of the Interior.
- Gehlbach, F. 1995. *Eastern Screech Owl (Otus asio)*. The Birds of North America, 165: 1-24.
- George, S.B., Choate, J.R., Genoways, H.H. 1986. *Blarina brevicauda*. American Society of Mammalogists; Mammalian Species 261.
- Getz, L.L. 1989. *A 14-year study of Blarina brevicauda populations in east-central Illinois*. J. Mammal. 70: 58-66.
- Gilbert, F.F., and Nancekivell, E.G. 1982. *Food habits of mink (Mustela vison) and otter (Lutra canadensis) in northeastern Alberta*. Canadian Journal of Zoology. 60: 1282-1288.
- Gochfeld, M., and Burger, J. 1984. *Age differences in foraging behavior of the American robin (Turdus migratorius)*. Behaviour. 88: 227-239.
- Gould, E.D. 1955. *The feeding efficiency of insectivorous bats*. J. Mammal. 36: 399-407.

- Greer, K.R. 1955. *Yearly food habits of the river otter in the Thompson Lakes region, Northwestern Montana, as indicated by scat analyses*. Am. Midl. Nat. 54: 299-313.
- Griffith, L.A., and Gates, J.E. 1985. *Food habits of cave-dwelling bats in the central Appalachians*. J. Mammal. 66(3): 451-460.
- Guilday, J.E. 1957. *Individual and geographic variation in Blarina brevicauda from Pennsylvania*. Ann. Carnegie Mus. 35: 41-68.
- Hamilton, W.J. 1940. *The summer food of minks and raccoons on the Montezuma Marsh, New York*. Journal of Wildlife Management. 4(1): 80-84.
- Hayward, G.D., and Garton, E.O. 1988. *Resource partitioning among forest owls in the River of No Return Wilderness, Idaho*. Oecologia. 75: 253-265.
- Hazelton, P.K., Robel, R.J., Dayton, A.D. 1984. *Preferences and influences of paired food items on energy intake of American robins (Turdus migratorius) and gray catbirds (Dumetella carolinensis)*. Journal of Wildlife Management. 48: 198-202.
- Heppner, F. 1965. *Sensory mechanisms and environmental clues used by the American Robin in locating earthworms*. Condor. 67:247-256.
- Heitmeyer, M.E. 1988. *Protein costs of the prebasic molt of female mallards*. Condor. 90: 263-266.
- Howell, J.C. 1942. *Notes on the nesting habits of the American robin (Turdus migratorius L.)*. Am. Midl. Nat. 28: 529-603.
- Johnsgard, P.A. 1988. *North American owls: Biology and Natural History*. Smithsonian Institution Press, Washington DC.
- Jones, S.R. 1998. *Eastern Screech-Owl*. pp. 214-215 In *Colorado Breeding Bird Atlas. Colorado Bird Atlas Partnership*. Denver, Co.
- Jorde, D.G., Krapu, G.L., Crawford, R.D. 1983. *Feeding ecology of mallards wintering in Nebraska*. J. Wildl. Manage. 47: 1044-1053.
- Kirby, R.E., Riechmann, J.H., Cowardin, L.M. 1985. *Home range and habitat use of forest-dwelling mallards in Minnesota*. Wilson Bull. 97: 215-219.
- Krohn, W.B. 1970. *Woodcock feeding habits as related to summer field usage in central Maine*. J. Wildl. Manage. 34: 769-775.
- Kurta, A. and Baker, R.H. 1990. *Eptesicus fuscus*. *Mammalian Species* 356: 1-10. The American Society of Mammalogists.
- Lauhachinda, V. 1978. *Life history of the river otter in Alabama with emphasis on food habits*. Unpublished Ph. D. dissertation, Auburn University. Auburn, 169 pp.
- Liers, E.E. 1951. *Notes on the river otter (Lutra canadensis)*. J. Mammal. 32: 1-9.
- Lokemoen, J.T., Duebbert, H.F., Sharp, D.E. 1990. *Homing and reproductive habits of mallards, gadwalls, and blue-winged teal*. Wildlife Monographs, 3-28.
- Mack, C.M. 1985. *River otter restoration in Grand County, Colorado [master's thesis]*. Fort Collins, CO: Colorado State University.
- Malmborg, P.K., and Willson, M.F. 1988. *Foraging ecology of avian frugivores and some consequences for seed dispersal in an Illinois woodlot*. Condor. 90: 173-186.

- Mammals of Texas. 2014. *Big brown bat*. Online Edison. Accessed on March 24, 2014 at: <http://www.nsrl.ttu.edu/tmot1/eptefusc.htm>
- Marchinton, R.L. and Hirth, D.H. 1984. Behavior. pp. 129-168. In: Halls, L.K., ed. *White-tailed Deer: Ecology and Management*. Harrisburg, PA: Stackpole Books.
- Martin, A.C., Zim, H.S., Nelson, A.L. 1951. *American Wildlife and Plants: A Guide to Wildlife Food Habits*. Dover Publications, N.Y.
- Mautz, W.W., Silver, H., Hayes, J.B., Urban, W.E. 1976. *Digestibility and related nutritional data for seven northern deer browse species*. Journal of Wildlife Management. 40: 630-638.
- McCarty, J.P. 2001. *Use of tree swallows in studies of environmental stress*. Rev Toxicol. 4: 61-104.
- Melquist, W.E., Dronkert, A.E. 1987. *River otter*. In: Novak, M., Baker, J.A., Obbarel, M.E., et al., eds. *Wild furbearer management and conservation*. Pittsburgh, PA: University of Pittsburgh Press; pp. 627-641.
- Melquist, W.E., Hornocker, M.G. 1983. *Ecology of river otters in west central Idaho*. In: Kirkpatrick, R. L., ed. *Wildlife monographs*: v. 83. Bethesda, MD: The Wildlife Society; 60 pp.
- Mengelkoch, J.M., Niemi, G.J., Regal, R.R. 2004. *Diet of the nestling tree swallow*. Condor. 106:423-429.
- Morrison, D.W., Caccamise, D.F. 1990. *Comparison of roost use by three species of communal roostmates*. Condor. 92: 405-412.
- Murray, G.A. 1976. *Geographic variation in the clutch sizes of seven owl species*. Auk. 93: 602-613.
- Nagy, K.A. 2001. *Food requirements of wild animals: predictive equations for free-living mammals, reptiles, and birds*. Nutrition Abstracts and Reviews Series B: Livestock Feeds and Feeding. 71(10): 21R-31R.
- National Geographic Society. 1987. *Field Guide to the Birds of North America*. 2nd Edition.
- Nelson, A.L., Martin, A.C. 1953. *Game bird weights*. Journal of Wildlife Management. 17: 36-42.
- Noble, P.L. 1990. *Distribution and density of owls at Monte Bello Open Space Preserve, Santa Clara County, California*. Western Birds. 21: 11-16.
- ODW (Ohio Division of Wildlife). 2014. Life History Notes, White-tailed Deer. Accessed on March 26, 2014 at: <http://www.dnr.state.oh.us/portals/9/pdf/pub101.pdf>
- Paszkowski, C.A. 1982. *Vegetation, ground, and frugivorous foraging of the American robin Turdus migratorius*. Auk 99: 701-709.
- Phillips, G.L. 1966. *Ecology of the big brown bat (Chiroptera: Vespertilionidae) in northeastern Kansas*. Am. Midl. Nat. 75(1): 168-198.
- Pitts, T.D. 1984. *Description of American robin territories in northwest Tennessee*. Migrant. 55: 1-6.
- Quinney, T.E., Ankney, C.D. 1985. *Prey size selection by tree swallows*. The Auk. 245-250.

- Robbins, C.T. 1993. *Wildlife Feeding and nutrition*. Academic Press, San Diego, California.
- Robertson, R.J., Stutchbury, B.J., Cohen, R.R. 1992. *Tree Swallow (Tachycineta bicolor)*. In Poole, A., and Gill, F. (eds.), *The Birds of North America*, No. 11. The Academy of Natural Sciences, Philadelphia, and the American Ornithologists Union, Washington, D.C.
- Salyer, J.C., Lagler, K.F. 1946. *The eastern belted kingfisher, Megaceryle alcyon (Linnaeus), in relation to fish management*. Trans. Am. Fish. Soc. 76: 97-117.
- Sample, B.E., and Suter, G.W. 1994. *Estimating exposure of terrestrial wildlife to contaminants*. Draft. Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, ES/ER/TM-125.
- Schlessinger, W.H., and Potter, G.L. 1974. *Lead, copper, and cadmium concentrations in small mammals in the Hubbard Brook experimental forest*. Oikos. 25: 148-152.
- Sheldon, W.G., and Toll, W.G. 1964. *Feeding habits of the river otter in a reservoir in central Massachusetts*. J. Mammal. 45: 449-455.
- Silva, M., and Downing, J.A. 1995. *CRC Handbook of Mammalian Body Masses*. CRC Press, Boca Raton, FL.
- Skorupa, J.P., and Hothem, R.L. 1985. *Consumption of commercially-grown grapes by American robins (Turdus migratorius): a field evaluation of laboratory estimates*. Journal of Field Ornithology. 56: 369-378.
- Smith, W.P. 1991. *Odocoileus virginianus*. *Mammal Species*. 388: 1-13.
- Sperry, C. 1940. *Food habits of a group of shore birds; woodcock, snipe, knot, and dowitcher*. U. S. Dept. Int., Bur. Biol. Survey, Wildl. Res. Bull. 1; 37 pp.
- Stribling, H.L., Doerr, P.D. 1985. *Nocturnal use of fields by American woodcock*. J. Wildl. Manage. 49: 485-491.
- Swanson, G. A., Meyer, M.I. 1973. *The role of invertebrates in the feeding ecology of Anatinae during the breeding season*. In: *The Waterfowl Habitat Management Symposium at Moncton, New Brunswick, Canada; July 30 -August 1, 1973*; The Atlantic Waterfowl Council; pp. 143-180.
- Swanson, G.A., Krapu, G.L., Serie, J.R. 1979. *Foods of laying female dabbling ducks on the breeding grounds*. In: Bookhout, T. A., ed. *Waterfowl and wetlands--an integrated review: proceedings of 1977 symposium*. Madison, WI, The Wildlife Society, NC Sect.; pp.47-57.
- Swanson, G.A., Meyer, M.I., Adomaitis, V.A. 1985. *Foods consumed by breeding mallards on wetlands of south-central North Dakota*. J. Wildl. Manage. 49: 197-203.
- Titman, R.D. 1983. *Spacing and three-bird flights of mallards breeding in pothole habitat*. Canadian Journal of Zoology. 61: 839-847.
- Torgerson, O., and Porath, W.R. 1984. *Midwest oak/hickory forest*. pp. 411-426. In: Halls, L.K., ed. *White-Tailed Deer: Ecology and Management*. Stackpole Books, Harrisburg, PA.

- USACHPPM (U.S. Army Center for Health Promotion and Preventive Medicine). 2004. *Development of Terrestrial Exposure and Bioaccumulation Information for the Army Risk Assessment Modeling System (ARAMS)*. U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) Contract Number DAAD050-00-P-8365, Aberdeen Proving Ground, Maryland, 2004.
- USDA (U.S. Department of Agriculture). 2002. *Conservation Assessment for the Eastern Screech-Owl in the Black Hills National Forest, South Dakota and Wyoming*. Forest Service, Rocky Mountain Region, Black Hills National Forest, Custer, South Dakota, December 2002.
- Wang, J., Newman, M.C. 2013. *Projected Hg dietary exposure of 3 bird species nesting on a contaminated floodplain (South River, Virginia, USA)*. Integrated Environmental Assessment and Management. 9: 285–293.
- Weeks, H.P., Jr. 1978. *Characteristics of mineral licks and behavior of visiting white-tailed deer in southern Indiana*. Am. Midl. Nat. 100:384-395.
- Wheelwright, N.T. 1986. *The diet of American robins: an analysis of U.S. Biological Survey records*. Auk. 103: 710-725.
- Whitaker, J.O., Jr. and Ferraro, M.G. 1963. *Summer food of 220 short-tailed shrews from Ithaca, New York*. J. Mammal. 44: 419.
- Whitaker, J.O., Jr. 1972. *Food habits of bats from Indiana*. Can. J. Zool. 50: 877-883.
- Whitaker, J.O., Jr., Maser, C., Cross, S.P. 1981. *Food habits of eastern Oregon bats, based on stomach and scat analyses*. Northwest Science 55(4): 281-292.
- Whyte, R.J., and Bolen, E.G. 1984. *Impact of winter stress on mallard body composition*. Condor. 86: 477-482.
- Young, H. 1955. *Territorial behavior in the eastern robin*. Proc. Linnaean Soc. NY. 58-62: 1-37.
- Zeiner, D.C., Laudenslayer, Jr., W.F., Mayer, K.E., White, M. 1990. *California's Wildlife, Volume III Mammals*. California Statewide Wildlife Habitat Relationships System. Department of Fish and Game, Sacramento, California.
- Zim, H.S., Martin, A.C., Nelson, A.L. 1951. *American wildlife and plants a guide to wildlife food habits*. Dover Publications, Inc. New York.

Tables

Table D-1
Summary of Exposure Factors for Dietary Exposure Modeling
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Focal Species		Home Range (HR, acres)	Reference	Area Use Factor (AUF) ^a	Mean Body Weight ^a (BW, g ww)	Reference	Dietary Preference Range (%) ^e												Ingestion Rates (IRs)							
Name	Receptor Category						Aquatic Vegetation	Aquatic Larval Insect	Emergent Adult Insects	Crayfish	Amphibians	Fish (<130 mm TL)	Fish (>130 mm TL)	Earthworms	Spiders	Small Birds	Small Mammals	Terrestrial Plants	g ww/day	Reference ^f	Liters / day	As % of FIR _{dw}	Reference/Notes ^g	g dw/day ^h	Reference ⁱ	
Avian Receptors																										
Belted kingfisher (<i>Megaceryle alcyon</i>)	Semi-aquatic piscivorous birds	1.5-20.8 ^b	EPA (2003)	1.0	148.0	Powdermill Nature Center ^c	--	--	--	5%	5%	90%	--	--	--	--	--	--	FIR=3.048×BW ^{0.665}	Eqn #64 for Carnivores (Nagy, 2001)	WIR = 0.059×BW ^{0.67}	1.0% (sediment)	Conservative assumption (see text)	SIR =0.01×0.849×BW ^{0.663}	Eqn #63 for Carnivores (Nagy, 2001)	
Mallard duck (<i>Anas platyrhynchos</i>)	Semi-aquatic invertivorous/ omnivorous birds	94-3560	EPA (2003)	1.0	1171	Delnicki & Reinecke (1986) ^c	5%	45%	--	45%	--	5%	--	--	--	--	--	--	FIR=2.094×BW ^{0.627}	Eqn #62 for Omnivores (Nagy, 2001)	WIR = 0.059×BW ^{0.67}	3.3% (sediment)	Beyer et al. (1994)	SIR =0.033×0.67×BW ^{0.627}	Eqn #61 for Omnivores (Nagy, 2001)	
Eastern screech owl (<i>Megascops asio</i>)	Terrestrial carnivorous birds	150	Hayward and Garton (1988)	1.0	164.0	ADW (2014)	--	--	--	13%	--	--	--	10%	7%	22%	48%	--	FIR=3.048×BW ^{0.665}	Eqn #64 for Carnivores (Nagy, 2001)	WIR = 0.059×BW ^{0.67}	1.0% (sediment) and 1% (soil)	Conservative assumption (see text)	SIR =0.01×0.849×BW ^{0.663} =0.01×0.849×BW ^{0.663}	Eqn #63 for Carnivores (Nagy, 2001)	
Tree swallow (<i>Tachycineta bicolor</i>)	Terrestrial aerial insectivorous birds	5-148	EPA (2003)	1.0	20.1	Robertson et al. (1992) ^c and Dunning (1993) ^c	--	--	95%	--	--	--	--	--	5%	--	--	--	FIR=2.438×BW ^{0.607}	Eqn #38 for Passerines (Nagy, 2001)	WIR = 0.059×BW ^{0.67}	0.0%	Assumed to be negligible (see text)	--	--	
American Robin (<i>Turdus migratorius</i>)	Terrestrial insectivorous birds	0.27-2.07	EPA (2003)	1.0	81.0	USACHPPM (2004)	--	--	--	--	--	--	--	70%	20%	--	--	10%	FIR=2.438×BW ^{0.607}	Eqn #38 for Passerines (Nagy, 2001)	WIR = 0.059×BW ^{0.67}	2.1% (soil)	Conservative assumption (see text)	SIR =0.021×0.630×BW ^{0.683}	Eqn #37 for Passerines (Nagy, 2001)	
Mammalian Receptors																										
River otter (<i>Lontra canadensis</i>)	Piscivorous mammals	> 729	EPA (2003)	1.0	7430	Lauhachinda (1978) ^c	--	--	--	5%	5%	45%	45%	--	--	--	--	--	FIR=0.469×BW ^{0.848}	Eqn #26 for Carnivores (Nagy, 2001)	WIR = 0.099×BW ^{0.90}	1.0% (sediment)	Conservative assumption (see text)	SIR =0.01×0.153×BW ^{0.834}	Eqn #25 for Carnivores (Nagy, 2001)	
Short-tailed shrew (<i>Blarina brevicauda</i>)	Terrestrial invertivorous mammals	0.07-4.45	EPA (2003)	1.0	17.3	Guilday (1957) ^c	--	--	--	--	--	--	--	60%	35%	--	--	5%	FIR=1.130×BW ^{0.622}	Eqn #32 for Insectivores (Nagy, 2001)	WIR = 0.099×BW ^{0.90}	2.4% (soil)	Conservative assumption (see text)	SIR =0.024×0.373×BW ^{0.622}	Eqn #31 for Insectivores (Nagy, 2001)	
White-tailed deer (<i>Odocoileus virginianus</i>)	Terrestrial herbivorous mammals	> 146	EPA (2003)	1.0	56500	Smith (1991) ^d	10%	--	--	--	--	--	--	--	--	--	--	90%	FIR=2.606×BW ^{0.628}	Eqn #30 for Herbivores (Nagy, 2001)	WIR = 0.099×BW ^{0.90}	2.0% (soil)	Beyer et al. (1994)	SIR =0.020×0.859×BW ^{0.628}	Eqn #29 for Herbivores (Nagy, 2001)	
Big brown bat (<i>Eptesicus fuscus</i>)	Terrestrial Aerial insectivorous mammals	> 776	Kurta and Baker (1990) ^d	1.0	20.8	Nagy (2001)	--	--	100%	--	--	--	--	--	--	--	--	--	FIR=1.219×BW ^{0.652}	Eqn #8 for Bats (Nagy, 2001)	WIR = 0.099×BW ^{0.90}	0.0%	Assumed to be negligible (see text)	--	--	

Notes:
--, Not applicable; FIR, Food ingestion rate; WIR, Water ingestion rate; SIR, Sediment ingestion rate; BW, Body weight; TL, Total length; ww = Wet weight; dw = Dry weight.
a, AUF may be refined based on the ratio of the home range to the exposure areas under consideration; an AUF = 1.0 is used in initial modeling.
b, Based on great blue heron data.
c, As cited in the Handbook (EPA, 1993).
d, As cited in Sample and Suter (1994).
e, See Receptor Profiles (Table D-2a through i) for the basis of the estimates and assumptions.
f, Food ingestion rates (FIRs, in g ww/day), calculated using respective equations from Nagy (2001); BWs are in g; Equation numbers in references refer to the equation numbers in Table 2 of Nagy (2001).
g, Water ingestion rates (WIRs, in L/day), calculated using respective equations for birds and mammals from Calder and Braun (1983, as cited in the Handbook); BWs are in kg.
h, Sediment or soil ingestion rates (SIRs, in g dw/day), calculated using assumptions regarding SIRs (as % of SIR_{Dry}) and corresponding equations fro SIR_{Dry} from Nagy (2001); BWs are in g.

Table D-2a
Receptor Profiles - Belted Kingfisher
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Receptor	Belted kingfisher (<i>Megaceryle alcyon</i>)
Body Weight (BW)	Adult Belted kingfishers (both male and female) weighed 136 ± 15.6 g SE in PA and 158 ± 11.5 g SE in OH [Brooks & Davis (1987) as cited in the Handbook]; Powdermill Nature Center (unpubl., as cited in the Handbook) reported a range of 125 - 215 g and mean of 148 ± 20.8 g SD for adult males and females in PA. Mean BW for Belted kingfisher is assumed to be 148 g [Powdermill Nature Center (unpubl., as cited in the Handbook)].
Food Ingestion Rate (FIR)	Equation #64 for Carnivorous birds (Nagy, 2001): $FIR (g \text{ ww/day}) = 3.048 \times BW^{0.665}$, where BW is in g; Using this equation with a mean BW of 148 g results in a FIR of 84.6 g ww/day. Alexander (1977) estimated a daily food intake of 0.5 g ww/g BW/day for adults in north central lower MI. Based on this daily food intake and a mean BW of 148 g, a FIR = 74 g ww/day can be estimated.
Drinking Water Ingestion Rate (WIR)	Estimated based on Calder and Braun (1983): $WIR (L/day) = 0.059 \times BW^{0.67}$, where BW is in kg.
Sediment Ingestion Rate (SIR)	Belted kingfishers feed almost exclusively in the pelagic zone of the water column (the Handbook). Consequently, they are unlikely to ingest any appreciable amount of sediment incidentally while foraging or indirectly through their prey. An incidental SIR of 1% of FIR (dw) is assumed as a result of foraging on crayfish and amphibians.
Population Densities (PD)	Brooks & Davis (1987, as cited in the Handbook) reported population densities of 2 to 6 pairs/10 km of shoreline.
Fecundity/Clutch Size etc.	Clutch size is reported to be 5.8 ± 0.7 SE to 6.8 ± 0.4 SE (the Handbook).
Home Range (HR)	Brooks and Davis (1987) and Davis (1982) (both cited in the Handbook) reported home ranges of 0.39 ± 0.093 km SE for breeding pairs and 2.19 ± 0.56 km SE for non-breeding individuals in PA and OH. EPA (2003) estimated a home range of 6,000-84,000 m ² (with a mean of 45,000 m ²) based on great blue herons, equivalent to 1.483 to 20.8 acres.
Seasonality/Migration in and out of Virginia	The Handbook reports that Belted kingfishers breed over most of the area of North America and winter in most regions of the continental United States (National Geographic Society, 1987) and although most northern kingfishers migrate to southern regions during the coldest months, some may stay in areas that remain ice-free where fishing is possible (Bent, 1940). Kingfishers are assumed to reside in AOC-4 for 300 days/year.
Dietary Composition	Belted kingfishers feed predominantly on fish. When fish are scarce, they supplement fish diet with aquatic macroinvertebrates, terrestrial prey, and/or plant material (Bent, 1940). Davis [1982, as cited in Sample & Suter (1994)] reported a dietary composition of 76.4% cyprinids, 10.2% other fish, and 13.3% crayfish. EPA (2003) estimated the following dietary preference for the Belted kingfishers in water/wetland setting: 2-41% - other invertebrates, 0-10% - small mammals, 0-10% - benthic filter feeders, 5-100% - trophic level 3 fish, 0-10% - forage, and 0-27% - small herpetofauna. Aquatic dietary preference of Belted kingfishers in AOC-4 is assumed to be: 90% fish (< 130 mm TL), 5% crayfish, and 5% amphibians. Fish size preference is based on the information on prey size (below) and what was sampled at the Study Area.
Prey Size	Fish caught by belted kingfishers ranged from 2.5 to 17.8 cm (with an average < 7.6 cm) in a Michigan study [Salyer and Lagler (1946) as cited in the Handbook]. In OH streams, Belted kingfishers caught fish ranging from 4 to 14 cm [Davis (1982) as cited in the Handbook].

Notes:

The Handbook refers to Wildlife Exposure Factors Handbook, Volumes I and II (EPA, 1993).

SE, Standard error.

SD, Standard deviation.

TL, Total length.

ww, Wet weight.

Table D-2b
Receptor Profiles - Mallard
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Receptor	Mallard (<i>Anas platyrhynchos</i>)
Body Weight (BW)	Nelson & Martin (1953) reported mean BWs of 1.225 kg (up to 1.814 kg) for adult males and 1.043 kg (up to 1.633 kg) for adult females throughout North America. Adults from western Mississippi weighed 1.246 ± 0.1108 kg SD (male) and 1.095 ± 0.106 kg SD (female) (Delnicki & Reinecke, 1986). Adults from Texas weighed 1.237 ± 0.118 kg SD (male) and 1.088 ± 0.105 kg SD (female) [Whyte and Bolen, (1984) as cited in the Handbook]. Mean BW for mallard is assumed to be 1.171 kg (based on data from Delnicki & Reinecke, 1986).
Food Ingestion Rate (FIR)	Equation #64 for Omnivorous birds (Nagy, 2001): $FIR (kg \text{ ww/day}) = 2.094 \times BW^{0.627}$, where BW is in g. Using this equation and a mean BW of 1171 g, a FIR of 175.8 g ww/day is estimated.
Drinking Water Ingestion Rate (WIR)	Estimated based on Calder and Braun (1983): $WIR (L/day) = 0.059 \times BW^{0.67}$, where BW is in kg.
Sediment Ingestion Rate (SIR)	Mallards feed on benthic macroinvertebrates for part of the year. In Beyer et al. (1994), samples from most mallards contained little or no sediment (mean = 3.3% of diet), but 10% of the Mallards (out of 88), with the highest sediment content consumed an estimated 26% sediment in their diet. Therefore, SIR for Mallards was conservatively assumed to be 3.5% of FIR(dw) based on the mean value presented in Beyer et al. (1994).
Population Densities (PD)	Lokemoen et al. (1990) reported mean densities of 0.036-0.047 pairs/ha. Average densities of breeding Mallards in the prairie pothole region range from 0.006 to 0.67 pairs/hectare (the Handbook). Titman (1983) reported breeding density of 4-7.5 pairs/km ² in prairie pothole habitat.
Fecundity/Clutch Size etc.	Clutch size ranges from 1-18 (mean = 9) with up to 4.5 clutches/year (if not successful) [the Handbook].
Home Range (HR)	Kirby et al. (1985, as cited in the Handbook) reported a HR of 40 - 1,440 ha (mean = 540 ha) for female and 70 -1,140 ha (mean = 620 ha) for male in Minnesota/wetlands and river. EPA (2003) estimated a HR of 380,000-14,400,000 m ² , equivalent to 94 to 3,558 acres.
Seasonality/Migration in and out of Virginia	Although Mallards winter in all four waterfowl flyways of North America (i.e., Pacific, Central, Mississippi, and Atlantic), the Mississippi flyway contains the highest numbers (Bellrose, 1976). Ducks winter farther north than in the past (Jorde et al., 1983). Mallards tend to arrive at their wintering grounds in the Mississippi Valley in mid-September through early November and depart for their northerly breeding grounds again in March (Fredrickson and Heitmeyer, 1988). [All references cited in the Handbook]. Mallards are assumed to be year-round residents in AOC-4.
Dietary Composition	Based on esophagus contents (% wet volume), Mallard's diets in south central ND prairie potholes consisted of 67-89% animals (gastropods 0-25%, insects 13-48%, crustacea 8-15%, annelids 0.2-38%, misc. 0-9%) and 11-33% plants (seeds 11-29%, tubers 0-4%, and stems 0-1%) (Swanson et al., 1985). EPA (2003) estimated the following dietary preference for the mallard in water/wetland setting: 10-60% - Other Invertebrates, 0-10% - benthic filter feeders, 0-10% - trophic level 3 fish, 0-10% - aquatic plants, 0-10% - forage, 0-24% exposed fruits, 50-100% -grains, 0-10% -roots, and 0-25% -silage. Aquatic dietary preference for mallards in AOC-4 is assumed to be: 45% midge larvae, 45% crayfish, 5% submerged aquatic vegetation (SAV), and 5% fish (<130 mm TL). Their dietary preference is conservatively assumed to include exclusively animal tissue, which is typical of the shift that occurs from a largely herbivorous diet in winter to a high protein of mainly animal tissue during spring molt and spring/summer egg production [Swanson and Meyer, 1973; Swanson et al., 1979; Swanson et al., 1985; Heitmeyer, 1988]. This dietary preference for mallards likely represents the most sensitive dietary exposure to mercury during a likely period of high foraging activity within AOC-4.
Prey Size	Mallards diet predominantly contains chironomidae, diptera, gastropods, crustaceans, and terrestrial annelids (Swanson et al., 1979).

Notes:

The Handbook refers to Wildlife Exposure Factors Handbook, Volumes I and II (EPA, 1993).

SD, standard deviation.

TL, Total length.

dw, Dry weight.

ww, Wet weight.

Table D-2c
Receptor Profiles - Screech Owl
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Former DuPont Waynesboro Plant, Waynesboro, Virginia

Receptor	Eastern Screech Owl (<i>Megascops asio</i>)
Body Weight (BW)	CLO (Cornell Lab of Ornithology, 2014b) reported an adult BW range of 121-244 g for adult Eastern screech owls. ADW (Animal Diversity Web, 2014) reported a mean BW of 164.1 g. Six experts surveyed by Wang and Newman (2013) indicated an adult BW range of 125-240 g. Mean BW for Eastern screech owl is assumed to be 164 g based on ADW (2014).
Food Ingestion Rate (FIR)	Equation #64 for Carnivorous birds (Nagy, 2001): $FIR (g \text{ ww/day}) = 3.048 \times BW^{0.665}$, where BW is in g. Using this equation and a mean BW of 164 g, a FR of 90.5 g ww/day is estimated. According to six experts surveyed by Wang and Newman (2013), daily food intake for Eastern screech owl ranged from less than 0.3 to 0.8 g ww/g/day. Based on this range and a mean BW of 164 g, FIRs from 49.2 to 131.2 g ww/day can be estimated, the mid point of which is 90.2 g ww/day.
Drinking Water Ingestion Rate (WIR)	Estimated based on Calder and Braun (1983): $WIR (L/day) = 0.059 \times BW^{0.67}$, where BW is in kg.
Soil/Sediment Ingestion Rate (SIR)	Information on incidental soil or sediment ingestion rates are not available for Eastern screech owl. However, its dietary preference indicates that it may consume approximately 15 percent each of soil invertebrates (e.g., earthworms and spiders) and aquatic invertebrates (crayfish). Therefore, the exposure model conservatively assumed that the incidental sediment and soil ingestion represents one percent each of dry food intake for eastern screech owl as a result of foraging on terrestrial and aquatic invertebrates.
Population Densities (PD)	Information on local population density is not available. Eastern screech-owls approached one pair per linear mile along creeks in Colorado [Jones (1998) as cited in USDA (2002)] and 0.4 pairs per ha in stands of canyon live oak in California [(Noble 1990) as cited in USDA (2002)].
Fecundity/Clutch Size etc.	Screech-owl clutch size increase in size to the north and decreased to the west, but average 3.42-4.01 eggs [Murray (1976) as cited in USDA (2002)]. Screech owls lay three to seven eggs, but usually four or five, with an average of five [Bent (1938) as cited in FWS (1975)]. Average clutch in Ohio was 4.43 (FWS, 1975).
Home Range (HR)	Gehlbach (1995) reported that Eastern screech-owls defended 12-19 % of the mean distance to the nearest alternate cavity, depending on tree density. Johnsgard (1988) indicated that in Arizona, territories for western screech owl (a similar species) averaged 275 m apart, except in mesquite where they averaged 45-90 m apart. In Idaho their home range was estimated to be a 1260 x 480 m rectangle along a riparian corridor (Hayward and Garton 1988). In California, an average distribution of western screech-owl territories was 2.1 territories per km of river channel with a minimum average distance of 420 m between nest sites (Feusier 1989). HR was assumed to be 6,04,800 m ² (or approximately 150 acres) based on Hayward and Garton (1988). [All as cited in USDA (2002)].
Seasonality/Migration in and out of Virginia	Eastern screech-owls are assumed to be year-round residents in AOC-4.
Dietary Composition	USDA (2002) indicate a broad range of diet for Eastern screech-owl, containing at least 138 vertebrate species and likely as many invertebrate species (Gehlbach, 1995; Del Hoyo et al., 1999). Generally, they prey on more rodents in the winter, while more birds, reptiles and insects are taken during nesting. FWS (1975) found at least 53 species of songbirds, 8 species of small mammals, 1 species of frog, 3 species of fishes and 2 species of invertebrates in Eastern screech owl diet in northern Ohio. Based on a composite of six expert estimations, Wang and Newman (2013) reported the following dietary composition (as % of prey items) for Eastern screech owl: Slug - 0.4%, Isopods - 4.8%, Earthworms - 3.6%, Eastern Tent Caterpillar - 0.5%, Wolf spider - 7.3%, Small birds - 22%, Mice - 48%, Crayfish - 13.4%. Dietary preference for Eastern screech owl in AOC-4 is assumed to be: 10% Earthworms and 7% spiders, 13% crayfish, 22% small birds, and 48% small mammals.
Prey Size	As indicated above the Eastern screen owl mostly feed on small mammals (e.g., mice) and small birds (e.g., song birds).

Notes:

ww, Wet weight.

Table D-2d
Receptor Profiles - Tree Swallow
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Receptor	Tree swallow (<i>Tachycineta bicolor</i>)
Body Weight (BW)	Nagy (2001) reports a BW of 20.2 g for Tree swallow. CLO (2014a) reports a range of 16-25 g. According to Robertson et al. (1992) and Dunning (1993), male adults > 2 years weighed 20.4 ± 1.5 g SD (N=86, range of 17-24g) and female adult > 2 years weighed 21.5 ± 1.7 g SD (N=134, range of 18-25.5g) and all adults (male and female) weighed 20.1 ± 1.58 g SD (N=82, range of 15.6-25.4g). Mean BW for Tree swallow is assumed to be 20.1 g (based on Robertson et al., 1992 and Dunning, 1993).
Food Ingestion Rate (FIR)	Equation #38 for Passerine birds (Nagy, 2001): $FIR (g \text{ ww/day}) = 2.438 \times BW^{0.607}$, where BW is in g. Using this equation and a mean BW of 20.1 g, a FIR of 15.1 g ww/day is estimated. Nagy (2001) reported FIRs of 11.6 g dw/day or 35.2 g ww/day for tree swallows.
Drinking Water Ingestion Rate (WIR)	Estimated based on Calder and Braun (1983): $WIR (L/day) = 0.059 \times BW^{0.67}$, where BW is in kg.
Sediment Ingestion Rate (SIR)	Tree swallows forage almost exclusively on flying insects captured during flight. As a result of this feeding behavior, there is no complete pathway with sediments; therefore, SIR for tree swallows is assumed to be negligible (i.e., SIR = 0).
Population Densities (PD)	Among tree swallows, breeding densities have been reported to range from 3.5 to 500 pairs/ha, the later estimate resulting from nest boxes placed at an artificially high density [DeGraaf et al. (1981) as cited in USACHPPM (2004)]
Fecundity/Clutch Size etc.	CLO (2014a) reports clutch sizes of 4-7 eggs and 1-2 broods.
Home Range (HR)	Tree swallows typically forage within 400 m of their nests [McCarty (2001) and Mengelkoch et al. (2004), both as cited in Brasso and Cristol (2008)]. Tree swallows foraging range is typically 300-500 m of their nests (Quinney and Ankney, 1985; Dunn and Hannon, 1992). EPA (2003) estimated a HR of 20,000-600,000 m ² , approximately equivalent to 5 to 148 acres.
Seasonality/Migration in and out of Virginia	Migration of Tree swallows to winter grounds begins shortly after breeding season, Jul-Aug (Burleigh, 1958). But Tree swallows are assumed to be year-round residents in AOC-4.
Dietary Composition	CLO (2014a) reports that Tree swallows live on a diet of insects, with occasional small animals and plant foods when prey is scarce. They eat all kinds of flying insects: dragonflies, damselflies, flies, mayflies, caddisflies, true bugs, sawflies, bees, ants, wasps, beetles, stoneflies, butterflies, and moths, as well as spiders, mollusks, and roundworms. During the breeding season, tree swallows eat high-calcium items like fish bones, crayfish exoskeletons, clamshells, and eggshells of gulls or loons. Tree swallow diet consisted of 65.2± 10.5% (dw) chironomidae (midges) and 3.7% spiders (Beck et al., 2013). EPA (2003) estimated the following dietary preference for the tree swallows as: 50-78% - other invertebrates, 0-25% - forage, and 0-25% exposed fruits. Beal (1918) reported that spiders consisted less than 4.64% (volume) of the diet in 343 Tree swallows from 22 states and Canada (as cited in USACHHMP, 2004). Dietary preference for Tree swallows in AOC-4 is assumed to be: 95% aquatic emergent insects and 5% spiders.
Prey Size	Quinney and Ankney (1985) report that 99 percent of the insects consumed by tree swallows are 10 mm in length. Blancher and McNicol (1991) observed that ~90% of prey were 25 mm in length. CLO (2014a) indicate that tree swallow prey may be smaller than a grain of sand or up to two inches long.

Notes:

SD, Standard deviation.

ww, Wet weight.

dw, Dry weight.

Table D-2e
Receptor Profiles - American Robin
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Receptor	American robin (<i>Turdus migratorius</i>)
Body Weight (BW)	Mean adult BW for American robin ranged from 77.3 to 86.2 g in New York and Pennsylvania (the Handbook, USACHPPM, 2004). Dunning (1984) reported a mean adult BW of 77 g [as cited in Sample and Suter (1994)]. A mean BW for American robin was assumed to be 81 g [based on an average of the adult mean BW reported in USACHPPM (2004)].
Food Ingestion Rate (FIR)	Equation #38 for Passerine birds (Nagy, 2001): $FIR (g \text{ ww/day}) = 2.438 \times BW^{0.607}$, where BW is in g. Using this equation and a mean BW of 81 g, a FIR of 35.1 g ww/day is estimated. For free living robins in Kansas, Hazelton et al. (1984) estimated a daily food intake of 1.52 g ww/g BW/day. For robins in California, Skorupa and Hothem (1985) reported a daily food intake of 0.89 g ww/g BW/day. Sample and Suter (1994) used a mean of 93 g ww/day estimated by Skorupa and Hothem (1985) and Hazelton et al. (1984) using mean BW of 77 g. Using a similar approach and a mean BW of 81 g, a FIR of 97.6 g ww/day is estimated.
Drinking Water Ingestion Rate (WIR)	Sample and Suter (1994) estimated 0.0106 L/d based on BW of 77 g. Estimated based on Calder and Braun (1983): $WIR (L/day) = 0.059 \times BW^{0.67}$, where BW is in kg.
Soil Ingestion Rate (SIR)	Soil ingestion rates for American robins are not available in the literature. But estimates are available based on birds with similar diet (USACHPPM, 2004). Both robins and woodcocks consume earthworms; however, earthworms comprise >60% to 99% of the American woodcock diet (Sperry, 1940; Krohn, 1970, Stribling and Doerr, 1985) compared to <20% of the American robin diet (Howell, 1942). Therefore, the SIR of 10.4% of the diet reported for American woodcocks (Beyer et al., 1994) is likely to be an extreme upperbound for the robin. Assuming soil ingestion is proportion to the % of earthworms in the diet, a SIR of 2.1% (dw) can be estimated for American robin. Sample and Suter (1994) used the same estimate. Therefore, SIR for American robin is estimated to be 2.1% of the diet (dw).
Population Densities (PD)	Population densities have been estimated at 8.6 pairs/ha (in spring in Tennessee), 8.6 pairs/ha (in dense conifers in New York), and 4.9 pairs/ha (in unspecified forest in New York) and 4.7 to 6.2 pairs/ha in Wisconsin [(Pitts, 1984; Howell, 1942) as cited in USACHPPM (2004); (Young, 1951) as cited in Sample and Suter (1994)].
Fecundity/Clutch Size etc.	Young (1955) indicated that first clutches usually contain three or four eggs, while later clutches contain fewer eggs. The average number of fledglings per successful nest was 2.9 in Wisconsin and 2.5 in Maine (Young, 1955; Knupp et al., 1977).
Home Range (HR)	During nonbreeding periods, robins are likely return to the same foraging sites for many weeks and join roosts within 1 to 3 km of these foraging areas [(Morrison and Caccamise, 1990) as cited in USACHPPM (2004)]. Mean territory sizes are estimated to be 0.42 ha (during spring in Tennessee), 0.11 ha (in dense conifers in New York), and 0.21 ha (in unspecified forest in New York) [Pitts (1984) and (Howell, 1942) as cited in USACHPPM (2004)]. EPA (2003) estimated a HR of 1,100-8,400 m ² , approximately equivalent to 0.27 to 2.07 acres.
Seasonality/Migration in and out of Virginia	Robins from northern US and Canada migrate and winter in the Gulf Coast and Carolinas (National Geographic Society, 1987) and are permanent residents in the southern portion of range (DeGraaf and Rudis, 1986) [Both as cited in Sample and Suter (1994)]. American robins are assumed to be year-round residents in AOC-4.
Dietary Composition	Robins forage for ground-dwelling invertebrates or fruit and foliage-dwelling insects in shrubs and low tree branches [(Malmborg and Wilson, 1988; Paszkowski, 1982) as cited in USACHPPM (2004)]. During breeding and preceding months, robins feed mainly on invertebrates (> 90 % volume) and on some fruits; the rest of the year, they primarily feed on fruits (over 80 to 99 % by volume) (Martin et al., 1951; Gochfeld and Burger, 1984; Wheelwright, 1986). Robins eat a wide variety of both plant and animal foods: fruits from 51 genera and invertebrates from 107 families (Wheelwright, 1986). Seasonally, Wheelwright (1986) indicate that robins in Eastern US eat 7% fruit and 93% invertebrates in spring to 92% fruit and 8% invertebrates in fall. Heppner (1965) indicate that earthworms constitute 8.7 to 20% of their diet in summer (as cited in Sample and Suter, 1994). EPA (2003) estimated the following dietary preference for American robins: 15-27% worms, 25-93% - other invertebrates, 7-92% exposed fruits, and 0-24% forage. Mean MeHg concentrations in various dietary items (e.g., beetles, caterpillars, worms, slug, and spiders) were compared in a limited number of areas within AOC 4 [based on data from Wang and Newman (2013)]. The comparisons indicate that wolf spiders contain the highest MeHg concentrations and concentrations in the rest of the invertebrates were either comparable or lower than in the earthworms. Hence, dietary preference for American robins in AOC-4 is assumed to be: 70% earthworms (representing earthworms and invertebrates other than wolf spider), 20% wolf spiders, and 10% terrestrial plants. Assumed dietary preference reflects the high invertebrate diet during breeding season and is expected to result in conservative risk estimates. Additionally, wolf spiders in the diet of American robin is purposely overestimated to account for the importance of aquatic to terrestrial transfer pathway.
Prey Size	As indicated above American robins diet constitute small invertebrates, small fruits and seeds.

Notes:

SD, Standard deviation.

dw, Dry weight.

Table D-2f
Receptor Profiles - River Otter
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Receptor	River otter (<i>Lontra canadensis</i>)
Body Weight (BW)	The Handbook reports that adult river otters (both male and female) weigh 5-15 kg (Melquist & Dronkert, 1987). Lauhachinda (1978) reported that in Alabama and Georgia adult males (mean BW = 8.13 ± 1.15 kg SD, range 5.84 -10.4 kg) are larger than females (mean BW 6.73 ± 1.00 kg SD, range 4.74 -8.72 kg). Similarly, Melquist & Hornocker (1983) reported that in Idaho, males weight 9.20 ± 0.6 kg SE and females weighed 7.90 ± 0.2 kg SE. Mean BW for River otters is assumed to be 7.43 kg [based on Lauhachinda (1978)].
Food Ingestion Rate (FIR)	Equation #26 for Carnivorous mammals (Nagy, 2001): $FIR (g \text{ ww/day}) = 0.469 \times BW^{0.848}$, BW is in g. Using this equation and a mean BW of 7430 g, a FIR of 899 g ww/day is estimated, which is within the range for otters in captivity, which required 700-900 g ww food daily (the Handbook).
Drinking Water Ingestion Rate (WIR)	Estimated based on Calder and Braun (1983). $WIR (L/day) = 0.099 \times BW^{0.9}$, where BW is in kg.
Sediment Ingestion Rate (SIR)	River otters may ingest a small amount of sediment incidentally while foraging and indirectly through their prey. Therefore, a conservatively estimated SIR of 1% of the dry diet may be assumed, based on Liers (1951, as cited in the Handbook). SIR for River otters is conservatively assumed to be 1% of FIR (in dw) to account for foraging on amphibians and crayfish.
Population Densities (PD)	Population densities of 1 to 10 otters/km of river or shoreline are typical (the Handbook).
Fecundity/Clutch Size etc.	Adult females appeared to reproduce yearly in Oregon, but they were reported to breed every other year in Alabama and Georgia. Litters usually consist of 2 to 3 pups, although litters as large as 6 pups occur (the Handbook).
Home Range (HR)	The Handbook indicates a wide ranging home range: 400-1,900 ha in marsh and streams in Michigan [Erickson et al., (1984, as cited in the Handbook)] and 2,900-5,700 ha in Colorado [Mack, (1985, as cited in the Handbook)]. EPA (2003) estimated a HR of 2,950,000-19,113,450,000 m ² (i.e., typically greater than 730 acres).
Seasonality/Migration in and out of Virginia	River otters are non-migratory, but will travel between different foraging locations throughout the course of the year. Melquist and Hornocker (1983, as cited in the Handbook) conservatively estimated the average daily distance traveled by otters (including family groups) to range from 0.4 to 3.1 miles in Idaho. River otters are assumed to be year-round residents in AOC-4.
Dietary Composition	Various fish species form the bulk of the River otters diet; however, they are opportunistic feeders and will prey on a variety of food items depending on availability and ease of capture (the Handbook). Other than fish, River otters may consume crustaceans (especially crayfish), aquatic insects (e.g., stonefly nymphs, aquatic beetles), amphibians, insects, birds (e.g., ducks), mammals (e.g., young beavers), turtles, and also waterfowls. Based on % frequency of occurrence in scats in Idaho, Missouri, Illinois, and Mississippi (Melquist & Hornocker, 1983; Greer, 1955; Anderson & Woolf, 1987; all as cited in the Handbook), River otters diet consisted of 69-100% fish, 1-13% birds, 2-12% invertebrates (of which 7-50% was crayfish in an Illinois River), 3-16% amphibians, and 1-8 % mammals. EPA (2003) estimated the following dietary preference for the river otters in water/wetland setting: 0-5% - other invertebrates, 0-25% - small birds, 0-25% - small mammals, 0-10% - benthic filter feeders, 25-94% - trophic level 3 fish, 25-94% - trophic level 4 fish, and 0-25% - small herpetofauna. Dietary preference for River otters in AOC-4 is assumed to be primarily fish, supplemented by crayfish and amphibians: Fish <130 mm TL and >130 mm TL, each at 45%, 5% amphibians, and 5% crayfish.
Prey Size	Most fish consumed by River otters were < 30 cm (Melquist & Hornocker, 1983; as cited in the Handbook). Sheldon and Toll (1964) reported a fish size range of 2-50 cm in River otters diet (as cited in the Handbook).

Notes:

The Handbook refers to Wildlife Exposure Factors Handbook, Volumes I and II (EPA, 1993).

SD, Standard deviation.

SE, Standard error.

TL, Total length.

ww, Wet weight.

Table D-2g
Receptor Profiles - Short-Tailed Shrew
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Receptor	Short-tailed shrew (<i>Blarina brevicauda</i>)
Body Weight (BW)	Bodyweights for male and female Short-tailed shrews ranged 12.5-22.5 g in the fall and summer in western Pennsylvania [Guilday (1957) as cited in the Handbook]; Mean BW for males were 19.21 ± 0.42 g SD and 16.87 ± 0.21 g SD in the summer and fall, respectively. Mean BW for females were 17.4 ± 0.48 g SD and 15.58 ± 0.23 g SD in the summer and fall, respectively. Schlessinger and Potter (1974) reported a mean of 15.0 ± 0.78 g SD in the field in New Hampshire (as cited in Sample and Suter (1994)). A mean BW for Short-tailed shrew was assumed to be 17.3 g based on the average of the mean BW for shrews in Pennsylvania (Guilday, 1957).
Food Ingestion Rate (FIR)	Equation #32 for insectivorous mammals (Nagy, 2001): $FIR (g \text{ ww/day}) = 1.130 \times BW^{0.622}$, BW is in g. Using this equation and mean BW of 17.3 g results in an estimated FIR of 6.65 g ww/day. Using Equation #31 for FIR in g dw/day, results in a FIR of 2.20 g dw/d. USACHPPM (2004) reported a daily food intake of 0.142 g dw/g BW/day, which is equivalent to a FIR of 2.46 g dw/day, with mean BW of 17.3 g. Based on laboratory studies, a mean FIR for males and females was 0.01 kg dw/day (on larch sawfly diet) and 0.00795 ± 0.00017 kg dw/day (on mealworm diet) [Buckner (1964) and Barrett and Stueck (1976) as cited in Sample and Suter (1994)].
Drinking Water Ingestion Rate (WIR)	Short-tailed shrews obtain water from both food and metabolic oxidation, but it must consume water to compensate for its high evaporative water loss (Chew, 1951). Chew (1951) reported a adult WIR of 0.223 mL/g BW/day in a laboratory (as cited in the Handbook). Estimated based on Calder and Braun (1983). $WIR (L/day) = 0.099 \times BW^{0.9}$, where BW is in kg.
Soil Ingestion Rate (SIR)	USACHPPM (2004) indicated that data concerning soil ingestion by Short-tailed shrews was not located in the literature; a SIR of 2.4% of diet (dw) was assumed based on soil ingestion meadow voles in Beyer et al. (1994).
Population Densities (PD)	Getz (1989) reported that mean population density ranged from 2.5 to 45 shrews per ha for different seasons in alfalfa, tallgrass and bluegrass habitats in Illinois [as cited in USACHPPM (2004)].
Fecundity/Clutch Size etc.	Litter size is 1-8 (average 4.7-5.4) and several litters per year reported in Blair (1940) and French (1984) [as cited in the Handbook] is consistent with George et al. (1986) who reported several litters, averaging four to five pups, each year [as cited in USACHPPM (2004)].
Home Range (HR)	The Handbook indicated that Short-tailed shrews inhabiting bluegrass areas of southern Michigan had summer home ranges of <0.1 to 0.36 ha for females and <0.1 to 1.8 ha for males (Blair, 1940) and breeding individuals living in tamarack bogs of south Manitoba had a mean (+SD) home range of 0.39 ± 0.036 ha (Buckner, 1966). EPA (2003) reported a home range of 300 to 18,000 m ² (i.e., 0.074 to 4.45 acre).
Seasonality/Migration in and out of Virginia	Short-tailed shrews are assumed to be year-round residents in AOC-4.
Dietary Composition	The short-tailed shrew is primarily carnivorous. Stomach contents indicate that insects, earthworms, slugs, and snails can make up most of the shrew's food, while plants, fungi, millipedes, centipedes, arachnids, and small mammals are also consumed (Hamilton, 1940; Whitaker and Ferraro, 1963). Diets of Short-tailed shrews in New York consisted (% by volume): earthworms 31.4%, slugs/snails 27.1%, soil/litter invertebrates 13.2%, fungi 8.4%, misc. animals 8.1%, coleoptera 5.9%, and vegetation 5.4% (Whitaker and Ferraro, 1963). EPA (2003) estimated the dietary preference for the short-tailed shrew to be: 25-50% worms, 10-50% other invertebrates, 0-10% small mammals, 0-10% exposed fruits, and 0-25% exposed vegetables. Based on these information, Short-tailed shrew dietary preference in AOC-4 is assumed be: 60% earthworms, 35% spiders, and 5% terrestrial vegetation.
Prey Size	As indicated above their diet constitutes mostly small invertebrates.

Notes:

The Handbook refers to Wildlife Exposure Factors Handbook, Volumes I and II (EPA, 1993).
SD, Standard deviation.
ww, Wet weight.
dw, Dry weight.

Table D-2h
Receptor Profiles - White-Tailed Deer
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Receptor	White-tailed deer (<i>Odocoileus virginianus</i>)
Body Weight (BW)	Smith (1991) reported mean adult BW of 68 kg and 48 kg for male and female, respectively [as cited in Sample and Suter (1994)]. Ohio Division of Wildlife (2014) reports BW ranges of 130-300 pounds for males and 90-210 pounds for females. Mean BW for White-tailed deer is assumed to be 56.5 kg (based on the average of mean weights for male and female deer in Smith (1991)).
Food Ingestion Rate (FIR)	Equation #30 for herbivorous mammals (Nagy, 2001): $FIR (g \text{ ww/day}) = 2.606 \times BW^{0.628}$, BW is in g. Using this equation and a mean BW of 56500 g, a FIR of 2513 g ww/day is estimated. Mautz et al. (1976) reported a FIR of 1740 g ww/day [as cited in Sample and Suter (1994)].
Drinking Water Ingestion Rate (WIR)	Sample and Suter (1994) estimated a WIR of 3.7 L/day based on Calder and Braun (1983). Estimated based on Calder and Braun (1983). $WIR (L/day) = 0.099 \times BW^{0.9}$, where BW is in kg.
Soil Ingestion Rate (SIR)	USACHPPM (2004) indicates that diets of many herbivores are deficient in sodium and other trace nutrients (Robbins, 1993). Ungulates, such as white-tailed deer have been observed to consume soils with elevated sodium levels, presumably to meet sodium needs (Weeks, 1978). However, a SIR of 2.0% diet (dw) is assumed based on Beyer et al. (1994).
Population Densities (PD)	Torgerson and Porath (1984) reported population densities 0.39-0.78/ha in oak hickory forests in the Mid-West and Barber (1984) reported a population density of 0.06/ha in eastern mixed deciduous forest in Tennessee [Both as cited in Sample and Suter (1984)].
Fecundity/Clutch Size etc.	1 per year in first year and 2 -3 per year after the second year (Ohio Division of Wildlife, 2014).
Home Range (HR)	Marchinton and Hirth (1984) reported a home range of 59-520 ha [as cited in Sample and Suter (1994)], whereas Ohio Division of Wildlife (2014) reports a home range of 0.5 to 2 square miles. EPA (2003) reported a home range of 590,000 to 8,040,000 m ² (i.e., > 146 acres).
Seasonality/Migration in and out of Virginia	White-tailed deer are assumed to be year-round residents in AOC-4.
Dietary Composition	White-tailed deer are exclusively herbivorous and depending on availability, their diet is diverse and variable. Major diet items include: buds and twigs of trees and shrubs, grasses and forbs in the summer, mast and fruits in the fall [(Zim et al., 1951; Smith, 1991) both as cited in Sample and Suter (1994)]. EPA (2003) estimated the following dietary preference for the white-tailed deer in a water body margin/wetland setting: 0-25% aquatic plants, 10-40% exposed fruits, 0-25% exposed vegetables, 50-100% forage, 0-78% grains, 0-78% silage. Based on this information, White-tailed deer dietary preference in AOC-4 is assumed be: 10% aquatic vegetation and 90% terrestrial vegetation.
Prey size	Diet items include buds, twigs, shrubs, grasses, forbs, mast and fruits (see above).

Notes:

ww, Wet weight.

Table D-2i
Receptor Profiles - Big Brown Bat
AOC 4 Ecological Risk Assessment Report
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Receptor	Big brown bat (<i>Eptesicus fuscus</i>)
Body Weight (BW)	USACHPPM (2004) reported a mean adult BW of 17.9 ± 5.7 g SD in Canada from Van Zyll de Jong (1985)a and world wide range of 11 to 33 g in adults. Nagy (2001) reported a mean BW of 20.8 g. Mean BW for adult Big brown bats was assumed to be 20.8 g based on Nagy (2001).
Food Ingestion Rate (FIR)	Equation #8 for bats (Nagy, 2001): $FIR (g \text{ ww/day}) = 1.219 \times BW^{0.652}$, BW is in g. Using this equation and mean BW of 20.8 g results in a FIR of 8.82 g ww/day. Fenton and Glen (1973)b studied captive Big brown bats fed beetles and <i>Tenebrio molitor</i> and found postlactating females ingested 0.24 g/g BW/day. In the wild, young Big brown bats with an average body mass of 9.1 g consumed 1.1 g/h in Massachusetts and an adult specimen weighing 18.9 g consumed 2.7 g/h (Gould, 1955) [All as cited in USACHPPM (2004)]; Nagy (2001) reported a 2.33 g dw/day and 7.07 g ww/day for a Big brown bat with BW of 20.8 g.
Drinking Water Ingestion Rate (WIR)	Captive male and female Big brown bats consumed 0.64 milliliters/week/g BW (0.09 L/kg BW/day) (Coutts et al., 1973, as cited in USACHPPM, 2004). Estimated based on Calder and Braun (1983). $WIR (L/day) = 0.099 \times BW^{0.9}$, where BW is in kg.
Sediment/Soil Ingestion Rate (SIR)	No published data were found on soil ingestion by Big brown bats; however, studies of food habits (Whitaker, 1972; Whitaker et al., 1981; Griffith and Gates, 1985) do not indicate soil in the diet. Additionally, the big brown bat is an aerial insectivore, therefore soil ingestion is assumed to be negligible, which is consistent with USACHPPM (2004).
Population Densities (PD)	Big brown bats form maternal colonies (10 to 300 individuals) and roost with other bat species (Zeiner et al., 1990). Big brown bats hibernate alone or in small clusters averaging 3.7 bats (Phillips, 1966). [All as cited in USACHPPM (2004)].
Fecundity/Clutch Size etc.	1-2 young born based on Phillips [1966, as cited in USACHPPM (2004)].
Home Range (HR)	Zeiner et al. (1990) estimated a home range of 11,100 ha with a decreasing ability to home as distance increases. Zeiner et al. (1990) also reported that Big brown bats are territorial and several days pass before a new bat will replace a bat missing from a territory. In a study by Kurta and Baker (1990), the distance between roost and forage grounds was 1-2 km. [All as cited in USACHPPM (2004)]. Based on Kurta and Baker (1990), the home range is expected to be > 776 acres.
Seasonality/Migration in and out of Virginia	Big brown bats hibernate in the winter, but they are assumed to be year-round residents in AOC-4.
Dietary Composition	Mammals of Texas (2014) indicate that diet of Big brown bat consists entirely of insects, which they capture in flight; Fecal pellets have shown that Big brown bats feed on beetles, bees and their allies, flies, stoneflies, mayflies, true bugs, nerve-wings, scorpion flies, caddisflies, and cockroaches. Coleoptera constitutes the dominant prey item with up to 80 to 100% based on %volume and %frequency [Phillips, 1966, as cited in USACHPPM (2004)]. Based on these information, dietary preference for Big brown bat in AOC-4 is assumed to be 100% emergent adult insects.
Prey Size	As indicated above they mostly feed on emergent insects.

Notes:

The Handbook refers to Wildlife Exposure Factors Handbook, Volumes I and II (EPA, 1993).

SD, Standard deviation.

ww, Wet weight.

dw, Dry weight.

a, as cited in CRC Handbook of Mammalian Body Masses (Silva and Downing, 1995).

b, as cited in USACHPPM (2004).

Appendix E
Exposure Point Concentrations

Exposure Point Concentrations (EPCs)

AOC 4 Ecological Risk Assessment Report

Former DuPont Waynesboro Plant, Waynesboro, Virginia

1.0 Introduction

In the exposure analysis, mercury concentrations in exposure media within AOC 4 are characterized for each receptor group identified in the CSM (see Section 3.5). Mercury concentration data from the site-specific investigations described in the Ecological Study Report (URS, 2012) provide the basis for evaluating ecological exposure in AOC 4. A Retrospective Data Quality Assessment (RDQA, Appendix A) was conducted for the quality and usability of the existing data for use in the ERA. Calculations of exposure estimates are described in this section, including the methods through which different types of exposure are estimated for each receptor group.

In general, the 95th percent upper confidence limit of the mean concentration (95% UCL) or the maximum detected concentration (where 95% UCL could not be calculated) was taken as the exposure point concentration (EPC) for each exposure medium and Assessment Reach to represent a conservative estimate of the average or typical exposure that a receptor may experience while foraging within the Assessment Reach. 95% UCLs were calculated using EPA ProUCL Version 5.0 (EPA, 2013). This application calculates 95% UCLs concentrations based on various data distributions and provides recommendations for selecting an appropriate 95% UCLs value based on the distribution of the test dataset. In general, ProUCL recommendations were used to select the most appropriate 95% UCLs to represent the EPC for a given exposure medium. In cases, where a 95% UCLs could not be calculated or exceeded the maximum detected concentration, the maximum detected concentrations were taken as the EPC.

Exposure point concentrations (EPCs) were calculated for each of the 13 Assessment Study Reaches (within RRM 0 to 24) and Reference Reaches (including RRM -2.7 to -0.8) for two purposes: for direct comparisons to respective toxicity benchmarks selected in Section 4 and for dose rate modeling to estimate wildlife exposures to mercury. Table E-1 shows the EPCs calculated for direct comparisons to the respective toxicity benchmarks and Table E-2 shows the EPCs calculated for use in dose rate models for the representative wildlife receptors. The following general approach was used in calculating the EPCs:

- Unless specified otherwise, the datasets were limited to samples collected from 2000- 2013 and included in the Master Database [See RDQA (Appendix A)];
- All concentrations for biotic media are expressed in wet weight (ww) basis; when only dry weight (dw) based concentrations were available, the dw-to-ww conversions were based on the following:
 - Species-specific mean moisture content [i.e., percent (%) solids] data collected at the site; or
 - Literature-based species-specific % solids data, when site-specific % solids data is not available.

- When paired THg and MeHg data were not available and where necessary, THg-to-MeHg conversions were generally based on % MeHg (i.e., the percent of THg that is MeHg) as follows:
 - Wherever possible, Assessment Reach-wide, species and size (or age) specific mean %MeHg values were used;
 - Where %MeHg was not expected to vary spatially, a site-wide mean %MeHg values were used. Whether the site-wide mean conversion factor is more conservative than the conversion factor based on the nearest representative reach/area was not evaluated because: 1) Assessment Reach-specific data were limited for specific media (in terms of species and size represented in pooled analysis) 2) site-wide %MeHg showed low variability (as indicated by the Site-wide standard deviations), and 3) the Site-wide mean %MeHg values are high (e.g., > 80% in fish tissues), i.e., the corresponding reach-specific mean conversion factors are not likely to deviate significantly (toward a higher conversion factor).
- Sample-specific IHg concentrations (required to calculate EPCs for dose rate modeling) were estimated by the differences between paired THg and MeHg concentrations (measured or estimated); in a few cases where MeHg concentration was higher than THg concentration, IHg concentrations were assumed to be zero.
- Dose rate modeling calculations are performed for 16 Assessment Reaches (see Table 3-1 in the ERA Report). Lack of data prevented calculation of EPCs for one or more Assessment Reaches for several media. In these cases, the EPCs were extrapolated from the remaining Assessment Reaches and are indicated as such.

The following sections describe the EPCs for specific media.

2.0 Abiotic Media

Mercury concentrations in abiotic media (surface water, sediment pore water, sediment, and soil) collected during various investigations provide a relevant measure of the magnitude and spatial distribution of potential mercury exposure in AOC 4. A discussion of mercury concentrations in the abiotic media (with the exception of sediment pore water) is already provided in Section 3.2 of the ERA Report. The following subsections provides further details on the calculation of EPCs for THg and MeHg in surface water (see Section 2.1), sediment pore water (see Section 2.2), sediment (see Section 2.3), and soil (see Section 2.4).

2.1 Surface Water

Surface water THg and MeHg concentration data are available for base flow and episodic storm conditions (see Section 3.2.5 of the ERA Report). Transient elevated concentrations during episodic storm events are likely not relevant for evaluating long-term chronic effects on ecological entities. Nonetheless, EPCs under both base flow and episodic storm conditions are calculated. Furthermore, data are available on both total (unfiltered) and dissolved (filtered using 0.45 um filter) THg and MeHg concentrations.

Surface water toxicity benchmarks (see Section 4.0 of the ERA Report) are expressed in terms of dissolved concentrations, but surface water ingestion by wildlife is likely to expose them to total mercury concentrations in the surface water. Therefore, EPCs are calculated for both total (for dose rate modeling) and dissolved concentrations (for direct comparisons with surface water toxicity benchmarks).

Exposure point concentrations (EPCs) for IHg (required for the dose rate modeling) are based on the differences in the EPCs for THg and MeHg. Surface water EPCs are shown in Table E-3.

2.2 Sediment Pore Water

Sediment pore water THg and MeHg concentration data are available for a limited number of Assessment Reaches for unfiltered pore water and several Assessment Reaches for filtered pore water (see Table E-4). EPCs for filtered pore water THg and MeHg are used for direct comparisons for corresponding effects benchmarks for benthic invertebrates, aquatic vegetation, and amphibians.

2.3 Sediment

Surficial sediment samples (at approximate depth of 0-6" from the sediment surface) were collected in the South River within AOC 4 due to general lack of sediment owing to its high gradient and coarse substrate (see Section 3.2.4 in the ERA Report). The 0-6" depth for surficial sediments is within the bioactive zone relevant for benthic organisms. Bulk and interstitial sediment samples were treated separately. Inorganic mercury (IHg) EPCs were estimated using the difference between THg and MeHg EPCs. Sediment EPCs are shown in Table E-5.

2.4 Soil

While the surficial samples (at a depth of 0-6" from the soil surface) represent the soil depth relevant for terrestrial invertebrates and incidental soil ingestion by wildlife, the sub-surface samples (at a depth of 6-24" from the soil surface) have the potential for future exposures. Therefore, EPCs were calculated for both surficial and sub-surface soils. The soil samples also represent various floodplains (0.3-, 2-, 5-, and 62-year floodplains, see Section 3.2.5 in the ERA Report). To capture the spatial variability within the floodplains, EPCs are calculated for all four floodplains, where possible.

Soil mercury EPCs are required for THg (for direct comparisons with soil toxicity benchmarks) and for MeHg and IHg (for dose rate modeling). Data on only THg concentrations are available. However, MeHg generally constitutes a negligible fraction of the THg in soils; for example, the RRM 11.8 and background soils used in the Floodplain Pilot Test had a mean %MeHg of 0.01% and 1.82%, respectively (URS, 2014a). Therefore EPCs for soil MeHg are conservatively assumed to be 2% of the corresponding EPCs for soil THg and hence the EPCs for soil IHg were assumed to be 98% of the corresponding EPCs for soil THg.

EPCs for soil THg are shown in Table E-6. Soil IHg and MeHg EPCs for Dose Rate Modeling (AOC 4 ERA Report, Appendix F) are estimated as 98% and 2% of the THg EPCs (Table E-6), respectively, for the surficial soil in the 0.3 Year Floodplain.

3.0 Invertebrate Tissue Residues

In addition to the EPCs summarized in the preceding section for surface water, sediment pore water, sediment, and soil, invertebrate exposure is estimated based on measured or estimated concentrations of THg and MeHg in tissues. The following subsections summarize the results of invertebrate tissue analyses for aquatic insects, emergent adult insects, crayfish, earthworms, and spiders.

3.1 Larval Aquatic Invertebrates Tissue Residues

Paired THg and MeHg concentrations in tissues of larval aquatic invertebrates (whole body) are available for the following orders: Basommatophora, Coleoptera, Diptera, Ephemeroptera, Megaloptera, Neotaenioglossa, Odonata, Plecoptera, Trichoptera, and Veneroida. The EPCs were calculated as follows:

- All available THg and MeHg concentrations are reported in ww-basis; thus dw-to-ww conversions are not necessary;
- Both THg and MeHg concentrations are available for each sample; thus THg-to-MeHg conversions are not necessary;
- Sample-specific IHg concentrations are based on the differences between paired THg and MeHg concentrations; and
- For final EPCs for each Assessment Reach with available data, data on all larval tissue samples are pooled.
- One Assessment Reach (RRM 4.4 to 5.2) for which data is not available, EPCs are conservatively estimated (for use in the dose rate modeling) to equal that of RRM 2.7 to 4.4, the adjacent Assessment Reach with the highest EPCs.

Larval aquatic insect tissue mercury concentrations and corresponding EPCs are shown in Table E-7.

3.2 Emergent Aquatic Invertebrate Tissue Residues

Whole body tissue concentrations of THg and MeHg in emergent invertebrates were available for the following orders: Diptera, Ephemeroptera, and Trichoptera. The EPCs were calculated as follows:

- All available THg and MeHg concentrations are reported in ww-basis; thus dw-to-ww conversions are not necessary;
- Both THg and MeHg concentrations are available for 82% of the samples. Only the paired THg and MeHg data are used; thus no THg-to-MeHg conversions are necessary;
- Sample-specific IHg concentrations are based on the differences between paired THg and MeHg concentrations; and
- For final EPCs for each Assessment Reach with available data, data on all emergent aquatic invertebrates were pooled.

- Seven Assessment Reaches within RRM 0.0 to 24.0, lacked empirical data. For these Assessment Reaches, EPCs are conservatively estimated (for use in the dose rate modeling) to equal the highest EPCs in adjacent Assessment Reaches.
- For the Upstream Reference Reach and Buffer Reach, for which measurements were not available, EPCs are calculated based on the ratio of EPCs for RRM -2.7 to -0.7 and RRM 1.7 to 2.7 for Larval Aquatic Invertebrates.

Emergent aquatic invertebrate tissue mercury concentrations and corresponding EPCs are shown in Table E-8.

3.3 Crayfish Tissue Residues

Whole body tissue mercury EPCs for crayfish (*Orconectes sp.* and *Cambarus sp.*) are required for THg and MeHg (for direct comparisons with CBRs) and MeHg and IHg (for dose rate modeling). The EPCs were calculated as follows:

- Whole body THg and MeHg concentrations in ww-basis are available for crayfish; thus dw-to-ww conversions are not necessary;
- Both THg and MeHg concentrations are available for 93% of the samples; only the paired THg and MeHg data are used; thus no THg-to-MeHg conversions are necessary; and
- Sample-specific IHg concentrations are based on the differences between paired THg and MeHg concentrations.

Mercury concentrations in tissues of crayfish (whole body) and corresponding EPCs are shown in Table E-9.

3.4 Earthworm Tissue Residues

Tissue mercury EPCs for whole body earthworms (available for Class Oligochaeta) are required for MeHg and IHg for dose rate modeling for terrestrial invertebrates. The EPCs were calculated as follows.

- Sample-specific % solids values are used for dw-to-ww conversions;
- 76% of the samples have paired THg and MeHg data, which are used for the EPCs calculations without THg-to-MeHg conversions; and
- Sample-specific IHg concentrations were based on the differences between paired THg and MeHg concentrations.
- Three Assessment Reaches within RRM 0.0 to 24.0, lacked empirical data. For these Assessment Reaches, EPCs are conservatively estimated (for use in the dose rate modeling) to equal the highest EPCs in adjacent Assessment Reaches.

Mercury concentrations in tissues of earthworms (whole body) and corresponding EPCs are shown in Table E-10.

3.5 Spider Tissue Residues

Tissue mercury EPCs for spiders (whole body) are required for MeHg and IHg for dose rate modeling as the spiders constitute an important dietary item for invertivorous birds. Wolf spider (Family Lycosidae) whole body tissue samples are available with all paired THg and MeHg concentrations and % solids values. EPCs are thus calculated as follows:

- Sample-specific % solids values were used for dw-to-ww conversions;
- THg-to-MeHg conversions are not necessary;
- Sample-specific IHg concentrations are based on the differences between paired THg and MeHg concentrations;
- EPCs are calculated for only four Assessment Reaches based on data availability; for the rest of the Assessment Reaches EPCs are conservatively estimated (for use in the dose rate modeling) to equal the highest EPCs in the adjacent Assessment Reaches, for which EPCs are calculated based on empirical data.
- For the Upstream Reference Reach and Buffer Reach, for which measurements were not available, EPCs are assumed to be 10 times lower than the lowest EPC calculated for the Assessment Reaches.

Mercury concentrations in wolf spiders tissue (whole body) and corresponding EPCs are show in Table E-11.

4.0 Fish Tissue Residues

Fish tissue EPCs are required for whole body THg and MeHg (for direct comparisons with CBRs) and whole body MeHg and IHg (for dose rate modeling). Fish tissue THg concentrations are available either on whole body, fillet, or plug samples. Tissue MeHg concentrations are also available for a subset of these samples. While the EPCs for whole body THg and MeHg are calculated only for smallmouth bass (*Micropterus dolomieu*) and largemouth bass (*Micropterus salmoides*) as CBRs were specifically based on bass species, EPCs for whole body MeHg and IHg were calculated for all fish species pooled together for dose rate modeling. These fish species included the following orders: Cypriniformes, Perciformes, Salmoniformes, Scorpaeniformes, and Siluriformes. In addition to samples collected from 2000 to 2013 and located in the Master Database, fish tissue data also included samples collected from 2000 to 2013 located in the VDEQ fish filet database, as well as samples collected in 2014 as part of the Long-Term Monitoring Program (URS, 2014b). Approaches for calculating EPCs for comparisons with CBRs and for dose rate modeling are shown below.

4.1 Dose Rate Modeling

Fish EPCs were calculated for two different size classes based on their total length (TL): TL < 130 millimeters (mm) and TL between 130 and 350 mm. These size classes were based on typical fish size preference of the representative piscivorous wildlife receptors. The EPCs were calculated as follows:

- No dw-to-ww conversions are necessary as all concentrations are available in ww-basis;
- Where necessary, plug data were converted to filet using linear regressions developed from the paired plug-filet data collected as part of the 2014 Long-Term Monitoring Program (largemouth bass, THg, $y = 0.637x + 263.72$, $R^2 = 0.93$; largemouth bass, MeHg, $y = 0.637x + 263.72$, $R^2 = 0.93$; smallmouth bass, THg, $y = 0.6993x + 89.986$, $R^2 = 0.89$; smallmouth bass, MeHg, $y = 0.7168x + 85.663$, $R^2 = 0.90$) for a subset of samples with only plug data;
- Where necessary, filet data were then converted to whole-body using a conversion factor of 0.70 (Harris and Bodaly, 1998) for a subset of samples with only filet data;
- Only 21 % of the samples (515/2430) consisted of paired THg and MeHg data; hence a site-wide mean % MeHg of 8% ($\pm 24\%$ SD) for all fish <130 mm, and 92% ($\pm 12\%$ SD) for all fish 130-350 mm is used for THg-to-MeHg conversions for a subset of samples with only THg data;
- Sample-specific IHg concentrations are based on the differences between paired THg and MeHg concentrations (measured or calculated); and
- For final EPCs for each Assessment Reach, data on all taxa within a size class were pooled.
- Several Assessment Reaches lacked data for EPCs calculations. EPCs for these Assessment Reaches were estimated as follows:
 - For Fish TL < 130 mm, EPCs for one Assessment Reach (RRM 4.4 to 5.2) are estimated based on EPCs for the Assessment Reach RRM 5.2 to 7.9, the adjacent Assessment Reach with the highest EPCs;
 - For Fish 130 mm < TL < 350 mm, EPCs for two Assessment Reaches (RRM 7.9 to 9.2 and RRM 12.5 to 13.5) were conservatively assumed to equal the highest EPCs in the closest adjacent Assessment Reaches, for which EPCs are calculated based on empirical data;

Mercury concentrations in fish and the corresponding EPCs are shown in Table E-12a.

4.2 Comparisons to Critical Body Residues

Fish EPCs (whole body) for only the focal species, smallmouth bass and largemouth bass, are calculated for comparisons to the critical body residues (CBRs). The EPCs are calculated in the same way as for the fish EPCs required for the dose rate modeling (see above), but the size classes represented the bass species with TL < 130 mm to represent juvenile (or YOY) bass, and bass species with TL > 130 mm to represent adult bass. The EPCs were calculated as follows:

- No dw-to-ww conversions are necessary as all concentrations are available in ww-basis;
- Where necessary, plug data were converted to filet using linear regressions developed from the paired plug-filet data collected as part of the 2014 Long-Term

Monitoring Program (largemouth bass, THg, $y = 0.637x + 263.72$, $R^2 = 0.93$; largemouth bass, MeHg, $y = 0.637x + 263.72$, $R^2 = 0.93$; smallmouth bass, THg, $y = 0.6993x + 89.986$, $R^2 = 0.89$; smallmouth bass, MeHg, $y = 0.7168x + 85.663$, $R^2 = 0.90$) for a subset of samples with only plug data;

- Only 12 samples are available for bass species with TL < 130 mm. Of these only five had paired THg and MeHg data; Based on these five samples, mean % MeHg was 90% ($\pm 11\%$ SD); hence a THg-to-MeHg conversions factor of 90% is used for the remainder of the samples with only THg data;
- Altogether, 1394 samples are available for bass species with > 130 mm. Only 216 samples had paired THg and MeHg data, with mean % MeHg of 96% ($\pm 5\%$ SD) among taxa and Assessment Reaches; hence a TH-to-MeHg conversion factor of 96% is used to calculated tissue MeHg concentrations for the remaining samples with only THg data; and
- EPCs are calculated on for the Assessment Reaches with available data and data on all taxa within a fish size class are pooled.

Mercury concentrations in bass species and the corresponding EPCs based on available data are shown in Table E-12b.

5.0 Amphibian Tissue Residues

Amphibian tissue mercury concentrations (whole body) are required for THg and MeHg (for direct comparisons with CBRs) and MeHg and IHg (for dose rate modeling). Data on whole body THg and MeHg concentrations was available for three species: American toad (*Anaxyrus americanus*), northern two-lined salamander (*Eurycea bislineata*), and red back salamander (*Plethodon cinereus*). All concentrations were reported on a dw-basis, without the corresponding sample-specific % solids data. Amphibian tissue residue EPCs are shown in Table E-13a and b, and the EPCs calculations are described below.

5.1 Dose Rate Modeling

For dose rate modeling, amphibians represent a significant portion of the diet for several focal wildlife species. Therefore, available data on all three species of amphibians are used to calculate EPCs as follows:

- Site-specific and species-specific mean % solids data were used for dw-to-ww conversions: 22.2%, 26.1%, and 24.1% for American toad, northern two-lined salamander, and red back salamander, respectively, from Hopkins et al. (2008);
- Paired MeHg data is available for only 22.1% of the samples; therefore, a site-wide mean % MeHg of 53% ($\pm 12\%$ SD, based on available data on American toad) was used for THg-to-MeHg conversions for all samples without paired MeHg data;
- Sample-specific IHg concentrations were based on the differences between paired THg and MeHg concentrations (measured or calculated); and

- Because uniform data (quantity and species type) are not available for each Assessment Reach, EPCs are first calculated for each species. For the Assessment Reaches lacking data, EPCs are estimated by taking the highest of the EPCs in the nearest upstream or downstream Assessment Reaches (see Table E-13a).
- Final amphibian EPCs are then based on the average of the EPCs for the three species of amphibians.

5.2 Comparisons to CBRs

For comparisons with CBRs, EPCs on whole THg and MeHg are calculated for the focal species, American toad. EPCs are based on available data whole body THg and MeHg concentrations (dw-basis). Conversions for dw-to-ww are based on the mean % solids of 22.2% for American bullfrogs from Hopkins et al. (2008). No further extrapolations are necessary. However, EPCs were calculated for only three Assessment Study Reaches within RRM 0.0 to 24.0, and two other Reference Reaches. Amphibian mercury tissue EPCs for comparisons with CBRs are shown in Table E-13b.

6.0 Avian Tissue Residues

Bird tissue mercury EPCs are required for muscle MeHg and IHg (for dose rate modeling) and blood THg and MeHg (for direct comparisons with CBRs). These EPCs are shown in Table E-14a and b. EPCs are calculated as follows for use in the dose rate modeling or in comparisons to CBRs.

6.1 Dose Rate Modeling

Bird EPCs on muscle MeHg and IHg were calculated for small birds that the representative carnivorous bird, Eastern screech owl, consumes. Small birds were defined as any taxa with adult average body weights less than 40 g based on the Eastern screech owl prey size preference [Gehlbach (1995) as cited in Wang and Newman (2012)]. Only blood THg data was available on birds, with blood MeHg data for a subset of samples (1.9% of 3,487 samples). Hence EPCs for small birds were calculated as follows:

- For both THg and MeHg data, a blood-to-muscle conversion factor of 2 was used based on a ratio published by Evers et al. [2005, as cited in Wang and Newman (2012)]. Mercury concentrations in bird tissue eaten by owls are assumed be similar to those measured in muscle tissue.
- No dw-to-ww conversions were necessary as all original blood THg data were in ww-basis and the above blood-to-muscle multiplier was applied to ww concentrations;
- For the subset of samples with only THg data, site-wide mean % MeHg of 92% ($\pm 9\%$ SD) is applied to generate supplemental muscle MeHg data based on paired MeHg and THg data pooled for all bird species with mean adult body weights < 40 g);

- Sample-specific IHg concentrations are calculated based on the differences between the resulting paired THg and MeHg concentrations; and
- For the final EPCs for each Assessment Reach, data are pooled for multiple taxa with average adult body weights less than 40 g.
- One Assessment Reach, RRM 0.0 to 0.8 lacked data for EPCs calculations; EPCs for this Assessment Reach is estimated to equal that of adjacent Assessment Reach (RRM 0.8 to 1.7) with the highest EPCs.

Estimated mercury concentrations in muscles of small birds and the corresponding EPCs are shown in Table E-14a.

6.2 Comparisons to CBRs

For comparisons to available CBRs for birds (blood THg based on piscivorous birds and blood MeHg for passerines), blood mercury EPCs are calculated for the focal bird species as follows:

- No dw-to-ww conversions are required as all original data was in ww-basis;
- Site-wide mean % MeHg of 88% ($\pm 11\%$, based on pooled data for all focal bird species) for THg-to-MeHg conversions for a subset of samples with only THg data; and
- For the Assessment Reaches with available data on THg concentration in blood, final EPCs were calculated for each focal bird species (belted kingfisher, mallard, eastern screech owl, tree swallow, and American robin).

Mercury concentrations in bloods of small birds and the corresponding EPCs are shown in Table E-14b.

7.0 Mammalian Tissue Residues

Exposure point concentrations (EPCs) for mammals are required on muscle MeHg and IHg (for dose rate modeling) and on blood and fur THg (for direct comparisons with CBRs). These EPCs are shown in Table E-15a, b and c. EPCs are calculated as follows for use in the dose rate modeling or in comparisons to CBRs.

7.1 Dose Rate Modeling

EPCs for MeHg and IHg in muscles are calculated for small mammals that are likely to be part of the diet for representative carnivorous bird, Eastern screech owl. Muscle THg and MeHg data are available on deer mouse and pine vole, which are used as follows to calculate EPCs:

- All THg concentrations are in ww-basis; therefore, no dw-to-ww conversions are required;
- MeHg data are available and hence no THg-to-MeHg conversions are necessary;
- Sample-specific IHg concentrations were based on the differences between paired THg and MeHg concentrations;

- For the Assessment Reaches with available data, final EPCs were calculated based on pooled dataset for both mammalian species; and
- EPCs are calculated for a limited number of Assessment Reaches based on data availability; for the Assessment Reaches with data gaps, the EPCs are estimated by taking the highest of the EPCs in the nearest upstream or downstream Assessment Reaches.

Mercury concentrations in bloods of small mammals and the corresponding EPCs are shown in Table E-15a.

7.2 Comparisons to CBRs

Mammalian CBRs are available for only blood and fur THg. Therefore, all available mammalian blood and fur THg data are used to calculate EPCs for the individual focal species, without any conversions. EPCs calculated based on available data are shown in Table E-15b and c for two bat species (data for little brown bat is included because of its similarity to big brown bat, which is the focal species) and the short-tailed shrew.

8.0 Plant Tissue Residues

Aquatic and terrestrial plants constitute dietary items for two focal wildlife receptors. Therefore, EPCs are required for MeHg and IHg concentrations in plant tissues. Calculations of these EPCs for aquatic and terrestrial plants are described in the following sections.

8.1 Aquatic Plants

Data on THg and MeHg concentrations in submerged aquatic vegetation (SAV), algae, and periphyton are available, based on which the EPCs for aquatic plants are calculated as follows:

- Site-wide mean % solids of 13% (for pooled aquatic plants) is used for dw-to-ww conversion for the subset of samples with dw-based concentrations data;
- Site-wide mean % MeHg of 9% for SAV and 13% for algae/periphyton are used for THg-to-MeHg concentrations for a subset of samples without paired MeHg data;
- Sample-specific IHg concentrations are based on the differences between paired THg and MeHg concentrations (measured or estimated); and
- For the final EPCs, data on all aquatic plants were pooled (thus assuming that all aquatic plant species are equally abundant and equally preferred by the receptors).

Table E-16 provides the EPCs for MeHg and IHg in aquatic plants.

8.2 Terrestrial Plants

Data on THg and MeHg concentrations in various garden crops, honeysuckle, grass, and violets are available, based on which the EPCs for terrestrial plants are calculated as follows:

- Site-wide mean % solids of 13% (for pooled terrestrial plants) is used for dw-to-ww conversion for the subset of samples with only dw-based concentrations data;
- Site-wide mean % MeHg of 3% (for pooled terrestrial plants) is used for THg-to-MeHg conversion for the subset of samples without paired MeHg data;
- Sample-specific IHg concentrations are based on the differences between paired THg and MeHg concentrations (measured or estimated); and
- For the final EPCs, data on all terrestrial plants were pooled (thus assuming that all terrestrial plant species equally represent the abundance of and preference for the vegetation consumed by the receptors).

Table E-17 provides the EPCs for MeHg and IHg in terrestrial plants.

9.0 References

- EPA, 2013b. ProUCL Version 5.0.00. Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations. September 2013. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC 20460. EPA/600/R-07/041. Available at: <http://www.epa.gov/osp/hstl/tsc/softwaredocs.htm>
- Evers, D.C., N.M. Burgess, L. Champoux, B. Hoskins, A. Major, W.M. Goodale, R.J. Taylor, R. Poppenga, and T. Daigle. 2005. Patterns and interpretation of mercury exposure in avian communities in northeastern North America. *Ecotoxicology* 14, 193-221.
- Gehlbach FR. 1995. Eastern Screech-Owl (*Otus asio*). In: Pool A, Gill F, editors. The Birds of North America. No 165. Philadelphia (PA): The Academy of Natural Sciences and Washington (DC): The American Ornithologists' Union. 24 p.
- Harris, R. C. and R. A. Bodaly. 1998. Temperature, growth and dietary effects on fish mercury dynamics in two Ontario lakes. *Biogeochemistry* 40:175-187.
- Hopkins, W.A., J.M. Unrine, C.M. Bergeron, and C.M. Bodinof. 2008. Mercury accumulation and maternal transfer in amphibians along the South River, VA. 2007-2008 Annual Report to E.I. DuPont de NeMours.
- Hopkins, W.A., J.D. Wilson, B.C. Hopkins, and M.J. Hepner. 2012. Mercury bioaccumulation, maternal transfer, and metapopulation dynamics in herpetofauna from the South River, VA. Annual Report to E.I. DuPont de NeMours.
- 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.
- URS, 2014a. Floodplain Laboratory Pilot Final Report for AOC 4, Former DuPont Waynesboro Plant, Waynesboro, Virginia. DRAFT. May 2014.
- URS, 2014b. Final AOC 4 Long-Term Monitoring Plan South River and a Segment of the South Fork of the Shenandoah River, Virginia. August 2014.

Wang, J., Newman, M.C. 2012. Projected Hg Dietary Exposure of 3 Bird Species Nesting on a Contaminated Floodplain (South River, Virginia, USA). Integrated Environmental Assessment and Management, 9(2): 285–293.

Tables

Table E-1
Environmental Media Requiring Mercury EPCs for Dose Rate Models (DRMs)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Media	Basis/Tissue Types	Mercury Species	
Abiotic Media			
Sediment ^a	dw	THg	MeHg
Soil ^b	dw	THg	MeHg
Surface Water	total and filtered	THg	MeHg
Pore Water	total and filtered	THg	MeHg
Biotic Media			
Aquatic Invertebrates - Larval (Pooled) ^c	ww - whole body	THg	MeHg
Aquatic Invertebrates - Emergent (Pooled) ^d	ww - whole body	THg	MeHg
Crayfish (<i>Orconectes</i> sp. and <i>Cambarus</i> sp.)	ww - whole body	THg	MeHg
Bass (TL < 130 mm) ^e	ww - whole body	THg	MeHg
Bass (TL > 130 mm) ^e	ww - whole body	THg	MeHg
Amphibians (Focal Species) ^f	ww - whole body	THg	MeHg
Birds (Focal Species) ^g	ww - blood	THg	MeHg
Mammals (Focal Species) ^h	ww - blood and/or fur	THg	--

Notes:

EPCs, Exposure point concentrations; dw, Dry weight; ww, Wet weight; THg, Total mercury; MeHg, Methylmercury; total, Total concentrations; filtered, Dissolved (< 0.45 µm) concentrations; TL, Total length; mm, Millimeter.

a, Includes surficial sediment (0-12").

b, Includes surficial soil (0-6") and subsurface soil (6"-24").

c, Includes the following orders: *Basommatophora*, *Coleoptera*, *Diptera*, *Ephemeroptera*, *Megaloptera*, *Neotaenioglossa*, *Odonata*, *Plecoptera*, *Trichoptera*, and *Veneroida*.

d, Includes the following orders: *Diptera*, *Ephemeroptera*, and *Trichoptera*.

e, Includes pooled data for all bass species [smallmouth bass (*Micropterus dolomieu*) and largemouth bass (*Micropterus salmoides*)] in two different size categories TL < 130 mm [representing Young-of-the-Year (YOY)] and TL > 130 mm (representing adult fish).

f, Includes data on three amphibian species [American toad (*Anaxyrus americanus*), northern two-lined salamander (*Eurycea bislineata*), and red back salamander (*Plethodon cinereus*)].

g, For focal species based on data availability; includes belted kingfisher, tree swallow, and American robin.

h, For focal species based on data availability; includes big brown bat.

Table E-2
Environmental Media Requiring Mercury EPCs for Dose Rate Models (DRMs)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Media	Basis/Tissue Types	Mercury Species	
Abiotic Media			
Sediment ^a	dw	MeHg	IHg
Soil ^a	dw	MeHg	IHg
Surface Water	total	MeHg	IHg
Biotic Media			
Aquatic Invertebrates - Larval (Pooled) ^b	ww - whole body	MeHg	IHg
Aquatic Invertebrates - Emergent (Pooled) ^c	ww - whole body	MeHg	IHg
Crayfish (<i>Orconectes</i> sp. and <i>Cambarus</i> sp.)	ww - whole body	MeHg	IHg
Fish (TL < 130 mm) ^d	ww - whole body	MeHg	IHg
Fish (130 mm < TL < 350 mm) ^d	ww - whole body	MeHg	IHg
Amphibians ^e	ww - whole body	MeHg	IHg
Earthworms ^f	ww - whole body	MeHg	IHg
Spiders ^g	ww - whole body	MeHg	IHg
Terrestrial Plants ^h	ww	MeHg	IHg
Aquatic Plants ⁱ	ww	MeHg	IHg
Small Birds ^j	ww - muscle	MeHg	IHg
Small Mammals ^j	ww - muscle	MeHg	IHg

Notes:

EPCs - Exposure point concentrations; dw - Dry weight; ww - Wet weight; MeHg - Methylmercury; IHg - Inorganic mercury; total - Total concentrations; TL - Total length; mm - Millimeters.

a, Includes only surficial samples: sediment (0-12") and soil (0-6").

b, Includes the following orders: *Basommatophora*, *Coleoptera*, *Diptera*, *Ephemeroptera*, *Megaloptera*, *Neotaenioglossa*, *Odonata*, *Plecoptera*, *Trichoptera*, and *Veneroida*.

c, Includes the following orders: *Diptera*, *Ephemeroptera*, and *Trichoptera*.

d, Data pooled for all fish species sampled.

e, Includes data on three amphibian species [American toad (*Anaxyrus americanus*), northern two-lined salamander (*Eurycea bislineata*), and red back salamander (*Plethodon cinereus*)].

f, Includes class *Oligochaeta*.

g, Includes family *Lycosidae*.

h, Includes various garden crops, honeysuckle, grass, and violets.

i, Includes data for the following plants: submerged aquatic vegetation, periphyton and algae.

j, Represents small birds (mean adult body weight less than 40 g) and small mammals (deer mouse and pine vole) that are likely consumed by eastern screech owl.

Table E-3a
Surface Water Mercury Exposure Point Concentrations (EPCs) - Baseline Conditions
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	THg (ng/L)								MeHg (ng/L)								
	Sample Size (n)	Detects (n)	Min	Max	95% UCL	95% UCL Method	UCL Notes*	EPC	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC
Unfiltered Surface Water																	
RRM -2.7 to -0.7	279	204	0.35	40.9	2.093	95% KM (BCA) UCL	--	2.093	114	88	0.017	0.083	0.039	0.0368	95% KM (BCA) UCL	--	0.0368
RRM -0.7 to 0.0	33	29	0.95	99.4	27.61	95% GROS Adjusted Gamma UCL	3	27.61	5	5	0.03	0.056	0.040	0.0511	95% Student's-t UCL	1	0.0511
RRM 0.0 to 0.8	277	276	0.65	311	24.33	95% KM (Chebyshev) UCL	--	24.33	119	105	0.021	1.528	0.115	0.13	95% KM (BCA) UCL	--	0.13
RRM 0.8 to 1.7	62	61	1.64	148.5	40.52	95% KM (Chebyshev) UCL	3	40.52	24	24	0.019	0.734	0.314	0.404	95% Student's-t UCL	--	0.404
RRM 1.7 to 2.7	251	250	1.94	449	53.74	95% KM (BCA) UCL	--	53.74	139	138	0.024	4.16	0.393	0.58	95% KM (Chebyshev) UCL	3	0.58
RRM 2.7 to 4.4	84	84	3.84	179.1	72.05	95% Approximate Gamma UCL	--	72.05	84	84	0.064	3.416	0.705	1.059	95% Chebyshev (Mean, SD) UCL	--	1.059
RRM 4.4 to 5.2	126	126	0.346	295	86.52	95% Chebyshev (Mean, SD) UCL	--	86.52	52	52	0.043	7.51	0.958	1.573	95% Chebyshev (Mean, SD) UCL	--	1.573
RRM 5.2 to 7.9	162	162	3.09	550.26	115.9	95% Chebyshev (Mean, SD) UCL	--	115.9	159	158	0.065	3.994	0.898	1.202	95% KM (Chebyshev) UCL	--	1.202
RRM 7.9 to 9.2	48	48	27.22	2727	388.1	95% Chebyshev (Mean, SD) UCL	--	388.1	44	44	0.172	5.305	1.584	2.058	95% Adjusted Gamma UCL	--	2.058
RRM 9.2 to 11.3	72	72	5.48	330	121	95% Chebyshev (Mean, SD) UCL	--	121	69	69	0.14	3.1	0.953	1.119	95% Approximate Gamma UCL	--	1.119
RRM 11.3 to 12.5	114	114	4.2	580	98.79	95% H-UCL	2	98.79	57	57	0.225	4.987	1.651	2.374	95% Chebyshev (Mean, SD) UCL	--	2.374
RRM 12.5 to 13.5	42	42	13.9	334.2	145.7	95% Chebyshev (Mean, SD) UCL	--	145.7	42	42	0.277	6.415	1.989	3.255	95% Chebyshev (Mean, SD) UCL	--	3.255
RRM 13.5 to 16.7	185	185	5.97	430	89.56	95% H-UCL	2	89.56	111	111	0.074	5.651	1.256	1.569	95% H-UCL	2	1.569
RRM 16.7 to 20.9	75	75	16.3	225	80.64	95% Approximate Gamma UCL	--	80.64	75	75	0.153	5.98	1.453	2.152	95% Chebyshev (Mean, SD) UCL	--	2.152
RRM 20.9 to 24.0	335	328	0.35	363	52.12	95% KM (Chebyshev) UCL	--	52.12	115	115	0.121	5.679	1.213	1.728	95% Chebyshev (Mean, SD) UCL	--	1.728
SFSR	103	103	1.5	156	18.39	95% H-UCL	--	18.39	41	41	0.059	1.048	0.378	0.475	95% Adjusted Gamma UCL	--	0.475
Filtered Surface Water																	
RRM -2.7 to -0.7	380	242	0.15	12.85	1.878	95% KM (Chebyshev) UCL	--	1.878	172	120	0.011	0.755	0.135	0.156	95% KM (Chebyshev) UCL	--	0.156
RRM -0.7 to 0.0	30	23	0.5	32.17	8.671	95% KM (t) UCL	3	8.671	5	2	0.024	0.032	0.028	0.0302	95% KM (t) UCL	1	0.0302
RRM 0.0 to 0.8	357	293	0.44	66.1	3.169	95% KM (BCA) UCL	--	3.169	169	131	0.017	0.5991	0.092	0.0875	95% KM (BCA) UCL	--	0.0875
RRM 0.8 to 1.7	86	62	0.95	87.7	8.435	95% KM (BCA) UCL	--	8.435	31	25	0.008	0.481	0.139	0.165	95% GROS Adjusted Gamma UCL	3	0.165
RRM 1.7 to 2.7	500	471	0.25	296	8.091	95% KM (BCA) UCL	--	8.091	254	249	0.018	62.359	0.922	2.043	95% KM (Chebyshev) UCL	--	2.043
RRM 2.7 to 4.4	157	157	1.23	126	9.876	95% Chebyshev (Mean, SD) UCL	--	9.876	157	157	0.022	2.3	0.456	0.603	95% Chebyshev (Mean, SD) UCL	--	0.603
RRM 4.4 to 5.2	109	91	1	27.1	3.898	95% KM (BCA) UCL	--	3.898	9	9	0.043	0.438	0.171	0.369	95% Adjusted Gamma UCL	1	0.369
RRM 5.2 to 7.9	197	197	1.56	43.4	9.093	95% Chebyshev (Mean, SD) UCL	--	9.093	193	192	0.042	5.94	0.566	0.772	95% KM (Chebyshev) UCL	--	0.772
RRM 7.9 to 9.2	83	83	2.59	26.96	12.13	95% Chebyshev (Mean, SD) UCL	--	12.13	82	81	0.111	2.768	0.938	1.044	95% KM (BCA) UCL	--	1.044
RRM 9.2 to 11.3	117	115	2.42	129	15.83	95% KM (BCA) UCL	--	15.83	109	109	0.032	48.2	2.385	5.451	95% Chebyshev (Mean, SD) UCL	--	5.451
RRM 11.3 to 12.5	151	151	1.5	61.4	13.09	95% Chebyshev (Mean, SD) UCL	--	13.09	86	86	0.123	3.053	1.190	1.32	95% Student's-t UCL	--	1.32
RRM 12.5 to 13.5	56	56	3.72	20.84	14.51	95% Chebyshev (Mean, SD) UCL	--	14.51	56	56	0.145	2.898	1.367	1.928	95% Chebyshev (Mean, SD) UCL	--	1.928
RRM 13.5 to 16.7	226	204	1.5	67.5	7.858	95% KM (BCA) UCL	--	7.858	113	113	0.041	2.605	0.835	1.131	95% Chebyshev (Mean, SD) UCL	--	1.131
RRM 16.7 to 20.9	82	81	3.36	32.7	10.53	95% Approximate Gamma KM-UCL	3	10.53	82	82	0.096	3.056	0.947	1.334	95% Chebyshev (Mean, SD) UCL	--	1.334
RRM 20.9 to 24.0	431	364	0.5	87	6.266	95% KM (BCA) UCL	--	6.266	162	162	0.082	5.308	0.902	1.005	95% Approximate Gamma UCL	--	1.005
SFSR	112	96	0.5	5.64	2.172	95% KM (BCA) UCL	--	2.172	41	41	0.042	0.738	0.249	0.313	95% Adjusted Gamma UCL	--	0.313

Notes:
RRM, Relative river mile.
ESV, Ecological screening value.
SFSR, South Fork Shenandoah River.
EPC, Exposure point concentration.
NC, Not calculated due to insufficient sample size.
--, Not applicable.

*UCL Note:
1, Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
2, H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide. It is therefore recommended to avoid the use of H-statistic based 95% UCLs.
3, Additional UCLs were recommended.

Table E-3b
Surface Water Mercury Exposure Point Concentrations (EPCs) - Storm Conditions
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	THg(ng/L)									MeHg (ng/L)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC
Unfiltered Surface Water																		
RRM -2.7 to -0.7	38	37	0.46	27.2	5.46	9.63	95% KM (Chebyshev) UCL	4	9.63	34	32	0.020	0.644	0.113	0.204	95% KM (Chebyshev) UCL	--	0.204
RRM -0.7 to 0.0	2	2	3.73	45.9	24.8	NC	--	1	45.9	1	1	0.485	0.485	0.485	NC	--	1	0.485
RRM 0.0 to 0.8	40	40	2.29	226	32.7	51.9	95% H-UCL	2	51.9	36	36	0.020	0.804	0.200	0.310	95% H-UCL	2	0.310
RRM 0.8 to 1.7	1	1	45.4	45.4	45.4	NC	--	1	45.4	0	0	NC	NC	NC	NC	--	--	NC
RRM 1.7 to 2.7	36	36	9.95	1501	162	229	95% Adjusted Gamma UCL	--	229	33	33	0.040	4.27	0.560	0.789	95% Adjusted Gamma UCL	--	0.789
RRM 2.7 to 4.4	0	0	NC	NC	NC	NC	--	--	NC	0	0	NC	NC	NC	NC	--	--	NC
RRM 4.4 to 5.2	4	4	31.2	413	131	352	95% Student's-t UCL	3	352	1	1	0.605	0.605	0.605	NC	--	1	0.605
RRM 5.2 to 7.9	33	33	23.8	2775	429	612	95% Adjusted Gamma UCL	--	612	32	32	0.105	9.62	1.395	1.99	95% Adjusted Gamma UCL	--	1.990
RRM 7.9 to 9.2	0		NC	NC	NC	NC	--	--	NC	0	0	NC	NC	NC	NC	--	--	NC
RRM 9.2 to 11.3	36	36	57.2	4519	687	1069	95% H-UCL	2	1069	33	33	0.208	20.8	3.319	4.84	95% Adjusted Gamma UCL	--	4.84
RRM 11.3 to 12.5	1	1	384	384	384	NC	--	1	384	0	0	NC	NC	NC	NC	--	--	NC
RRM 12.5 to 13.5	0	0	NC	NC	NC	NC	--	--	NC	0	0	NC	NC	NC	NC	--	--	NC
RRM 13.5 to 16.7	53	53	50.0	4344	731	962	95% Approximate Gamma UCL	--	962	27	27	0.271	17.03	3.21	6.21	95% H-UCL	2	6.21
RRM 16.7 to 20.9	21	21	46.1	4489	598	1608	95% Chebyshev (Mean, SD) UCL	--	1608	21	21	0.267	17.64	2.46	4.07	95% Adjusted Gamma UCL	--	4.07
RRM 20.9 to 24.0	29	29	36.8	4656	800	1314	95% Adjusted Gamma UCL	--	1314	28	28	0.248	28.2	4.30	9.04	95% H-UCL	2	9.04
SFSR	1	1	21.8	21.8	21.8			1	21.8	0	0	NC	NC	NC	NC	--	--	NC
Filtered Surface Water																		
RRM -2.7 to -0.7	35	34	0.24	2.73	1.16	1.102	95% Approximate Gamma KM-UCL	4	1.102	33	29	0.020	0.061	0.038	0.039	95% KM (t) UCL	4	0.039
RRM -0.7 to 0.0	1	1	6.73	6.73	6.73	NC	--	1	6.73	1	1	0.104	0.104	0.104	NC	--	1	0.104
RRM 0.0 to 0.8	37	37	0.51	17.30	3.19	4.104	95% H-UCL	2	4.10	34	31	0.021	0.195	0.052	0.060	95% Adjusted Gamma KM-UCL	4	0.060
RRM 0.8 to 1.7	1	1	3.42	3.42	3.42	NC	--	1	3.42	0	0	NC	NC	NC	NC	--	--	NC
RRM 1.7 to 2.7	34	34	1.01	10.70	3.81	4.607	95% Adjusted Gamma UCL	--	4.61	33	32	0.030	0.356	0.108	0.13	95% Adjusted Gamma KM-UCL	4	0.130
RRM 2.7 to 4.4	0	0	NC	NC	NC	NC	--	--	NC	0	0	NC	NC	NC	NC	--	--	NC
RRM 4.4 to 5.2	4	4	4.10	7.95	5.31	7.42	95% Student's-t UCL	3	7.42	1	1	0.058	0.058	0.058	NC	--	1	0.058
RRM 5.2 to 7.9	32	32	0.24	33.8	6.75	8.958	95% Adjusted Gamma UCL	--	8.96	32	32	0.057	0.896	0.261	0.429	95% Chebyshev (Mean, SD) UCL	--	0.429
RRM 7.9 to 9.2	0	0	NC	NC	NC	NC	--	--	NC	0	0	NC	NC	NC	NC	--	--	NC
RRM 9.2 to 11.3	34	34	1.48	412	27.5	82.8	95% Chebyshev (Mean, SD) UCL	--	82.8	33	33	0.098	2.15	0.527	0.673	95% Adjusted Gamma UCL	--	0.673
RRM 11.3 to 12.5	1	1	8.37	8.37	8.37	NC	--	1	8.37	0	0	NC	NC	NC	NC	--	--	NC
RRM 12.5 to 13.5	0	0	NC	NC	NC	NC	--	--	NC	0	0	NC	NC	NC	NC	--	--	NC
RRM 13.5 to 16.7	39	39	2.60	75.4	8.55	16.56	95% Chebyshev (Mean, SD) UCL	--	16.56	27	27	0.110	1.583	0.531	0.706	95% Adjusted Gamma UCL	--	0.706
RRM 16.7 to 20.9	21	21	3.29	19.60	7.51	8.97	95% Student's-t UCL	--	8.97	21	20	0.153	1.236	0.435	0.751	95% KM (Chebyshev) UCL	5	0.751
RRM 20.9 to 24.0	29	29	3.78	17.71	8.86	10.0	95% Student's-t UCL	--	10.00	28	28	0.145	1.776	0.615	1.01	95% Chebyshev (Mean, SD) UCL	--	1.01
SFSR	2	2	1.80	2.60	2.20	NC	--	1	2.60	0	0	NC	NC	NC	NC	--	--	NC

Notes:
THg, Total mercury.
MeHg, Methylmercury.
RRM, Relative river mile.
NC, Not calculated due to insufficient sample size.
SFSR, South Fork Shenandoah River.
EPC, Exposure point concentration.
--, Not applicable.

*UCL Notes:
1, Data set is too small to compute reliable and meaningful statistics and estimates.
2, H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide. It is therefore recommended to avoid the use of H-statistic based 95% UCLs.
3, Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
4, Additional UCLs were recommended.

Table E-4
Sediment Pore Water Mercury Exposure Point Concentrations (EPCs)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	THg(ng/L)									MeHg (ng/L)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC
Unfiltered Pore Water																		
RRM -0.7 to 0.0	14	0	0.73	5.67	2.2	2.804	95% Student's-t UCL	--	2.80	--	--	--	--	--	--	--	--	
RRM 0.0 to 0.8	12	0	1.01	114.84	13.4	54.03	95% Chebyshev (Mean, SD) UCL	--	54.03	--	--	--	--	--	--	--	--	
Filtered Pore Water																		
RRM -0.7 to 0.0	14	14	0.45	3.91	1.02	1.472	95% Adjusted Gamma UCL	--	1.47	--	--	--	--	--	--	--	--	
RRM 0.0 to 0.8	229	229	0.76	293.67	16.26	27.33	95% Chebyshev (Mean, SD) UCL	--	27.33	202	188	0.04	22.06	1.97	2.801	95% KM (Chebyshev) UCL	--	2.80
RRM 1.7 to 2.7	50	50	0.22	1502.00	85.57	256.8	95% Chebyshev (Mean, SD) UCL	--	256.80	2	2	11.14	14.19	12.67	NA	--	1	14.19
RRM 2.7 to 4.4	120	120	5.98	2180.42	148.89	255.8	95% Chebyshev (Mean, SD) UCL	--	255.80	120	117	0.05	78.50	11.66	21.87	97.5% KM (Chebyshev) UCL	--	21.87
RRM 5.2 to 7.9	2	2	106.30	348.40	227.35	NA	--	1	348.40	2	2	6.22	17.41	11.81	NA	--	1	17.41
RRM 7.9 to 9.2	145	145	1.98	3227.14	162.71	227.6	95% H-UCL	2	227.60	144	121	0.06	34.32	4.88	6.789	95% KM (Chebyshev) UCL	--	6.79
RRM 9.2 to 11.3	2	2	81.38	292.40	186.89	NA	--	1	292.40	2	2	3.36	4.86	4.11	NA	--	1	4.86
RRM 11.3 to 12.5	58	58	0.39	151.27	45.27	58.61	95% Approximate Gamma UCL	--	58.61	52	52	0.29	24.07	3.90	5.571	95% H-UCL	2	5.57
RRM 20.9 to 24.0	129	129	1.89	306.40	28.28	44.5	95% Chebyshev (Mean, SD) UCL	--	44.50	129	120	0.08	48.64	4.13	6.556	95% KM (Chebyshev) UCL	--	6.56

Notes:
THg, Total mercury.
MeHg, Methylmercury.
RRM, Relative river mile.
NC, Not calculated due to insufficient sample size.
EPC, Exposure point concentration.
--, Not applicable.

*UCL Notes:
1, Data set is too small to compute reliable and meaningful statistics and estimates.
2, H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide. It is therefore recommended to avoid the use of H-statistic based 95% UCLs.

Table E-5
Sediment Exposure Point Concentrations (EPCs) Calculated for Food Web Modeling
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	THg (mg/kg dw)									MeHg (mg/kg dw)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Note*	EPC	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Note*	EPC ^a
Bulk Sediment																		
RRM -2.7 to -0.7	2	1	0.05	0.05	0.05	NC	--	1	0.05	1	1	0.002	0.002	0.002	NC	--	1	0.002
RRM -0.7 to 0.0	2	2	0.94	4.89	2.92	NC	--	1	4.89	0	0	NC	NC	NC	NC	--	--	0.002
RRM 0.0 to 0.8	21	19	0.13	12.62	1.98	4.71	95% KM (Chebyshev) UCL	6	4.71	1	1	0.030	0.030	0.030	NC	--	1	0.030
RRM 0.8 to 1.7	13	13	0.90	10.90	5.36	7.817	95% Adjusted Gamma UCL	--	7.82	16	16	0.002	0.009	0.005	0.00577	95% Student's-t UCL	--	0.006
RRM 1.7 to 2.7	51	51	0.03	212	25.42	35.44	95% Adjusted Gamma UCL	--	35.4	11	11	0.0003	0.372	0.092	0.334	95% Adjusted Gamma UCL	--	0.334
RRM 2.7 to 4.4	83	83	0.07	300	22.15	41.73	95% Chebyshev (Mean, SD) UCL	--	41.7	7	7	0.010	0.113	0.046	0.0751	95% Student's-t UCL	4	0.075
RRM 4.4 to 5.2	61	61	0.05	884	85.16	200	95% Chebyshev (Mean, SD) UCL	--	200	30	30	0.006	0.098	0.032	0.0456	95% H-UCL	2	0.046
RRM 5.2 to 7.9	50	50	1.00	268	20.74	27.78	95% H-UCL	2	27.8	23	23	0.002	0.123	0.038	0.0566	95% Adjusted Gamma UCL	--	0.057
RRM 7.9 to 9.2	42	42	0.24	418	36.62	84.34	95% Chebyshev (Mean, SD) UCL	--	84.3	19	19	0.002	0.103	0.030	0.046	95% Adjusted Gamma UCL	--	0.046
RRM 9.2 to 11.3	37	37	0.72	86.2	20.97	27.61	95% Adjusted Gamma UCL	--	27.6	24	23	0.005	0.131	0.029	0.0552	95% KM (Chebyshev) UCL	--	0.055
RRM 11.3 to 12.5	36	36	0.01	32.5	8.26	13.87	95% Chebyshev (Mean, SD) UCL	--	13.87	4	4	0.0003	0.389	0.112	0.33	95% Student's-t UCL	4	0.330
RRM 12.5 to 13.5	27	27	0.30	28.6	11.93	14.07	95% Student's-t UCL	--	14.07	20	20	0.008	0.124	0.033	0.045	95% Adjusted Gamma UCL	--	0.045
RRM 13.5 to 16.7	2	2	6.69	14.72	10.71	NC	--	1	14.72	1	1	0.089	0.089	0.089	NC	--	1	0.089
RRM 16.7 to 20.9	3	3	2.39	12.90	6.49	15.97	95% Student's-t UCL	4	12.90	0	0	NC	NC	NC	NC	--	--	0.089
RRM 20.9 to 24.0	20	20	0.78	24.2	11.20	14.32	95% Student's-t UCL	--	14.32	2	2	0.028	0.072	0.050	NC	--	1	0.072
SFSR	14	14	0.19	1.36	0.67	0.815	95% Student's-t UCL	--	0.82	0	0	NC	NC	NC	NC	--	--	0.072
Interstitial Sediment																		
RRM -2.7 to -0.7	43	43	0.04	0.19	0.07	0.0731	95% Modified-t UCL	--	0.07	41	41	0.0004	0.026	0.003	0.00559	95% Chebyshev (Mean, SD) UCL	--	0.006
RRM -0.7 to 0.0	13	13	0.07	3.34	0.86	1.762	95% Adjusted Gamma UCL	--	1.76	0	0	NC	NC	NC	NC	--	--	NC
RRM 0.0 to 0.8	111	111	0.06	53.5	3.13	3.705	95% H-UCL	2	3.71	50	50	0.001	0.096	0.015	0.0198	95% Approximate Gamma UCL	--	0.020
RRM 0.8 to 1.7	10	10	0.27	59.5	9.53	68.43	99% Chebyshev (Mean, SD) UCL	3	59.5	7	7	0.001	0.017	0.007	0.011	95% Student's-t UCL	4	0.011
RRM 1.7 to 2.7	48	48	3.22	26.0	9.74	10.77	95% Adjusted Gamma UCL	--	10.77	39	39	0.002	0.052	0.014	0.0191	95% H-UCL	2	0.019
RRM 2.7 to 4.4	108	108	3.56	211	23.37	34.22	95% Chebyshev (Mean, SD) UCL	--	34.2	110	110	0.001	0.240	0.054	0.061	95% Approximate Gamma UCL	--	0.061
RRM 4.4 to 5.2	50	50	4.28	60.4	18.57	20.91	95% Approximate Gamma UCL	--	20.9	54	54	0.011	0.288	0.054	0.0641	95% Approximate Gamma UCL	--	0.064
RRM 5.2 to 7.9	48	48	3.12	42.6	20.02	21.9	95% Student's-t UCL	--	21.9	53	53	0.011	0.216	0.066	0.0792	95% Approximate Gamma UCL	--	0.079
RRM 7.9 to 9.2	61	61	8.88	50.6	20.80	22.2	95% Modified-t UCL	6	22.2	67	67	0.017	0.775	0.086	0.147	95% Chebyshev (Mean, SD) UCL	--	0.147
RRM 9.2 to 11.3	4	4	15.60	24.6	18.81	23.55	95% Student's-t UCL	4	23.6	1	1	0.141	0.141	0.141	NC	--	1	0.141
RRM 11.3 to 12.5	67	67	8.03	42.9	15.78	16.91	95% Modified-t UCL	6	16.91	64	64	0.015	0.440	0.084	0.126	95% Chebyshev (Mean, SD) UCL	--	0.126
RRM 12.5 to 13.5	38	38	9.87	40.1	15.68	17.16	95% Modified-t UCL	6	17.16	37	37	0.006	0.261	0.063	0.107	95% Chebyshev (Mean, SD) UCL	--	0.107
RRM 13.5 to 16.7	40	40	8.47	18.37	12.86	13.45	95% Student's-t UCL	--	13.45	36	36	0.012	0.206	0.060	0.0777	95% Adjusted Gamma UCL	--	0.078
RRM 16.7 to 20.9	40	40	2.76	15.4	10.28	11.07	95% Student's-t UCL	5	11.07	36	36	0.015	0.188	0.069	0.111	95% Chebyshev (Mean, SD) UCL	--	0.111
RRM 20.9 to 24.0	59	59	2.41	26.0	9.86	10.55	95% Modified-t UCL	6	10.55	52	52	0.003	0.189	0.067	0.0816	95% Approximate Gamma UCL	--	0.082
SFSR	47	47	0.37	2.47	1.24	1.593	95% Chebyshev (Mean, SD) UCL	5	1.593	36	36	0.001	0.045	0.013	0.0168	95% Adjusted Gamma UCL	--	0.017

Notes:
THg, Total mercury.
MeHg, Methylmercury.
RRM, Relative river mile.
SFSR, South Fork Shenandoah River.
EPC, Exposure point concentration.
NC, Not calculated due to insufficient sample size.
dw, Dry weight.
--, Not applicable.
a, EPCs in ***bold and italics*** are extrapolations based on the EPCs for the appropriate next adjacent Reach; Used only for DRMs.

*UCL Note:
1, Data set is too small to compute reliable and meaningful statistics and estimates.
2, H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide. It is therefore recommended to avoid the use of H-statistic based 95% UCLs.
3, Recommended UCL exceeds the maximum observation.
4, Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
5, For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positively skewed data sets.
6, Additional UCLs were recommended.
Highlighted cells are estimated based on the next highest EPC for adjacent RRM, in FWM only.

Table E-6
Soil Mercury Exposure Point Concentration (EPCs)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	Floodplain	THg (mg/kg dw)																		
		Surficial (0.0'- 0.5')										Sub-surface (0.5'- 2.0')								
		Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes ^a	EPC ^b	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes ^a	EPC ^a	
RRM -2.7 to -0.7	0.3 Year	5	5	0.08	0.18	0.13	0.161	95% Student's-t UCL	1	0.2	0	0	NC	NC	NC	NC	--	--	0.6	
	0.3 Year	0	0	NC	NC	NC	NC	--	--	0.2	0	0	NC	NC	NC	NC	--	--	0.6	
RRM -0.7 to 0.0	2 Year	5	5	0.01	0.40	0.15	0.300	95% Student's-t UCL	1	0.3	2	2	0.10	0.60	0.35	NC	--	2	0.6	
	5 Year	7	7	0.01	12.70	2.27	36.380	95% Adjusted Gamma UCL	1,3	12.7	5	5	0.01	3.10	0.92	2.151	95% Student's-t UCL	1	2.2	
RRM 0.0 to 0.8	0.3 Year	275	275	0.14	941.00	16.12	36.290	95% Chebyshev (Mean, SD) UCL	--	36.3	14	14	2.27	164.00	28.71	59.120	95% Adjusted Gamma UCL	--	59.1	
	2 Year	53	53	0.02	160.00	10.09	31.970	95% H-UCL	4	32.0	14	14	1.63	39.70	18.68	22.570	95% Student's-t UCL	--	22.6	
	5 Year	22	22	0.03	24.30	4.20	12.860	97.5% Chebyshev (Mean, SD) UCL	--	12.9	16	16	0.03	248.00	44.91	126.800	95% Adjusted Gamma UCL	--	126.8	
	62 Year	35	35	0.03	47.50	5.01	13.580	95% Chebyshev (Mean, SD) UCL	--	13.6	20	20	0.04	55.10	16.87	61.470	95% Adjusted Gamma UCL	--	55.1	
	0.3 Year	378	375	0.09	817.00	23.88	47.180	97.5% KM (Chebyshev) UCL	5	47.2	23	23	0.53	608.00	63.62	256.300	97.5% Chebyshev (Mean, SD) UCL	5	256.3	
	2 Year	89	89	0.03	494.00	28.18	61.690	95% Chebyshev (Mean, SD) UCL	--	61.7	9	9	0.03	231.00	51.00	97.820	95% Student's-t UCL	--	97.8	
RRM 0.8 to 1.7	5 Year	86	86	0.03	307.00	14.93	35.710	95% Chebyshev (Mean, SD) UCL	--	35.7	34	34	0.11	89.30	11.71	19.800	95% Adjusted Gamma UCL	--	19.8	
	62 Year	33	33	0.16	85.70	6.86	11.680	95% H-UCL	4	11.7	19	19	0.05	341.00	64.40	333.500	99% Chebyshev (Mean, SD) UCL	5	333.5	
	0.3 Year	367	367	0.02	515.00	15.09	23.770	95% Chebyshev (Mean, SD) UCL	--	23.8	41	41	0.10	132.00	31.19	46.690	95% Adjusted Gamma UCL	--	46.7	
RRM 1.7 to 2.7	2 Year	157	157	0.01	60.95	12.26	14.810	95% Approximate Gamma UCL	--	14.8	43	43	0.05	72.10	12.05	17.770	95% Adjusted Gamma UCL	--	17.8	
	5 Year	64	64	0.03	173.00	10.99	15.090	95% Approximate Gamma UCL	--	15.1	53	52	0.03	714.00	51.02	254.400	99% KM (Chebyshev) UCL	5	254.4	
	62 Year	25	24	0.02	19.30	1.79	9.877	99% KM (Chebyshev) UCL	5	9.9	25	22	0.02	5.99	0.80	1.865	95% KM (Chebyshev) UCL	6	1.9	
RRM 2.7 to 4.4	0.3 Year	610	609	0.02	476.00	16.20	22.070	95% KM (Chebyshev) UCL	--	22.1	71	70	0.07	403.00	25.38	66.280	95% KM (Chebyshev) UCL	6	66.3	
	2 Year	31	31	0.02	77.50	14.49	26.040	95% Adjusted Gamma UCL	--	26.0	22	20	0.07	69.10	12.94	28.200	95% KM (Chebyshev) UCL	6	28.2	
	5 Year	9	9	1.87	38.70	8.76	21.110	95% Adjusted Gamma UCL	1	21.1	16	16	0.10	18.70	3.29	6.690	95% Adjusted Gamma UCL	--	6.7	
RRM 4.4 to 5.2	62 Year	7	7	0.13	1.56	0.71	1.093	95% Student's-t UCL	1	1.1	7	7	0.01	0.48	0.16	0.272	95% Student's-t UCL	1	0.3	
	0.3 Year	133	133	0.04	485.00	24.40	42.030	95% H-UCL	4	42.0	5	5	1.22	11.90	5.36	9.419	95% Student's-t UCL	1	9.4	
	2 Year	19	18	0.14	28.00	11.71	14.160	95% KM (t) UCL	6	14.2	4	4	0.35	26.60	7.29	22.45	95% Student's-t UCL	1	22.5	
	5 Year	11	11	0.18	29.90	6.51	37.950	99% Chebyshev (Mean, SD) UCL	3	29.9	12	12	0.04	36.00	5.01	35.39	99% Chebyshev (Mean, SD) UCL	5	35.4	
RRM 5.2 to 7.9	62 Year	14	14	0.05	0.54	0.28	0.355	95% Student's-t UCL	--	0.4	14	14	0.02	0.15	0.07	0.09	95% Student's-t UCL	--	0.1	
	0.3 Year	100	99	0.05	120.00	14.10	17.020	95% KM (BCA) UCL	--	17.0	15	15	0.19	96.60	16.93	35.74	95% Adjusted Gamma UCL	--	35.7	
	2 Year	16	16	0.47	83.40	12.78	26.340	95% Adjusted Gamma UCL	--	26.3	10	10	0.11	22.20	5.12	18.02	95% Adjusted Gamma UCL	--	18.0	
	5 Year	23	23	0.05	22.30	4.65	8.313	95% Adjusted Gamma UCL	--	8.3	24	24	0.05	8.87	1.16	3.07	95% Chebyshev (Mean, SD) UCL	--	3.1	
	62 Year	21	21	0.02	2.81	0.21	0.781	95% Chebyshev (Mean, SD) UCL	--	0.8	21	21	0.01	0.29	0.05	0.10	95% Chebyshev (Mean, SD) UCL	--	0.1	
	0.3 Year	71	69	0.02	42.40	12.78	14.470	95% KM (Percentile Bootstrap) UCL	6	14.5	16	16	0.23	163.00	21.05	46.06	95% Adjusted Gamma UCL	--	46.1	
RRM 7.9 to 9.2	2 Year	18	18	3.60	55.60	19.43	25.170	95% Student's-t UCL	--	25.2	16	16	0.29	270.00	34.80	232.20	99% Chebyshev (Mean, SD) UCL	5	232.2	
	5 Year	7	7	0.06	21.20	7.65	14.010	95% Student's-t UCL	1	14.0	9	9	0.03	33.50	11.75	19.43	95% Student's-t UCL	1	19.4	
	62 Year	7	7	0.06	1.49	0.35	1.197	95% Chebyshev (Mean, SD) UCL	1	1.2	7	7	0.01	0.61	0.12	0.61	95% Adjusted Gamma UCL	1	0.6	
	0.3 Year	42	42	0.04	80.20	20.06	25.610	95% Adjusted Gamma UCL	--	25.6	21	21	0.61	94.30	24.20	47.38	95% Chebyshev (Mean, SD) UCL	--	47.4	
RRM 9.2 to 11.3	2 Year	27	27	1.08	60.20	16.61	23.460	95% Adjusted Gamma UCL	--	23.5	17	17	0.40	57.90	8.75	17.88	95% Adjusted Gamma UCL	--	17.9	
	5 Year	32	32	0.20	50.40	15.67	18.730	95% Student's-t UCL	--	18.7	37	37	0.06	124.00	13.47	22.00	95% Adjusted Gamma UCL	--	22.0	
	62 Year	16	15	0.02	20.90	4.51	11.030	95% GROS Adjusted Gamma UCL	6	11.0	17	17	0.02	13.50	1.71	4.17	95% Adjusted Gamma UCL	--	4.2	
RRM 11.3 to 12.5	0.3 Year	30	30	1.38	36.60	12.58	15.120	95% Student's-t UCL	--	15.1	5	5	0.05	13.20	6.85	12.59	95% Student's-t UCL	1,7	12.6	
	2 Year	151	151	0.04	79.30	33.52	41.530	95% Chebyshev (Mean, SD) UCL	--	41.5	21	21	0.02	53.80	8.21	31.19	97.5% Chebyshev (Mean, SD) UCL	5	31.2	
	5 Year	54	54	0.17	28.90	4.61	6.005	95% Approximate Gamma UCL	--	6.0	19	19	0.03	14.90	2.98	14.91	99% Chebyshev (Mean, SD) UCL	3	14.9	
	62 Year	33	33	0.20	2.62	0.49	0.815	95% Chebyshev (Mean, SD) UCL	--	0.8	7	7	0.07	1.03	0.30	0.87	95% Adjusted Gamma UCL	1	0.9	
RRM 12.5 to 13.5	0.3 Year	8	8	0.67	12.50	5.82	8.288	95% Student's-t UCL	1	8.3	6	6	0.49	10.10	4.51	7.74	95% Student's-t UCL	1	7.7	
	2 Year	3	3	0.21	14.90	6.97	19.470	95% Student's-t UCL	1,3	14.9	3	3	0.07	4.49	1.57	5.83	95% Student's-t UCL	1,3	4.5	
	5 Year	2	2	2.23	10.30	6.27	NC	--	2	10.3	2	2	3.13	23.00	13.07	NC	--	2	23.0	
	62 Year	7	7	0.03	0.56	0.20	0.340	95% Student's-t UCL	1	0.3	7	7	0.03	0.14	0.07	0.10	95% Student's-t UCL	1	0.1	
RRM 13.5 to 16.7	0.3 Year	17	17	0.04	11.10	5.99	7.439	95% Student's-t UCL	7	7.4	9	9	0.88	30.70	13.36	20.09	95% Student's-t UCL	1	20.1	
	2 Year	6	6	1.43	20.00	10.10	16.320	95% Student's-t UCL	1	16.3	6	6	0.94	6.25	3.45	4.97	95% Student's-t UCL	1	5.0	
	5 Year	14	14	0.33	18.10	5.05	7.384	95% Student's-t UCL	--	7.4	14	14	0.07	17.90	2.63	16.04	99% Chebyshev (Mean, SD) UCL	5	16.0	
	62 Year	12	12	0.04	7.13	1.73	4.841	95% Adjusted Gamma UCL	--	4.8	12	12	0.02	1.18	0.29	0.68	95% Adjusted Gamma UCL	--	0.7	
RRM 16.7 to 20.9	0.3 Year	56	56	0.24	22.20	5.93	7.208	95% Approximate Gamma UCL	--	7.2	15	15	0.52	18.60	4.79	6.94	95% Student's-t UCL	--	6.9	
	2 Year	34	33	0.04	21.20	7.54	8.865	95% KM (t) UCL	6	8.9	29	28	0.05	44.40	4.69	14.75	97.5% KM (Chebyshev) UCL	5	14.8	
	5 Year	35	35	0.03	22.50	5.96	8.598	95% Adjusted Gamma UCL	--	8.6	37	37	0.03	16.50	3.01	4.53	95% Adjusted Gamma UCL	--	4.5	
	62 Year	33	33	0.01	15.30	2.25	3.782	95% Adjusted Gamma UCL	--	3.8	33	33	0.02	5.48	0.58	1.42	95% Chebyshev (Mean, SD) UCL	--	1.4	
RRM 20.9 to 24.0	0.3 Year	80	80	0.05	85.70	6.92	12.640	95% Chebyshev (Mean, SD) UCL	--	12.6	17	17	0.42	72.90	11.89	21.71	95% Adjusted Gamma UCL	--	21.7	
	2 Year	26	26	0.71	33.10	8.78	12.280	95% Adjusted Gamma UCL	--	12.3	26	25	0.22	28.20	5.21	11.06	95% KM (Chebyshev) UCL	6	11.1	
	5 Year	37	37	0.07	7.36	1.04	6.100	95% Chebyshev (Mean, SD) UCL	--	6.1	37	35	0.03	7.25	0.85	6.83	99% KM (Chebyshev) UCL	5	6.8	
	62 Year	31	30	0.02	10.00	1.86	7.107	99% KM (Chebyshev) UCL	5	7.1	31	30	0.02	7.00	0.87	3.67	99% KM (Chebyshev) UCL	5	3.7	
SFSR	NA	2	2	0.01	0.02	0.02	NC	--	2	0.0	6	6	0.02	0.40	0.10	0.22	95% Student's-t UCL	1	0.2	

Notes:

THg, Total mercury.
RRM, Relative river mile.
NC, Not calculated due to insufficient sample size.
NA, Not available.
SFSR, South Fork Shenandoah River.
EPC, Exposure point concentration.
NC, Not calculated due to insufficient sample size.
dw, Dry weight.
--, Not applicable.
a, EPCs in ***bold and italics*** are extrapolations based on the EPCs for the appropriate next adjacent Reach.
b, Soil I-Hg and MeHg EPCs for Dose Rate Modeling are estimated as 98% and 2% of the THg EPCs, respectively, for the surficial soil in the 0.3 Year Floodplain.

*UCL Note:

1, Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
2, Data set is too small to compute reliable and meaningful statistics and estimates.
3, Recommended UCL exceeds the maximum observation.
4, H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide. It is therefore recommended to avoid the use of H-statistic based 95% UCLs.
5, UCL > 95%.
6, Additional UCLs were recommended.
7, For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positively skewed data sets.

Table E-7
Larval Aquatic Invertebrates Tissue Mercury Exposure Point Concentrations (EPCs)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	WHOLE BODY THg (mg/kg ww)									WHOLE BODY IHg (mg/kg ww)									WHOLE BODY MeHg (mg/kg ww)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC ^a	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Note	EPC ^a
MR Middle	3	3	0.030	0.031	0.031	0.031	95% Student's-t UCL	1, 2	0.031	3	3	0.013	0.015	0.014	0.0157	95% Student's-t UCL	1, 2	0.015	3	3	0.015	0.018	0.017	0.019	95% Student's-t UCL	1, 2	0.018
NR Upper	32	30	0.003	0.019	0.009	0.009	95% KM (t) UCL	3	0.009	23	21	0.000	0.009	0.004	0.004	95% KM (t) UCL	--	0.004	23	21	0.001	0.018	0.005	0.00888	95% KM (Chebyshev) UCL	--	0.009
RRM -2.7 to -0.7	15	13	0.004	0.034	0.016	0.019	95% KM (t) UCL	3	0.019	15	13	0.000	0.019	0.006	0.007	95% KM (t) UCL	--	0.007	15	13	0.003	0.026	0.010	0.0133	95% KM (t) UCL	--	0.013
RRM -0.7 to 0.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.007	--	--	--	--	--	--	--	--	<i>0.013</i>
RRM 0.0 to 0.8	36	35	0.011	1.097	0.153	0.378	97.5% KM (Chebyshev) UCL	--	0.378	24	23	0.000	0.427	0.090	0.318	99% KM (Chebyshev) UCL	--	0.318	24	23	0.003	0.304	0.067	0.18	97.5% KM (Chebyshev) UCL	--	0.180
RRM 0.8 to 1.7	45	45	0.023	1.080	0.177	0.224	95% Adjusted Gamma UCL	--	0.224	11	11	0.000	0.469	0.124	0.337	95% Chebyshev (Mean, SD) UCL	--	0.337	11	11	0.007	0.244	0.061	0.162	95% Chebyshev (Mean, SD) UCL	--	0.162
RRM 1.7 to 2.7	38	38	0.004	2.72	0.250	0.568	95% Chebyshev (Mean, SD) UCL	--	0.568	16	16	0.000	0.179	0.071	0.095	95% Student's-t UCL	--	0.095	16	16	0.003	0.240	0.037	0.0669	95% Adjusted Gamma UCL	--	0.067
RRM 2.7 to 4.4	50	50	0.057	5.79	0.743	1.491	95% Chebyshev (Mean, SD) UCL	--	1.491	50	50	0.039	5.437	0.615	1.324	95% Chebyshev (Mean, SD) UCL	--	1.324	50	50	0.013	0.585	0.128	0.16	95% Approximate Gamma UCL	--	0.160
RRM 4.4 to 5.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	<i>1.324</i>	--	--	--	--	--	--	--	--	<i>0.188</i>
RRM 5.2 to 7.9	60	60	0.020	2.19	0.603	0.858	95% Chebyshev (Mean, SD) UCL	--	0.858	30	30	0.007	1.227	0.290	0.403	95% Adjusted Gamma UCL	--	0.403	30	30	0.013	0.445	0.139	0.188	95% Adjusted Gamma UCL	--	0.188
RRM 7.9 to 9.2	127	127	0.017	4.40	0.473	0.547	95% Approximate Gamma UCL	--	0.547	127	127	0.006	4.208	0.330	0.431	95% H-UCL	4	0.431	127	127	0.006	1.245	0.143	0.207	95% Chebyshev (Mean, SD) UCL	--	0.207
RRM 9.2 to 11.3	445	445	0.012	23.6	0.780	0.816	95% H-UCL	4	0.816	417	417	0.000	22.965	0.613	0.942	95% Chebyshev (Mean, SD) UCL	--	0.942	417	417	0.001	3.184	0.189	0.221	95% H-UCL	4	0.221
RRM 11.3 to 12.5	67	67	0.083	2.26	0.566	0.653	95% Approximate Gamma UCL	--	0.653	55	55	0.004	1.684	0.306	0.373	95% Approximate Gamma UCL	--	0.373	55	55	0.032	0.926	0.300	0.422	95% Chebyshev (Mean, SD) UCL	--	0.422
RRM 12.5 to 13.5	12	12	0.035	12.00	1.271	5.53	95% Chebyshev (Mean, SD) UCL	--	5.53	12	12	0.011	3.124	0.406	1.488	95% Chebyshev (Mean, SD) UCL	--	1.488	12	12	0.024	8.879	0.865	4.043	95% Chebyshev (Mean, SD) UCL	--	4.043
RRM 13.5 to 16.7	12	12	0.054	0.711	0.301	0.402	95% Student's-t UCL	--	0.402	12	12	0.026	0.335	0.152	0.198	95% Student's-t UCL	--	0.198	12	12	0.028	0.548	0.149	0.268	95% Adjusted Gamma UCL	--	0.268
RRM 16.7 to 20.9	12	12	0.023	0.626	0.301	0.396	95% Student's-t UCL	--	0.396	12	12	0.012	0.227	0.133	0.169	95% Student's-t UCL	--	0.169	12	12	0.011	0.454	0.168	0.332	95% Adjusted Gamma UCL	--	0.332
RRM 20.9 to 24.0	45	45	0.014	0.629	0.333	0.448	95% Chebyshev (Mean, SD) UCL	--	0.448	33	33	0.000	0.454	0.126	0.211	95% Chebyshev (Mean, SD) UCL	--	0.211	33	33	0.001	0.535	0.176	0.218	95% Student's-t UCL	--	0.218
SFSR	40	40	0.000	0.226	0.067	0.079	95% Student's-t UCL	--	0.079	16	16	0.000	0.210	0.030	0.087	95% Chebyshev (Mean, SD) UCL	--	0.087	16	16	0.006	0.132	0.037	0.0583	95% Adjusted Gamma UCL	--	0.058

Notes:
MeHg, Methylmercury; IHg, Inorganic mercury; RRM, Relative river mile; MR, Middle River; NR, North River; SFSR, South Fork Shenandoah River; ww, Wet weight.
Min, Max, and Mean - Minimum, Maximum, and Mean of the detected concentrations.
95% UCL, 95% Upper confidence level of the mean concentrations.
EPC, Exposure point concentration; Max or the 95% UCL, whichever is lower; For N < 5, data set is too small to compute reliable and meaningful statistics and estimates.
--, Not applicable.
a, EPCs in ***bold and italics*** are extrapolations based on the EPCs for the appropriate next adjacent Reach; Used only for DRMs.

*UCL Notes:
1, Sample size is small (e.g., <10).
2, Recommended UCL exceeds the maximum observation.
3, Additional UCLs were recommended.
4, H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide. It is therefore recommended to avoid the of H-statistic based 95% UCLs.

Table E-8
Emergent Aquatic Invertebrates Tissue Mercury Exposure Point Concentrations (EPCs)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	WHOLE BODY THg (mg/kg ww)									WHOLE BODY IHg (mg/kg ww)									WHOLE BODY MeHg (mg/kg ww)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Note	EPC ^a	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC ^a
RRM -2.7 to -0.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.02	--	--	--	--	--	--	--	--	0.01
RRM -0.7 to 0.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.02	--	--	--	--	--	--	--	--	0.01
RRM 0.0 to 0.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.26	--	--	--	--	--	--	--	--	0.06
RRM 0.8 to 1.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.26	--	--	--	--	--	--	--	--	0.06
RRM 1.7 to 2.7	9	9	0.060	0.475	0.132	0.321	95% Chebyshev (Mean, SD) UCL	1	0.321	9	9	0.026	0.395	0.085	0.255	95% Chebyshev (Mean, SD) UCL	1	0.26	9	9	0.022	0.080	0.047	0.0594	95% Student's-t UCL	1	0.06
RRM 2.7 to 4.4	18	18	0.079	3.467	0.881	2.022	95% Chebyshev (Mean, SD) UCL	--	2.022	18	18	0.034	2.327	0.428	1.214	95% Chebyshev (Mean, SD) UCL	--	1.21	18	18	0.028	1.190	0.453	0.726	95% Adjusted Gamma UCL	--	0.73
RRM 4.4 to 5.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.21	--	--	--	--	--	--	--	--	1.85
RRM 5.2 to 7.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.21	--	--	--	--	--	--	--	--	1.85
RRM 7.9 to 9.2	18	18	0.129	5.088	1.000	2.659	95% Chebyshev (Mean, SD) UCL	--	2.659	18	18	0.000	2.015	0.277	0.848	95% Chebyshev (Mean, SD) UCL	--	0.85	18	18	0.084	3.181	0.723	1.851	95% Chebyshev (Mean, SD) UCL	--	1.85
RRM 9.2 to 11.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.85	--	--	--	--	--	--	--	--	1.85
RRM 11.3 to 12.5	12	12	0.226	1.171	0.504	0.666	95% Student's-t UCL	--	0.666	12	12	0.006	0.356	0.136	0.204	95% Student's-t UCL	--	0.20	12	12	0.146	0.817	0.367	0.641	95% Chebyshev (Mean, SD) UCL	--	0.64
RRM 12.5 to 13.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.01	--	--	--	--	--	--	--	--	0.64
RRM 13.5 to 16.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.01	--	--	--	--	--	--	--	--	0.64
RRM 16.7 to 20.9	9	9	0.178	1.580	0.568	1.316	95% H-UCL	1, 2	1.316	9	9	0.035	1.094	0.352	1.013	95% Adjusted Gamma UCL	1	1.01	9	9	0.085	0.585	0.216	0.31	95% Student's-t UCL	1	0.31
RRM 20.9 to 24.0	12	12	0.130	0.638	0.298	0.395	95% Student's-t UCL	--	0.395	12	12	0.000	0.462	0.120	0.304	95% Chebyshev (Mean, SD) UCL	--	0.30	12	12	0.037	0.418	0.180	0.234	95% Student's-t UCL	--	0.23
SFSR	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.30	--	--	--	--	--	--	--	--	0.23

Notes:

MeHg, Methylmercury; IHg, Inorganic mercury; RRM, Relative river mile; SFSR, South Fork Shenandoah River; ww, Wet weight.
Min, Max, and Mean - Minimum, Maximum, and Mean of the detected concentrations.
95% UCL, 95% Upper confidence level of the mean concentrations.
EPC, Exposure point concentration; Max or the 95% UCL, whichever is lower.
--, Not applicable.
a, EPCs in **bold and italics** are extrapolations based on the higher of the EPCs in the adjacent Reaches; Used only for DRMs; EPCs for the Reference (RRM -2.7 -0-0.7) and Buffer (RRM -0.7 - 0.0) Reaches, for which measurements were not available, EPCs are calculated based on the ratio of EPCs for RRM -2.7- -0.7 and RRM 1.7-2.7 for Larval Aquatic Invertebrates.

*UCL Notes:

- 1, Sample size is small (e.g., <10).
- 2, H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide. It is therefore recommended to avoid the of H-statistic based 95% UCLs.

Table E-9
Crayfish Tissue Mercury Exposure Point Concentrations (EPCs)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	WHOLE BODY THg (mg/kg ww)									WHOLE BODY IHg (mg/kg ww)									WHOLE BODY MeHg (mg/kg ww)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Note	EPC ^a	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Note	EPC	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Note	EPC ^a
MR Lower	1	1	0.025	0.025	0.025	NA	NA	1	0.025	1	1	0.000	0.000	0.000	NA	NA	1	0.000	1	1	0.025	0.025	0.025	NA	NA	1	0.025
MR Middle	7	7	0.016	0.023	0.020	0.0217	95% Student's-t UCL	2, 3	0.022	7	7	0.000	0.007	0.003	0.00427	95% Student's-t UCL	3	0.004	7	7	0.014	0.020	0.017	0.0188	95% Student's-t UCL	2, 3	0.019
NR Upper	42	42	0.006	0.674	0.033	0.104	95% Chebyshev (Mean, SD) UCL	--	0.104	40	40	0.000	0.145	0.008	0.0247	95% Chebyshev (Mean, SD) UCL	--	0.025	40	40	0.002	0.056	0.009	0.0115	95% Student's-t UCL	--	0.012
RRM -2.7 to -0.7	20	20	0.008	0.023	0.014	0.0155	95% Student's-t UCL	--	0.016	20	20	0.000	0.017	0.003	0.00691	95% Chebyshev (Mean, SD) UCL	--	0.007	20	20	0.003	0.017	0.011	0.0125	95% Student's-t UCL	2	0.013
RRM -0.7 to 0.0	--	--	--	--	--	--	--	--	0.016	--	--	--	--	--	--	--	--	0.007	--	--	--	--	--	--	--	--	0.013
RRM 0.0 to 0.8	23	23	0.029	0.484	0.106	0.186	95% Chebyshev (Mean, SD) UCL	--	0.186	21	21	0.005	0.381	0.047	0.123	95% Chebyshev (Mean, SD) UCL	--	0.123	21	21	0.023	0.105	0.059	0.0684	95% Student's-t UCL	--	0.068
RRM 0.8 to 1.7	10	10	0.059	0.226	0.130	0.159	95% Student's-t UCL	--	0.159	4	4	0.006	0.061	0.033	0.0598	95% Student's-t UCL	3	0.060	4	4	0.044	0.095	0.077	0.104	95% Student's-t UCL	2, 3, 4	0.095
RRM 1.7 to 2.7	28	28	0.062	0.543	0.215	0.245	95% Student's-t UCL	--	0.245	25	25	0.000	0.350	0.081	0.140	95% Chebyshev (Mean, SD) UCL	--	0.140	25	25	0.016	0.332	0.143	0.166	95% Student's-t UCL	--	0.166
RRM 2.7 to 4.4	42	42	0.223	1.129	0.481	0.529	95% Student's-t UCL	--	0.529	42	42	0.000	0.647	0.162	0.254	95% Chebyshev (Mean, SD) UCL	--	0.254	42	42	0.104	0.619	0.321	0.351	95% Adjusted Gamma UCL	--	0.351
RRM 4.4 to 5.2	--	--	--	--	--	--	--	--	0.529	--	--	--	--	--	--	--	--	0.254	--	--	--	--	--	--	--	--	0.367
RRM 5.2 to 7.9	42	42	0.084	1.050	0.479	0.523	95% Student's-t UCL	--	0.523	37	37	0.000	0.711	0.147	0.245	95% Chebyshev (Mean, SD)	--	0.245	37	37	0.073	0.582	0.335	0.367	95% Student's-t UCL	2	0.367
RRM 7.9 to 9.2	20	20	0.397	0.670	0.535	0.565	95% Student's-t UCL	--	0.565	20	20	0.044	0.288	0.145	0.167	95% Student's-t UCL	--	0.167	20	20	0.259	0.566	0.390	0.424	95% Student's-t UCL	--	0.424
RRM 9.2 to 11.3	7	7	0.250	0.713	0.385	0.561	95% Adjusted Gamma UCL	3	0.561	3	3	0.051	0.113	0.087	0.141	95% Student's-t UCL	2, 3, 4	0.113	3	3	0.232	0.269	0.246	0.28	95% Student's-t UCL	3, 4	0.269
RRM 11.3 to 12.5	29	29	0.306	0.636	0.477	0.502	95% Student's-t UCL	--	0.502	27	27	0.000	0.230	0.082	0.0983	95% Student's-t UCL	--	0.098	27	27	0.199	0.543	0.404	0.433	95% Student's-t UCL	2	0.433
RRM 12.5 to 13.5	20	20	0.206	0.856	0.566	0.622	95% Student's-t UCL	2	0.622	20	20	0.029	0.300	0.158	0.188	95% Student's-t UCL	--	0.188	20	20	0.134	0.655	0.408	0.464	95% Student's-t UCL	--	0.464
RRM 13.5 to 16.7	20	20	0.338	0.851	0.551	0.606	95% Student's-t UCL	--	0.606	20	20	0.000	0.223	0.0787	0.104	95% Student's-t UCL	--	0.104	20	20	0.228	0.953	0.484	0.555	95% Student's-t UCL	--	0.555
RRM 16.7 to 20.9	23	23	0.010	0.742	0.455	0.505	95% Student's-t UCL	2	0.505	23	23	0.000	0.160	0.084	0.104	95% Student's-t UCL	2	0.104	23	23	0.008	0.708	0.371	0.48	95% Chebyshev (Mean, SD) UCL	2	0.480
RRM 20.9 to 24.0	29	29	0.263	0.665	0.483	0.516	95% Student's-t UCL	2	0.516	27	27	0.000	0.407	0.078	0.153	95% Chebyshev (Mean, SD) UCL	--	0.153	27	27	0.176	0.597	0.399	0.433	95% Student's-t UCL	2	0.433
SFSR	25	25	0.010	0.391	0.135	0.201	95% Chebyshev (Mean, SD) UCL	--	0.201	23	23	0.000	0.213	0.024	0.0669	95% Chebyshev (Mean, SD) UCL	--	0.067	23	23	0.008	0.289	0.117	0.137	95% Student's-t UCL	--	0.137

Notes:
MeHg, Methylmercury; IHg, Inorganic mercury; RRM, Relative river mile; MR, Middle River; NR, North River; SFSR, South Fork Shenandoah River; ww, Wet weight.
Min, Max, and Mean - Minimum, Maximum, and Mean of the detected concentrations.
95% UCL, 95% Upper confidence level of the mean concentrations.
EPC, Exposure point concentration; Max or the 95% UCL, whichever is lower.
--, Not applicable.
a, EPCs in **bold and italics** are extrapolations based on the EPCs for the Reference Reach (RRM -2.7- -0.7); Used only for DRMs.

*UCL Notes:
1, Data set is too small to compute reliable and meaningful statistics and estimates.
2, For highly negative-skewed data, confidence limits (e.g., (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable.
3, Sample size is small (e.g., <10).
4, Recommended UCL exceeds the maximum observation.

Table E-10
Earthworm (Class Oligochaeta) Tissue (Whole Body) Mercury Exposure Point Concentrations (EPCs) for Dose Rate Modeling
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	WHOLE BODY IHg (mg/kg ww)									WHOLE BODY MeHg (mg/kg ww)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Note	EPC ^a	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Note	EPC ^a
RRM -2.7 to -0.7	6	6	0.065	0.182	0.133	0.17	95% Student's-t UCL	1, 2	0.17	6	6	0.002	0.004	0.003	0.003	95% Student's-t UCL	1	0.003
RRM -0.7 to 0.0	--	--	--	--	--	--	--	--	0.17	--	--	--	--	--	--	--	--	0.003
RRM 0.0 to 0.8	6	6	0.848	1.715	1.288	1.56	95% Student's-t UCL	1, 2	1.56	6	6	0.023	0.072	0.048	0.063	95% Student's-t UCL	1, 2	0.063
RRM 0.8 to 1.7	6	6	0.845	2.098	1.175	1.57	95% Student's-t UCL	1	1.57	6	6	0.068	0.210	0.138	0.186	95% Student's-t UCL	1, 2	0.186
RRM 1.7 to 2.7	15	15	0.530	5.369	2.947	3.58	95% Student's-t UCL	2	3.58	15	15	0.021	0.222	0.095	0.183	95% Chebyshev (Mean, SD) UCL	--	0.183
RRM 2.7 to 4.4	--	--	--	--	--	--	--	--	4.28	--	--	--	--	--	--	--	--	0.241
RRM 4.4 to 5.2	6	6	2.701	4.544	3.615	4.28	95% Student's-t UCL	1	4.28	6	6	0.075	0.241	0.130	0.273	95% Chebyshev (Mean, SD) UCL	1, 3	0.241
RRM 5.2 to 7.9	6	6	2.096	4.793	3.349	4.21	95% Student's-t UCL	1	4.21	6	6	0.071	0.088	0.080	0.086	95% Student's-t UCL	1	0.086
RRM 7.9 to 9.2	--	--	--	--	--	--	--	--	4.21	--	--	--	--	--	--	--	--	0.086
RRM 9.2 to 11.3	6	6	1.980	3.679	3.007	3.55	95% Student's-t UCL	1, 2	3.55	6	6	0.011	0.021	0.016	0.019	95% Student's-t UCL	1	0.019
RRM 11.3 to 12.5	6	6	2.010	5.758	3.559	4.65	95% Student's-t UCL	1	4.65	6	6	0.044	0.076	0.062	0.073	95% Student's-t UCL	1, 2	0.073
RRM 12.5 to 13.5	--	--	--	--	--	--	--	--	4.65	--	--	--	--	--	--	--	--	0.073
RRM 13.5 to 16.7	6	6	1.208	3.494	2.276	2.96	95% Student's-t UCL	1	2.96	6	6	0.017	0.033	0.027	0.032	95% Student's-t UCL	1, 2	0.032
RRM 16.7 to 20.9	9	9	0.648	4.646	1.834	2.62	95% Student's-t UCL	--	2.62	9	9	0.038	0.067	0.047	0.053	95% Student's-t UCL	--	0.053
RRM 20.9 to 24.0	6	6	0.374	1.739	0.995	1.40	95% Student's-t UCL	1	1.40	6	6	0.074	0.106	0.087	0.099	95% Student's-t UCL	1	0.099
SFSR	--	--	--	--	--	--	--	--	1.40	--	--	--	--	--	--	--	--	0.099

Notes:
MeHg, Methylmercury; IHg, Inorganic mercury; RRM, Relative river mile; SFSR, South Fork Shenandoah River; ww, Wet weight.
Min, Max, and Mean - Minimum, Maximum, and Mean of the detected concentrations.
95% UCL - 95% Upper confidence level of the mean concentrations.
EPC - Exposure point concentration; Max or the 95% UCL, whichever is lower.
--, Not applicable.
a, EPCs in **bold and italics** are extrapolations based on the EPCs for the appropriate next adjacent Reach.

*UCL Notes:
1, Sample size is small (e.g., <10).
2, For highly negative-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable.
3, Recommended UCL exceeds the maximum observation.

Table E-11
Wolf Spider (Family Lycosidae) Tissue (Whole Body) Mercury Exposure Point Concentrations (EPCs) for Dose Rate Modeling
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	WHOLE BODY IHg (mg/kg ww)									WHOLE BODY MeHg (mg/kg ww)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC ^a	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC ^a
RRM -2.7 to -0.7	--	--	--	--	--	--	--	--	<i>0.020</i>	--	--	--	--	--	--	--	--	<i>0.009</i>
RRM -0.7 to 0.0	--	--	--	--	--	--	--	--	<i>0.020</i>	--	--	--	--	--	--	--	--	<i>0.009</i>
RRM 0.0 to 0.8	--	--	--	--	--	--	--	--	<i>0.204</i>	--	--	--	--	--	--	--	--	<i>0.657</i>
RRM 0.8 to 1.7	--	--	--	--	--	--	--	--	<i>0.204</i>	--	--	--	--	--	--	--	--	<i>0.657</i>
RRM 1.7 to 2.7	3	3	0.055	0.204	0.117	0.248	95% Student's-t UCL	1, 3	0.204	3	3	0.177	0.657	0.360	0.797	95% Student's-t UCL	1, 3	0.657
RRM 2.7 to 4.4	--	--	--	--	--	--	--	--	<i>0.703</i>	--	--	--	--	--	--	--	--	<i>0.657</i>
RRM 4.4 to 5.2	--	--	--	--	--	--	--	--	<i>0.703</i>	--	--	--	--	--	--	--	--	<i>0.657</i>
RRM 5.2 to 7.9	--	--	--	--	--	--	--	--	<i>0.703</i>	--	--	--	--	--	--	--	--	<i>0.657</i>
RRM 7.9 to 9.2	--	--	--	--	--	--	--	--	<i>0.703</i>	--	--	--	--	--	--	--	--	<i>0.657</i>
RRM 9.2 to 11.3	--	--	--	--	--	--	--	--	<i>0.703</i>	--	--	--	--	--	--	--	--	<i>0.657</i>
RRM 11.3 to 12.5	3	3	0.013	0.703	0.409	1.01	95% Student's-t UCL	1, 2, 3	0.703	3	3	0.257	0.329	0.289	0.351	95% Student's-t UCL	1, 3	0.329
RRM 12.5 to 13.5	--	--	--	--	--	--	--	--	<i>0.703</i>	--	--	--	--	--	--	--	--	<i>1.028</i>
RRM 13.5 to 16.7	--	--	--	--	--	--	--	--	<i>0.703</i>	--	--	--	--	--	--	--	--	<i>1.028</i>
RRM 16.7 to 20.9	3	3	0.050	0.246	0.134	0.304	95% Student's-t UCL	1, 3	0.246	3	3	0.172	1.028	0.484	1.282	95% Student's-t UCL	1, 3	1.028
RRM 20.9 to 24.0	3	3	0.083	0.138	0.108	0.155	95% Student's-t UCL	1, 3	0.138	3	3	0.045	0.091	0.064	0.104	95% Student's-t UCL	1, 3	0.091
SFSR	--	--	--	--	--	--	--	--	<i>0.138</i>	--	--	--	--	--	--	--	--	<i>0.091</i>

Notes:
MeHg, Methylmercury; IHg, Inorganic mercury; RRM, Relative river mile; SFSR, South Fork Shenandoah River; ww, Wet weight.
Min, Max, and Mean - Minimum, Maximum, and Mean of the detected concentrations.
95% UCL - 95% Upper confidence level of the mean concentrations.
EPC - Exposure point concentration; Max or the 95% UCL, whichever is lower; For N < 5, data set is too small to compute reliable and meaningful statistics and estimates.
--, Not applicable.
a, EPCs in bold and italics are extrapolations based on the highest of the EPCs for the adjacent Reaches; EPCs for the Reference (RRM -2.7 -0-0.7) and Buffer (RRM -0.7 - 0.0) Reaches are assumed to be one tenth (1/10) of the minimum EPC calculated for the Assessment Reaches.

*UCL Notes:
1, Sample size is small (e.g., <10).
2, For highly negative-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable.
3, Recommended UCL exceeds the maximum observation.

Table E-12a
Fish Tissue (Whole Body) Mercury Exposure Point Concentrations (EPCs) for Food Web Modeling
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	WHOLE BODY IHg (mg/kg ww)									WHOLE BODY MeHg (mg/kg ww)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC
Small Fish (0-130 mm)																		
RRM -2.7 to -0.7	28	28	0.00	0.22	0.02	0.06	95% Chebyshev (Mean, SD) UCL	--	0.06	28	28	0.01	0.32	0.09	0.12	95% Adjusted Gamma UCL	--	0.12
RRM -0.7 to 0.0	--	--	--	--	--	--	--	--	0.06	--	--	--	--	--	--	--	--	0.12
RRM 0.0 to 0.8	13	13	0.002	0.746	0.336	0.485	95% Student's-t UCL	--	0.49	13	13	0.013	0.639	0.137	0.222	95% Student's-t UCL	--	0.22
RRM 0.8 to 1.7	19	19	0.00	0.29	0.05	0.07	95% Adjusted Gamma UCL	--	0.07	19	19	0.02	1.39	0.24	0.37	95% Adjusted Gamma UCL	--	0.37
RRM 1.7 to 2.7	26	26	0.00	0.26	0.07	0.09	95% Student's-t UCL	--	0.09	26	26	0.11	0.94	0.42	0.49	95% Student's-t UCL	--	0.49
RRM 2.7 to 4.4	38	38	0.00	0.40	0.13	0.21	95% Chebyshev (Mean, SD) UCL	--	0.21	38	38	0.13	1.32	0.57	0.69	95% Adjusted Gamma UCL	--	0.69
RRM 4.4 to 5.2	--	--	--	--	--	--	--	--	0.32	--	--	--	--	--	--	--	--	1.18
RRM 5.2 to 7.9	8	8	0.00	0.52	0.19	0.32	95% Student's-t UCL	2	0.32	8	8	0.78	1.29	1.06	1.18	95% Student's-t UCL	1, 2	1.18
RRM 7.9 to 9.2	4	4	0.00	0.22	0.13	0.25	95% Student's-t UCL	1, 2, 3	0.22	4	4	0.98	1.51	1.21	1.50	95% Student's-t UCL	2	1.50
RRM 9.2 to 11.3	27	27	0.00	0.27	0.07	0.09	95% Student's-t UCL	--	0.09	27	27	0.01	1.44	0.50	0.79	95% Chebyshev (Mean, SD) UCL	--	0.79
RRM 11.3 to 12.5	33	33	0.00	0.63	0.22	0.32	95% Chebyshev (Mean, SD) UCL	--	0.32	33	33	0.29	1.62	0.79	0.90	95% Student's-t UCL	--	0.90
RRM 12.5 to 13.5	4	4	0.00	0.18	0.07	0.16	95% Student's-t UCL	2	0.16	4	4	0.67	1.50	1.05	1.45	95% Student's-t UCL	2	1.45
RRM 13.5 to 16.7	4	4	0.00	0.20	0.10	0.23	95% Student's-t UCL	2, 3	0.20	4	4	0.79	2.56	1.52	2.44	95% Student's-t UCL	2	2.44
RRM 16.7 to 20.9	9	9	0.00	0.22	0.08	0.12	95% Student's-t UCL	2	0.12	9	9	0.26	1.71	0.86	1.20	95% Student's-t UCL	2	1.20
RRM 20.9 to 24.0	34	34	0.00	0.61	0.13	0.23	95% Chebyshev (Mean, SD) UCL	--	0.23	34	34	0.15	1.40	0.71	0.80	95% Student's-t UCL	--	0.80
SFSR	23	23	0.00	0.10	0.03	0.04	95% Student's-t UCL	--	0.04	23	23	0.08	0.50	0.20	0.24	95% Student's-t UCL	--	0.24
Large Fish (130-350 mm)																		
RRM -2.7 to -0.7	100	95	0.00	0.07	0.01	0.01	95% KM (BCA) UCL	--	0.01	100	95	0.03	1.74	0.16	0.18	95% KM (BCA) UCL	--	0.18
RRM -0.7 to 0.0	--	--	--	--	--	--	--	--	0.01	--	--	--	--	--	--	--	--	0.18
RRM 0.0 to 0.8	270	252	0.00	0.32	0.04	0.05	97.5% KM (Chebyshev) UCL	--	0.05	270	252	0.01	1.89	0.40	0.46	95% KM (Chebyshev) UCL	--	0.46
RRM 0.8 to 1.7	64	64	0.00	0.13	0.05	0.07	95% Chebyshev (Mean, SD) UCL	--	0.07	64	64	0.03	1.49	0.55	0.62	95% Student's-t UCL	--	0.62
RRM 1.7 to 2.7	108	108	0.01	0.24	0.08	0.09	95% Approximate Gamma UCL	--	0.09	108	108	0.23	2.75	0.98	1.05	95% Student's-t UCL	--	1.05
RRM 2.7 to 4.4	47	47	0.00	0.35	0.08	0.11	95% Chebyshev (Mean, SD) UCL	--	0.11	47	47	0.19	3.97	0.91	1.06	95% Adjusted Gamma UCL	--	1.06
RRM 4.4 to 5.2	59	59	0.05	0.18	0.12	0.13	95% Student's-t UCL	--	0.13	59	59	0.29	2.13	1.30	1.40	95% Student's-t UCL	--	1.40
RRM 5.2 to 7.9	40	40	0.00	0.32	0.13	0.17	95% Adjusted Gamma UCL	--	0.17	40	40	0.05	3.09	1.09	1.39	95% Adjusted Gamma UCL	--	1.39
RRM 7.9 to 9.2	--	--	--	--	--	--	--	--	0.17	--	--	--	--	--	--	--	--	1.39
RRM 9.2 to 11.3	47	47	0.00	0.32	0.12	0.16	95% Chebyshev (Mean, SD) UCL	--	0.16	47	47	0.49	2.29	1.16	1.30	95% Adjusted Gamma UCL	--	1.30
RRM 11.3 to 12.5	197	197	0.01	0.28	0.12	0.12	95% Student's-t UCL	--	0.12	197	197	0.17	3.25	1.35	1.41	95% Student's-t UCL	--	1.41
RRM 12.5 to 13.5	--	--	--	--	--	--	--	--	0.13	--	--	--	--	--	--	--	--	1.47
RRM 13.5 to 16.7	37	37	0.01	0.22	0.10	0.13	95% Adjusted Gamma UCL	--	0.13	37	37	0.10	2.58	1.27	1.47	95% Student's-t UCL	--	1.47
RRM 16.7 to 20.9	61	47	0.00	0.33	0.10	0.13	97.5% KM (Chebyshev) UCL	--	0.13	61	47	0.06	1.74	0.91	0.82	95% KM (t) UCL	--	0.82
RRM 20.9 to 24.0	224	224	0.00	0.32	0.09	0.10	95% Chebyshev (Mean, SD) UCL	--	0.10	224	224	0.01	3.26	1.00	1.17	95% Chebyshev (Mean, SD) UCL	--	1.17
SFSR	717	717	0.00	0.37	0.04	0.04	95% Chebyshev (Mean, SD) UCL	--	0.04	717	717	0.02	1.36	0.48	0.52	95% Chebyshev (Mean, SD) UCL	--	0.52

Notes:
MeHg, Methylmercury; IHg, Inorganic mercury; RRM, Relative river mile; SFSR, South Fork Shenandoah River; ww, Wet weight.
Min, Max, and Mean - Minimum, Maximum, and Mean of the detected concentrations.
95% UCL, 95% Upper confidence level of the mean concentrations.
EPC, Exposure point concentration; Max or the 95% UCL, whichever is lower.
--, Not applicable.
a, EPCs in **bold and italics** are extrapolations based on the EPCs for the appropriate next adjacent Reach.

*UCL Notes:
1, Sample size is small (e.g., <10).
2, For highly negative-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable.
3, Recommended UCL exceeds the maximum observation.

Table E-12b
Bass Tissue (Whole Body) Mercury Exposure Point Concentrations (EPCs) for Comparisons with Critical Body Residues (CBRs)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	WHOLE BODY THg (mg/kg ww)									WHOLE BODY MeHg (mg/kg ww)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC
Young of the Year Bass (YOY, TL < 130 mm)																		
RRM 0.0 to 0.8	1	1	0.088	0.088	0.088	--	--	1	0.088	1	1	0.079	0.079	0.079	--	--	1	0.079
RRM 2.7 to 4.4	1	1	1.330	1.330	1.330	--	--	1	1.330	1	1	1.197	1.197	1.197	--	--	1	1.197
RRM 9.2 to 11.3	5	5	0.549	1.717	1.042	1.537	95% Student's-t UCL	2	1.537	5	5	0.494	1.444	0.948	1.369	95% Student's-t UCL	2	1.369
RRM 11.3 to 12.5	1	1	1.400	1.400	1.400	--	--	1	1.400	1	1	1.260	1.260	1.260	--	--	1	1.260
RRM 16.7 to 20.9	2	2	0.849	1.149	0.999	--	--	1	1.149	2	2	0.632	1.105	0.869	--	--	1	1.105
SFSR	2	2	0.093	0.213	0.153	--	--	1	0.213	2	2	0.083	0.192	0.138	--	--	1	0.192
Adult Bass (TL > 130 mm)																		
RRM -2.7 to -0.7	58	58	0.07	1.814	0.2387	0.405	95% Chebyshev (Mean, SD) UCL	--	0.405	58	58	0.066	1.744	0.2295	0.391	95% Chebyshev (Mean, SD) UCL	--	0.391
RRM 0.0 to 0.8	223	223	0.106	2.248	0.533	0.573	Use 95% H-UCL	3	0.573	223	223	0.102	2.158	0.512	0.55	Use 95% H-UCL	3	0.550
RRM 0.8 to 1.7	39	39	0.070	2.166	0.749	0.879	Use 95% Student's-t UCL	--	0.879	39	39	0.067	2.080	0.717	0.842	Use 95% Student's-t UCL	--	0.842
RRM 1.7 to 2.7	67	67	0.339	4.487	1.312	1.427	Use 95% Student's-t UCL	--	1.427	67	67	0.329	4.278	1.257	1.358	95% Approximate Gamma UCL	--	1.358
RRM 2.7 to 4.4	49	49	0.209	4.320	1.155	1.334	95% Adjusted Gamma UCL	--	1.334	49	49	0.201	4.147	1.109	1.28	95% Adjusted Gamma UCL	--	1.280
RRM 4.4 to 5.2	29	29	1.071	3.017	1.909	2.044	Use 95% Student's-t UCL	--	2.044	29	29	1.028	2.896	1.824	1.948	Use 95% Student's-t UCL	--	1.948
RRM 5.2 to 7.9	21	21	0.081	4.988	2.237	2.691	Use 95% Student's-t UCL	--	2.691	21	21	0.075	4.801	2.097	2.542	Use 95% Student's-t UCL	--	2.542
RRM 9.2 to 11.3	20	20	1.122	3.234	1.996	2.197	Use 95% Student's-t UCL	--	2.197	20	20	1.098	3.105	1.908	2.104	Use 95% Student's-t UCL	--	2.104
RRM 11.3 to 12.5	176	176	0.429	3.588	1.582	1.656	95% Approximate Gamma UCL	--	1.656	176	176	0.417	3.495	1.518	1.59	95% Approximate Gamma UCL	--	1.590
RRM 13.5 to 16.7	23	23	0.259	2.807	1.918	2.142	Use 95% Student's-t UCL	4	2.142	23	23	0.249	2.695	1.844	2.059	Use 95% Student's-t UCL	4	2.059
RRM 16.7 to 20.9	21	21	0.378	2.359	1.424	1.617	Use 95% Student's-t UCL	--	1.617	21	21	0.363	2.265	1.362	1.551	Use 95% Student's-t UCL	4	1.551
RRM 20.9 to 24.0	215	215	0.106	3.548	1.284	1.469	95% Chebyshev (Mean, SD) UCL	--	1.469	215	215	0.102	3.406	1.233	1.409	95% Chebyshev (Mean, SD) UCL	--	1.409
SFSR	453	453	0.07	2.282	0.7271	0.789	95% Chebyshev (Mean, SD) UCL	--	0.789	453	453	0.067	1.876	0.6975	0.756	95% Chebyshev (Mean, SD) UCL	--	0.756

Notes:
MeHg, Methylmercury; IHg, Inorganic mercury; RRM, Relative river mile; SFSR, South Fork Shenandoah River; ww, Wet weight.
Min, Max, and Mean - Minimum, Maximum, and Mean of the detected concentrations.
95% UCL - 95% Upper confidence level of the mean concentrations.
EPC, Exposure point concentration; Max or the 95% UCL, whichever is lower.
--, Not applicable.

*UCL Notes:
1, Data set is too small to compute reliable and meaningful statistics and estimates.
2, A sample size of N = 5 may not adequate enough to compute meaningful and reliable test statistics and estimates.
3, H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide. It is therefore recommended to avoid the use of H-statistic based 95% UCLs.
4, For highly negative-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable.

Table E-13a
Amphibian Tissue (Whole Body) Mercury Exposure Point Concentrations (EPCs) for Dose Rate Modeling
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Whole Body THg (mg/kg ww)																													
Assessment Reach	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC ^a	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC ^a	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC ^a	Average EPC ^b	
	AMERICAN TOAD									NORTHERN TWO-LINED SALAMANDER									RED-BACK SALAMANDER										
SR WNP Lower ^c	3	3	0.011	0.022	0.015	0.0253	95% Student's-t UCL	1	0.022	10	10	0.011	0.061	0.027	0.0351	95% Student's-t UCL	NA	0.035	6	6	0.010	0.015	0.012	0.0137	95% Student's-t UCL	3	0.014	0.024	
RRM -2.7 to -0.7	10	10	0.008	0.026	0.019	0.0231	95% Student's-t UCL	2	0.023	--	--	--	--	--	--	--	--	0.035	--	--	--	--	--	--	--	--	0.014	0.024	
RRM -0.7 to 0.0	--	--	--	--	--	--	--	--	0.023	--	--	--	--	--	--	--	--	0.035	--	--	--	--	--	--	--	--	0.014	0.024	
RRM 0.0 to 0.8	--	--	--	--	--	--	--	--	0.026	--	--	--	--	--	--	--	--	0.267	6	6	0.013	0.043	0.028	0.0377	95% Student's-t UCL	3	0.038	0.110	
RRM 0.8 to 1.7	--	--	--	--	--	--	--	--	0.026	--	--	--	--	--	--	--	--	0.267	--	--	--	--	--	--	--	--	0.232	0.175	
RRM 1.7 to 2.7	--	--	--	--	--	--	--	--	0.026	5	5	0.132	0.279	0.212	0.267	95% Student's-t UCL	3	0.267	--	--	--	--	--	--	--	--	0.232	0.175	
RRM 2.7 to 4.4	--	--	--	--	--	--	--	--	0.026	--	--	--	--	--	--	--	--	0.650	--	--	--	--	--	--	--	--	0.232	0.303	
RRM 4.4 to 5.2	12	12	0.015	0.038	0.022	0.0262	95% Student's-t UCL	--	0.026	5	5	0.275	0.710	0.489	0.65	95% Student's-t UCL	3	0.650	--	--	--	--	--	--	--	--	0.232	0.303	
RRM 5.2 to 7.9	--	--	--	--	--	--	--	--	0.125	--	--	--	--	--	--	--	--	0.650	--	--	--	--	--	--	--	--	0.232	0.336	
RRM 7.9 to 9.2	13	13	0.015	0.227	0.070	0.125	95% Adjusted Gamma UCL	--	0.125	5	5	0.201	0.509	0.345	0.451	95% Student's-t UCL	3	0.451	--	--	--	--	--	--	--	--	0.232	0.269	
RRM 9.2 to 11.3	--	--	--	--	--	--	--	--	0.138	--	--	--	--	--	--	--	--	0.451	--	--	--	--	--	--	--	--	0.232	0.274	
RRM 11.3 to 12.5	--	--	--	--	--	--	--	--	0.138	1	1	0.444	0.444	0.444	--	--	--	0.444	--	--	--	--	--	--	--	--	0.232	0.271	
RRM 12.5 to 13.5	--	--	--	--	--	--	--	--	0.138	--	--	--	--	--	--	--	--	0.530	6	6	0.011	0.383	0.121	0.232	95% Student's-t UCL	3	0.232	0.300	
RRM 13.5 to 16.7	--	--	--	--	--	--	--	--	0.138	9	9	0.375	0.605	0.484	0.53	95% Student's-t UCL	--	0.530	--	--	--	--	--	--	--	--	0.232	0.300	
RRM 16.7 to 20.9	10	10	0.006	0.190	0.093	0.138	95% Student's-t UCL	4	0.138	5	5	0.344	0.774	0.502	0.685	95% Student's-t UCL	3	0.685	6	6	0.018	0.090	0.050	0.0733	95% Student's-t UCL	3	0.073	0.299	
RRM 20.9 to 24.0	--	--	--	--	--	--	--	--	0.138	5	5	0.370	0.504	0.449	0.501	95% Student's-t UCL	3	0.501	--	--	--	--	--	--	--	--	0.073	0.237	
SFSR	--	--	--	--	--	--	--	--	0.138	5	5	0.111	0.233	0.147	0.195	95% Student's-t UCL	3	0.195	--	--	--	--	--	--	--	--	0.073	0.135	
Whole Body MeHg (mg/kg ww)																													
River Reach	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC ^a	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC ^a	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC ^a	Average EPC ^b	
	AMERICAN TOAD									NORTHERN TWO-LINED SALAMANDER									RED-BACK SALAMANDER										
SR WNP Lower ^c	3	3	0.012	0.021	0.015	0.0238	95% Student's-t UCL	3	0.021	10	10	0.012	0.068	0.030	0.0396	95% Student's-t UCL	NA	0.040	6	6	0.012	0.017	0.014	0.0155	95% Student's-t UCL	3	0.016	0.025	
RRM -2.7 to -0.7	10	10	0.013	0.031	0.021	0.0245	95% Student's-t UCL	--	0.025	--	--	--	--	--	--	--	--	0.040	--	--	--	--	--	--	--	--	0.016	0.027	
RRM -0.7 to 0.0	--	--	--	--	--	--	--	--	0.025	--	--	--	--	--	--	--	--	0.040	--	--	--	--	--	--	--	--	0.016	0.027	
RRM 0.0 to 0.8	--	--	--	--	--	--	--	--	0.027	--	--	--	--	--	--	--	--	0.301	6	6	0.015	0.048	0.031	0.0425	95% Student's-t UCL	3	0.043	0.123	
RRM 0.8 to 1.7	--	--	--	--	--	--	--	--	0.027	--	--	--	--	--	--	--	--	0.301	--	--	--	--	--	--	--	--	0.261	0.196	
RRM 1.7 to 2.7	--	--	--	--	--	--	--	--	0.027	5	5	0.148	0.315	0.239	0.301	95% Student's-t UCL	3	0.301	--	--	--	--	--	--	--	--	0.261	0.196	
RRM 2.7 to 4.4	--	--	--	--	--	--	--	--	0.027	--	--	--	--	--	--	--	--	0.733	--	--	--	--	--	--	--	--	0.261	0.340	
RRM 4.4 to 5.2	12	12	0.017	0.043	0.023	0.0265	95% Student's-t UCL	--	0.027	5	5	0.310	0.800	0.551	0.733	95% Student's-t UCL	3	0.733	--	--	--	--	--	--	--	--	0.261	0.340	
RRM 5.2 to 7.9	--	--	--	--	--	--	--	--	0.150	--	--	--	--	--	--	--	--	0.733	--	--	--	--	--	--	--	--	0.261	0.381	
RRM 7.9 to 9.2	13	13	0.017	0.256	0.078	0.15	95% H-UCL	5	0.150	5	5	0.226	0.573	0.389	0.509	95% Student's-t UCL	3	0.509	--	--	--	--	--	--	--	--	0.261	0.307	
RRM 9.2 to 11.3	--	--	--	--	--	--	--	--	0.200	--	--	--	--	--	--	--	--	0.509	--	--	--	--	--	--	--	--	0.261	0.323	
RRM 11.3 to 12.5	--	--	--	--	--	--	--	--	0.200	1	1	0.501	0.501	0.501	--	--	--	0.501	--	--	--	--	--	--	--	--	0.261	0.321	
RRM 12.5 to 13.5	--	--	--	--	--	--	--	--	0.200	--	--	--	--	--	--	--	--	0.598	6	6	0.013	0.432	0.136	0.261	95% Student's-t UCL	3	0.261	0.353	
RRM 13.5 to 16.7	--	--	--	--	--	--	--	--	0.200	9	9	0.423	0.682	0.546	0.598	95% Student's-t UCL	--	0.598	--	--	--	--	--	--	--	--	0.261	0.353	
RRM 16.7 to 20.9	10	10	0.011	0.337	0.125	0.2	95% Student's-t UCL	--	0.200	5	5	0.388	0.872	0.566	0.773	95% Student's-t UCL	3	0.773	6	6	0.020	0.102	0.056	0.0827	95% Student's-t UCL	3	0.083	0.352	
RRM 20.9 to 24.0	--	--	--	--	--	--	--	--	0.200	5	5	0.417	0.568	0.506	0.565	95% Student's-t UCL	3	0.565	--	--	--	--	--	--	--	--	0.083	0.283	
SFSR	--	--	--	--	--	--	--	--	0.200	5	5	0.125	0.262	0.165	0.219	95% Student's-t UCL	3	0.219	--	--	--	--	--	--	--	--	0.083	0.167	

Notes:
MeHg, Methylmercury; IHg, Inorganic mercury; RRM, Relative river mile; SFSR, South Fork Shenandoah River; ww, Wet weight.
Min, Max, and Mean - Minimum, Maximum, and Mean of the detected concentrations.
95% UCL - 95% Upper confidence level of the mean concentrations.
EPC, Exposure point concentration; Max or the 95% UCL, whichever is lower; For N < 5, data set is too small to compute reliable and meaningful statistics and estimates.
--, Not applicable.
a, EPCs in **bold and italics** are extrapolations based on the EPCs for the appropriate next adjacent Reach.
b, Final EPCs used in Dose Rate Models (DRMs) are the averages of three species EPCs for the Reach.
c, Reference Area [Lower South River Waynesboro Nursery Property (SR WNP Lower)] used to fill data gaps for EPCs in the Reference (RRM -2.7 - -0.7) and Buffer (RRM -0.07 - 0.0) Reaches.

*UCL Notes:
1, Data set is too small to compute reliable and meaningful statistics and estimates.
2, For highly negative-skewed data, confidence limits (e.g., (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable.
3, Sample size is small (e.g., <10).
4, Recommended UCL exceeds the maximum observation.
5, H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide. It is therefore recommended to avoid the use of H-statistic based 95% UCLs.

Table E-13b
Amphibian Tissue (Whole Body) Mercury Exposure Point Concentrations (EPCs) for Direct Comparisons Critical Body Residues (CBRs)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	Whole Body THg (mg/kg ww)									Whole Body MeHg (mg/kg ww)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Note*	EPC
AMERICAN TOAD																		
SR WNP Lower	3	3	0.024	0.043	0.030	0.049	95% Student's-t UCL	1	0.043	2	2	0.012	0.021	0.017	NA	--	1	0.021
RRM -2.7 to -0.7	10	10	0.021	0.052	0.040	0.047	95% Student's-t UCL	2	0.047	8	8	0.013	0.031	0.023	0.0263	Use 95% Student's-t UCL	2	0.026
RRM 4.4 to 5.2	12	12	0.032	0.081	0.045	0.054	95% Adjusted Gamma UCL	--	0.054	5	5	0.018	0.028	0.022	0.0252	Use 95% Student's-t UCL	3	0.025
RRM 7.9 to 9.2	13	13	0.031	0.484	0.148	0.259	95% Adjusted Gamma UCL	--	0.259	2	2	0.033	0.036	0.034	NA	--	1	0.036
RRM 16.7 to 20.9	10	10	0.020	0.522	0.219	0.333	95% Student's-t UCL	--	0.333	10	10	0.011	0.337	0.125	0.2	Use 95% Student's-t UCL	--	0.200
NORTHERN TWO-LINED SALAMANDER																		
SR WNP Lower	10	10	0.023	0.129	0.057	0.075	Use 95% Student's-t UCL	--	0.075									
RRM 1.7 to 2.7	5	5	0.280	0.594	0.452	0.567	Use 95% Student's-t UCL	2,3	0.567									
RRM 4.4 to 5.2	5	5	0.586	1.510	1.040	1.384	Use 95% Student's-t UCL	3	1.384									
RRM 7.9 to 9.2	5	5	0.427	1.082	0.733	0.959	Use 95% Student's-t UCL	3	0.959									
RRM 11.3 to 12.5	1	1	0.945	0.945	0.945	NA	--	1	0.945									
RRM 13.5 to 16.7	9	9	0.798	1.286	1.030	1.128	Use 95% Student's-t UCL	--	1.128									
RRM 16.7 to 20.9	5	5	0.733	1.646	1.068	1.458	Use 95% Student's-t UCL	3	1.458									
RRM 20.9 to 24.0	5	5	0.787	1.072	0.954	1.066	Use 95% Student's-t UCL	2,3	1.066									
SFSR	5	5	0.237	0.495	0.312	0.414	Use 95% Student's-t UCL	3	0.414									
RED BACK SALAMANDER																		
SR WNP Lower	6	6	0.022	0.033	0.026	0.029	Use 95% Student's-t UCL	3	0.029									
RRM 0.0 to 0.8	6	6	0.028	0.091	0.059	0.080	Use 95% Student's-t UCL	3	0.080									
RRM 12.5 to 13.5	6	6	0.024	0.816	0.257	0.493	95% Student's-t UCL	3	0.493									
RRM 16.7 to 20.9	6	6	0.038	0.192	0.105	0.156	Use 95% Student's-t UCL	3	0.156									

Notes:
THg, Total mercury; MeHg, Methylmercury; SR WNP, South River Waynesboro Nursery Property; SFSR, South Fork Shenandoah River; ww, Wet weight.
Min, Max, and Mean - Minimum, Maximum, and Mean of the detected concentrations.
95% UCL, 95% Upper confidence level of the mean concentrations.
EPC, Exposure point concentration; Max or the 95% UCL, whichever is lower; For N < 5, data set is too small to compute reliable and meaningful statistics and estimates.
NA, Not calculated.
--, Not applicable.

*UCL Notes:
1, Data set is too small to compute reliable and meaningful statistics and estimates.
2, For highly negative-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable.
3, Sample size is small (e.g., <10).

Table E-14a
Small Birds Tissue (Muscle) Mercury Exposure Point Concentrations (EPCs) for Dose Rate Modeling
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	MUSCLE IHg (mg/kg ww)									MUSCLE MeHg (mg/kg ww)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC ^a	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC ^a
RRM -2.7 to -0.7	116	116	0.001	0.295	0.036	0.0426	95% Approximate Gamma UCL	--	0.043	116	116	0.008	2.165	0.315	0.37	95% Approximate Gamma UCL	--	0.370
RRM 0.0 to 0.7	--	--	--	--	--	--	--	--	0.043	--	--	--	--	--	--	--	--	0.370
RRM 0.0 to 0.8	--	--	--	--	--	--	--	--	0.179	--	--	--	--	--	--	--	--	1.703
RRM 0.8 to 1.7	60	60	0.001	0.850	0.138	0.1790	95% Approximate Gamma UCL	--	0.179	60	60	0.013	7.231	1.319	1.703	95% Approximate Gamma UCL	--	1.703
RRM 1.7 to 2.7	209	209	0.001	1.066	0.184	0.2360	95% Chebyshev (Mean, SD) UCL	--	0.236	209	209	0.005	7.816	1.593	2.011	95% Chebyshev (Mean, SD) UCL	--	2.011
RRM 2.7 to 4.4	138	138	0.002	1.205	0.181	0.2640	95% Chebyshev (Mean, SD) UCL	--	0.264	138	138	0.021	8.887	1.628	2.304	95% Chebyshev (Mean, SD) UCL	--	2.304
RRM 4.4 to 5.2	119	119	0.000	1.193	0.215	0.3180	95% Chebyshev (Mean, SD) UCL	--	0.318	119	119	0.003	9.522	1.902	2.735	95% Chebyshev (Mean, SD) UCL	--	2.735
RRM 5.2 to 7.9	19	19	0.014	0.583	0.255	0.3420	95% Student's-t UCL	--	0.342	19	19	0.105	4.277	2.063	2.685	95% Student's-t UCL	--	2.685
RRM 7.9 to 9.2	91	91	0.002	1.195	0.274	0.3450	95% Approximate Gamma UCL	--	0.345	91	91	0.025	13.741	2.784	4.304	95% Chebyshev (Mean, SD) UCL	--	4.304
RRM 9.2 to 11.3	404	404	0.003	2.856	0.304	0.3870	95% Chebyshev (Mean, SD) UCL	--	0.387	404	404	0.031	20.944	2.416	3.027	95% Chebyshev (Mean, SD) UCL	--	3.027
RRM 11.3 to 12.5	429	429	0.000	1.660	0.270	0.338	95% Chebyshev (Mean, SD) UCL	--	0.338	429	429	0.011	13.892	2.290	2.8270	95% Chebyshev (Mean, SD) UCL	--	2.827
RRM 12.5 to 13.5	22	22	0.003	1.083	0.218	0.3970	95% Adjusted Gamma UCL	--	0.397	22	22	0.038	12.457	2.510	4.566	95% Adjusted Gamma UCL	--	4.566
RRM 13.5 to 16.7	205	205	0.002	1.850	0.284	0.3940	95% Chebyshev (Mean, SD) UCL	--	0.394	205	205	0.028	14.922	2.596	3.54	95% Chebyshev (Mean, SD) UCL	--	3.540
RRM 16.7 to 20.9	234	234	0.002	2.592	0.264	0.3760	95% Chebyshev (Mean, SD) UCL	--	0.376	234	234	0.004	19.008	2.516	3.661	95% H-UCL	1	3.661
RRM 20.9 to 24.0	328	328	0.000	2.336	0.306	0.408	95% Chebyshev (Mean, SD) UCL	--	0.408	328	328	0.023	26.864	2.792	3.7500	95% Chebyshev (Mean, SD) UCL	--	3.750
SFSR	43	43	0.003	0.415	0.140	0.2250	95% Chebyshev (Mean, SD) UCL	--	0.225	43	43	0.031	3.045	1.182	1.825	95% Chebyshev (Mean, SD) UCL	--	1.825

Notes:
IHg, Inorganic mercury; MeHg, Methylmercury; ww, Wet weight.
Min, Max, and Mean - Minimum, Maximum, and Mean of the detected concentrations.
95% UCL, 95% Upper confidence level of the mean concentrations.
EPC, Exposure point concentration; Max or the 95% UCL, whichever is lower; For N < 5, data set is too small to compute reliable and meaningful statistics and estimates.
--, Not applicable.
a, EPCs in ***bold and italics*** are extrapolations based on the EPCs for adjacent Reach.

*UCL Notes:
1, H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide. It is therefore recommended to avoid the of H-statistic based 95% UCLs.

Table E-14b
Avian Tissue (Blood) Mercury Exposure Point Concentrations (EPCs) Calculated for Comparisons with Critical Body Residues (CBRs)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	BLOOD THg (mg/kg ww)									BLOOD MeHg (mg/kg ww)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Note*	EPC	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC
AMERICAN ROBIN																		
MR Middle	1	1	0.041	0.041	0.041	--	--	1	0.041	1	1	0.036	0.036	0.036	--	--	1	0.036
NR Upper	2	2	0.023	0.029	0.026	--	--	1	0.029	2	2	0.020	0.025	0.023	--	--	1	0.025
SR WNP Lower	1	1	0.089	0.089	0.089	--	--	1	0.089	1	1	0.078	0.078	0.078	--	--	1	0.078
RRM 1.7 to 2.7	5	5	0.089	4.633	1.313	3.140	95% Student's-t UCL	3	3.140	5	5	0.078	4.403	1.239	2.979	95% Student's-t UCL	3	2.979
RRM 4.4 to 5.2	1	1	0.774	0.774	0.774	--	--	1	0.774	1	1	0.681	0.681	0.681	--	--	1	0.681
RRM 16.7 to 20.9	2	2	0.198	0.363	0.280	--	--	1	0.363	2	2	0.174	0.351	0.263	--	--	1	0.351
RRM 20.9 to 24.0	1	1	0.259	0.259	0.259	--	--	1	0.259	1	1	0.228	0.228	0.228	--	--	1	0.228
BELTED KINGFISHER																		
MR Lower	18	18	0.038	3.190	0.457	1.316	95% Chebyshev (Mean, SD) UCL	--	1.316	18	18	0.033	2.807	0.402	1.158	95% Chebyshev (Mean, SD) UCL	--	1.158
MR Middle	22	22	0.035	1.160	0.156	0.235	95% Adjusted Gamma UCL	--	0.235	22	22	0.031	1.021	0.137	0.206	95% Adjusted Gamma UCL	--	0.206
MR Upper	2	2	0.115	0.313	0.214	--	--	1	0.313	2	2	0.101	0.275	0.188	--	--	1	0.275
NR Lower	4	4	0.347	10.700	3.005	9.043	95% Student's-t UCL	3	9.043	4	4	0.305	9.416	2.644	7.958	95% Student's-t UCL	3	7.958
NR Upper	37	37	0.032	0.317	0.089	0.136	95% Chebyshev (Mean, SD) UCL	--	0.136	37	37	0.028	0.279	0.078	0.120	95% Chebyshev (Mean, SD) UCL	--	0.120
SR RRM 16.7 to 20.9a	1	1	3.060	3.060	3.060	--	--	1	3.060	1	1	2.693	2.693	2.693	--	--	1	2.693
RRM 0.8 to 1.7	17	17	0.129	1.850	0.450	0.995	95% Chebyshev (Mean, SD) UCL	--	0.995	17	17	0.114	1.628	0.396	0.875	95% Chebyshev (Mean, SD) UCL	--	0.875
RRM 2.7 to 4.4	10	10	0.153	2.840	0.869	1.789	95% Adjusted Gamma UCL	--	1.789	10	10	0.135	2.499	0.764	1.574	95% Adjusted Gamma UCL	--	1.574
RRM 4.4 to 5.2	10	10	0.047	4.600	1.182	2.940	95% Adjusted Gamma UCL	--	2.940	10	10	0.042	4.048	1.040	2.587	95% Adjusted Gamma UCL	--	2.587
RRM 5.2 to 7.9	1	1	4.490	4.490	4.490	--	--	1	4.490	1	1	3.951	3.951	3.951	--	--	1	3.951
RRM 7.9 to 9.2	13	13	0.168	5.740	0.915	2.835	95% Chebyshev (Mean, SD) UCL	--	2.835	13	13	0.148	5.051	0.805	2.495	95% Chebyshev (Mean, SD) UCL	--	2.495
RRM 9.2 to 11.3	4	4	2.750	4.661	3.783	4.787	95% Student's-t UCL	2, 3, 4	4.661	4	4	2.420	4.101	3.329	4.213	95% Student's-t UCL	2, 3, 4	4.101
RRM 11.3 to 12.5	2	2	0.948	8.389	4.668	--	--	1	8.389	2	2	0.834	7.382	4.108	--	--	1	7.382
RRM 13.5 to 16.7	5	5	0.097	9.990	2.098	436.1	95% Hall's Bootstrap UCL	3, 6	9.990	5	5	0.085	8.791	1.846	368.300	95% Hall's Bootstrap UCL	3, 6	8.791
SFSR	32	32	0.024	1.230	0.226	0.312	95% Adjusted Gamma UCL	--	0.312	32	32	0.021	1.082	0.199	0.275	95% Adjusted Gamma UCL	--	0.275
EASTERN SCREECH OWL																		
MR Middle	4	4	0.109	0.228	0.167	0.228	95% Student's-t UCL	3, 4	0.228	4	4	0.096	0.201	0.147	0.201	95% Student's-t UCL	3, 4	0.201
NR Lower	2	2	2.150	2.260	2.205	--	--	1	2.260	2	2	1.892	1.989	1.940	--	--	1	1.989
NR Upper	4	4	0.071	0.201	0.119	0.185	95% Student's-t UCL	3	0.185	4	4	0.062	0.176	0.105	0.163	95% Student's-t UCL	3	0.163
RRM -2.7 to -0.7	1	1	0.623	0.623	0.623	--	--	1	0.623	1	1	0.548	0.548	0.548	--	--	1	0.548
RRM 0.8 to 1.7	1	1	1.621	1.621	1.621	--	--	1	1.621	1	1	1.426	1.426	1.426	--	--	1	1.426
RRM 1.7 to 2.7	2	2	1.736	2.322	2.029	--	--	1	2.322	2	2	1.638	2.191	1.915	--	--	1	2.191
RRM 2.7 to 4.4	3	3	2.340	3.470	2.733	3.810	95% Student's-t UCL	3, 4	3.470	3	3	2.059	3.054	2.405	3.353	95% Student's-t UCL	3, 4	3.054
RRM 7.9 to 9.2	2	2	1.110	1.610	1.360	--	--	1	1.610	2	2	0.977	1.417	1.197	--	--	1	1.417
RRM 11.3 to 12.5	5	5	0.587	1.640	1.065	1.482	95% Student's-t UCL	3	1.482	5	5	0.373	1.443	0.870	1.277	95% Student's-t UCL	3	1.277
RRM 13.5 to 16.7	2	2	0.441	0.822	0.632	--	--	1	0.822	2	2	0.388	0.723	0.556	--	--	1	0.723
RRM 16.7 to 20.9	3	3	0.500	3.350	1.713	4.194	95% Student's-t UCL	3, 4	3.350	3	3	0.474	2.948	1.519	3.679	95% Student's-t UCL	3, 4	2.948
RRM 20.9 to 24.0	6	6	1.181	4.130	2.601	3.752	95% Student's-t UCL	3	3.752	6	6	0.875	3.634	2.293	3.313	95% Student's-t UCL	2, 3	3.313
MALLARD																		
MR Upper	2	2	0.050	0.060	0.055	--	--	1	0.060	2	2	0.044	0.053	0.048	--	--	1	0.053
NR Upper	8	8	0.006	0.062	0.028	0.039	95% Student's-t UCL	3	0.039	8	8	0.006	0.054	0.025	0.034	95% Student's-t UCL	3	0.034
RRM 1.7 to 2.7	49	49	0.020	2.339	0.801	0.948	95% Student's-t UCL	--	0.948	49	49	0.018	2.058	0.705	0.834	95% Student's-t UCL	--	0.834
RRM 4.4 to 5.2	2	2	0.795	1.110	0.953	--	--	1	1.110	2	2	0.700	0.977	0.838	--	--	1	0.977
RRM 5.2 to 7.9	6	6	0.552	1.890	1.291	1.692	95% Student's-t UCL	2, 3	1.692	6	6	0.486	1.663	1.136	1.489	95% Student's-t UCL	2, 3	1.489
RRM 9.2 to 11.3	7	7	0.091	4.437	1.576	2.839	95% Student's-t UCL	3	2.839	7	7	0.080	3.905	1.387	2.499	95% Student's-t UCL	3	2.499
RRM 11.3 to 12.5	19	19	0.110	5.405	1.481	2.349	95% Adjusted Gamma UCL	--	2.349	19	19	0.097	4.756	1.303	2.068	95% Adjusted Gamma UCL	--	2.068
RRM 16.7 to 20.9	46	46	0.073	2.282	0.905	1.039	95% Student's-t UCL	--	1.039	46	46	0.064	2.008	0.796	0.914	95% Student's-t UCL	--	0.914
RRM 20.9 to 24.0	2	2	0.789	1.110	0.950	--	--	1	1.110	2	2	0.694	0.977	0.836	--	--	1	0.977
TREE SWALLOW																		
MR Middle	126	126	0.004	2.185	0.124	0.200	95% Chebyshev (Mean, SD) UCL	--	0.200	126	126	0.003	1.923	0.109	0.176	95% Chebyshev (Mean, SD) UCL	--	0.176
MR Upper	450	450	0.000	1.440	0.114	0.136	95% Chebyshev (Mean, SD) UCL	--	0.136	450	450	0.000	1.267	0.101	0.119	95% Chebyshev (Mean, SD) UCL	--	0.119
NR Lower	9	9	0.051	1.480	0.513	0.721	95% Hall's Bootstrap UCL	3, 6	0.721	9	9	0.045	1.302	0.452	0.634	95% Hall's Bootstrap UCL	3, 6	0.634
NR Upper	188	188	0.003	3.674	0.133	0.229	95% Chebyshev (Mean, SD) UCL	--	0.229	188	188	0.003	3.233	0.117	0.201	95% Chebyshev (Mean, SD) UCL	--	0.201
SR WNP Lower	20	20	0.015	0.268	0.154	0.219	95% Chebyshev (Mean, SD) UCL	2	0.219	20	20	0.014	0.236	0.136	0.193	95% Chebyshev (Mean, SD) UCL	2	0.193
SR WNP Upper	95	95	0.017	0.970	0.149	0.197	95% Chebyshev (Mean, SD) UCL	--	0.197	95	95	0.015	0.854	0.131	0.174	95% Chebyshev (Mean, SD) UCL	--	0.174
RRM -2.7 to -0.7	47	47	0.018	1.230	0.241	0.382	95% Chebyshev (Mean, SD) UCL	--	0.382	47	47	0.016	1.082	0.212	0.336	95% Chebyshev (Mean, SD) UCL	--	0.336

Table E-14b
Avian Tissue (Blood) Mercury Exposure Point Concentrations (EPCs) Calculated for Comparisons with Critical Body Residues (CBRs)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	BLOOD THg (mg/kg ww)									BLOOD MeHg (mg/kg ww)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Note*	EPC	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC
RRM 0.8 to 1.7	15	15	0.588	3.540	1.048	1.378	95% Student's-t UCL	--	1.378	15	15	0.518	3.115	0.922	1.213	95% Student's-t UCL	--	1.213
RRM 1.7 to 2.7	102	102	0.003	4.441	1.106	1.419	95% Chebyshev (Mean, SD) UCL	--	1.419	102	102	0.002	3.908	0.973	1.249	95% Chebyshev (Mean, SD) UCL	--	1.249
RRM 2.7 to 4.4	52	52	0.013	5.020	1.195	1.932	95% Chebyshev (Mean, SD) UCL	--	1.932	52	52	0.011	4.418	1.052	1.700	95% Chebyshev (Mean, SD) UCL	--	1.700
RRM 4.4 to 5.2	41	41	0.002	4.970	1.648	2.001	95% Student's-t UCL	--	2.001	41	41	0.002	4.374	1.450	1.761	95% Student's-t UCL	--	1.761
RRM 5.2 to 7.9	13	13	0.059	2.430	1.262	4.124	99% Chebyshev (Mean, SD) UCL	2, 3, 4	2.430	13	13	0.052	2.138	1.111	3.629	99% Chebyshev (Mean, SD) UCL	2, 3, 4	2.138
RRM 7.9 to 9.2	17	17	0.152	4.344	1.979	2.552	95% Student's-t UCL	2	2.552	17	17	0.134	3.823	1.741	2.245	95% Student's-t UCL	2	2.245
RRM 9.2 to 11.3	202	202	0.072	11.900	2.163	2.709	95% Chebyshev (Mean, SD) UCL	--	2.709	202	202	0.063	10.472	1.903	2.384	95% Chebyshev (Mean, SD) UCL	--	2.384
RRM 11.3 to 12.5	161	161	0.082	6.916	2.172	2.641	95% Chebyshev (Mean, SD) UCL	--	2.641	161	161	0.072	6.086	1.912	2.324	95% Chebyshev (Mean, SD) UCL	--	2.324
RRM 13.5 to 16.7	48	48	0.048	7.710	2.843	3.270	95% Student's-t UCL	--	3.270	48	48	0.042	6.785	2.501	2.878	95% Student's-t UCL	--	2.878
RRM 16.7 to 20.9	49	49	0.325	10.800	2.613	3.261	95% Adjusted Gamma UCL	--	3.261	49	49	0.286	9.504	2.299	2.870	95% Adjusted Gamma UCL	--	2.870
RRM 20.9 to 24.0	122	122	0.057	9.180	1.912	2.659	95% Chebyshev (Mean, SD) UCL	--	2.659	122	122	0.050	8.078	1.682	2.340	95% Chebyshev (Mean, SD) UCL	--	2.340
SFSR	22	22	0.085	1.730	0.843	1.391	95% Chebyshev (Mean, SD) UCL	2	1.391	22	22	0.075	1.522	0.742	1.224	95% Chebyshev (Mean, SD) UCL	2	1.224

Notes:
THg, Total mercury; RRM, Relative river mile; SR, South River; MR, Middle River; NR, North River; ww, Wet weight.
Min, Max, and Mean - Minimum, Maximum, and Mean of the detected concentrations.
95% UCL, 95% Upper confidence level of the mean concentrations.
EPC, Exposure point concentration; Max or the 95% UCL, whichever is lower; For N < 5, data set is too small to compute reliable and meaningful statistics and estimates.
--, Not applicable.
a, Outside of the 62-year floodplain (considered reference area).

*UCL Notes:
1, Data set is too small to compute reliable and meaningful statistics and estimates.
2, For highly negative-skewed data, confidence limits (e.g., (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable.
3, Sample size is small (e.g., <10).
4, Recommended UCL exceeds the maximum observation.
5, H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide. It is therefore recommended to avoid the use of H-statistic based 95% UCLs.
6, In Case Bootstrap t and/or Hall's Bootstrap yields an unreasonably large UCL value, 97.5% or 99% Chebyshev (Mean, SD) UCL.

Table E-15a
Small Mammals Tissue (Muscle) Mercury Exposure Point Concentrations (EPCs) for Dose Rate Modeling
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	MUSCLE IHg (mg/kg ww)									MUSCLE MeHg (mg/kg ww)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Note	EPC ^a	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC ^a
RRM -2.7 to 0.7	--	--	--	--	--	--	--	--	0.040	--	--	--	--	--	--	--	--	0.054
RRM -0.7 to 0.0	--	--	--	--	--	--	--	--	0.040	--	--	--	--	--	--	--	--	0.054
RRM 0.0 to 0.8	--	--	--	--	--	--	--	--	0.040	--	--	--	--	--	--	--	--	0.054
RRM 0.8 to 1.7	--	--	--	--	--	--	--	--	0.040	--	--	--	--	--	--	--	--	0.054
RRM 1.7 to 2.7	3	3	0.016	0.040	0.025	0.0471	95% Student's-t UCL	1, 2	0.040	3	3	0.023	0.054	0.034	0.0633	95% Student's-t UCL	1, 2	0.054
RRM 2.7 to 4.4	--	--	--	--	--	--	--	--	0.078	--	--	--	--	--	--	--	--	0.054
RRM 4.4 to 5.2	--	--	--	--	--	--	--	--	0.078	--	--	--	--	--	--	--	--	0.054
RRM 5.2 to 7.9	--	--	--	--	--	--	--	--	0.078	--	--	--	--	--	--	--	--	0.054
RRM 7.9 to 9.2	--	--	--	--	--	--	--	--	0.078	--	--	--	--	--	--	--	--	0.054
RRM 9.2 to 11.3	--	--	--	--	--	--	--	--	0.078	--	--	--	--	--	--	--	--	0.054
RRM 11.3 to 12.5	3	3	0.006	0.078	0.030	0.0993	95% Student's-t UCL	1, 2	0.078	3	3	0.015	0.023	0.018	0.0249	95% Student's-t UCL	1, 2	0.023
RRM 12.5 to 13.5	--	--	--	--	--	--	--	--	0.078	--	--	--	--	--	--	--	--	0.412
RRM 13.5 to 16.7	--	--	--	--	--	--	--	--	0.078	--	--	--	--	--	--	--	--	0.412
RRM 16.7 to 20.9	3	3	0.003	0.023	0.011	0.029	95% Student's-t UCL	1, 2	0.023	3	3	0.003	0.412	0.151	0.533	95% Student's-t UCL	1, 2	0.412
RRM 20.9 to 24.0	4	4	0.006	0.063	0.029	0.0577	95% Student's-t UCL	1	0.058	4	4	0.003	0.020	0.008	0.0174	95% Student's-t UCL	1	0.017
SFSR	--	--	--	--	--	--	--	--	0.058	--	--	--	--	--	--	--	--	0.017

Notes:

IHg, Inorganic mercury; MeHg, Methylmercury; RRM, Relative river mile; ww, Wet weight.
Min, Max, and Mean - Minimum, Maximum, and Mean of the detected concentrations.
95% UCL, 95% Upper confidence level of the mean concentrations.
EPC, Exposure point concentration; Max or the 95% UCL, whichever is lower; For N < 5, data set is too small to compute reliable and meaningful statistics and estimates.
--, Not applicable.
a, EPCs in ***bold and italics*** are extrapolations based on the next highest EPC for adjacent Reach.

*UCL Notes:

1, Sample size is small (e.g., <10).
2, Recommended UCL exceeds the maximum observation.

Table E-15b
Mammalian Tissue (Blood) Mercury Exposure Point Concentrations (EPCs) for Comparisons with Critical Body Residues (CBRs)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	THg (mg/kg ww)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC
BIG BROWN BAT									
MR Middle	6	6	0.021	0.035	0.027	0.0316	95% Student's-t UCL	3	0.032
SR Fisherville	48	48	0.013	0.102	0.044	0.0496	95% Student's-t UCL	--	0.050
SR RRM 16.7 to 20.9a	38	38	0.024	0.892	0.152	0.187	95% H-UCL	4	0.187
RRM 1.7 to 2.7	14	14	0.036	0.291	0.100	0.13	95% Student's-t UCL	--	0.130
RRM 11.3 to 12.5	9	9	0.064	0.824	0.284	0.426	95% Student's-t UCL	--	0.426
LITTLE BROWN BAT									
MR Middle	1	1	0.090	0.090	0.090	--	--	1	0.090
MR Lower	74	74	0.014	0.915	0.088	0.173	95% Chebyshev (Mean, SD) UCL	--	0.173
NR Moscow	120	120	0.005	0.061	0.023	0.0251	95% Approximate Gamma UCL	--	0.025
NR Upper	13	13	0.015	0.033	0.024	0.0266	95% Student's-t UCL	2	0.027
RRM 16.7 to 20.9	65	65	0.025	3.756	1.374	1.574	95% Student's-t UCL	--	1.574

Notes:

THg, Total mercury; RRM, Relative river mile; SR, South River; MR, Middle River; NR, North River; ww, Wet weight.

Min, Max, and Mean - Minimum, Maximum, and Mean of the detected concentrations.

95% UCL - 95% Upper confidence level of the mean concentrations.

EPC, Exposure point concentration; Max or the 95% UCL, whichever is lower.

--, Not applicable.

a, Outside of the 62-year floodplain (considered reference area).

***UCL Notes:**

1, Data set is too small to compute reliable and meaningful statistics and estimates.

2, For highly negative-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable.

3, Sample size is small (e.g., <10).

4, H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide. It is therefore recommended to avoid the use of H-statistic based 95% UCLs.

Table E-15c
Mammalian Tissue (Fur) Mercury Exposure Point Concentrations (EPCs) for Comparisons with Critical Body Residues (CBRs)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	THg (mg/kg ww)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC
BIG BROWN BAT									
MR Middle	6	6	0.885	4.84	3.14	4.58	95% Student's-t UCL	2, 3	4.6
SR Fisherville	48	48	2.19	13.40	8.04	10.36	95% Chebyshev (Mean, SD) UCL	2	10.4
SR RRM 16.7 to 20.9a	38	38	3.97	200	31.5	42.2	95% H-UCL	4	42.2
RRM 1.7 to 2.7	14	14	5.81	49.1	14.25	20.4	95% Adjusted Gamma UCL	--	20.4
RRM 11.3 to 12.5	9	9	3.72	42.2	17.77	25.2	95% Student's-t UCL	--	25.2
SHORT-TAILED SHREW									
RRM 13.5 to 16.7	12	12	6.21	31.500	19.56	23.7	95% Student's-t UCL	--	23.7
RRM 16.7 to 20.9	22	22	6.08	88.400	32.5	40.7	95% Student's-t UCL	--	40.7
LITTLE BROWN BAT									
NR Moscow	130	130	0.289	14.87	2.88	3.298	95% H-UCL	4	3.3
MR Lower	74	74	1.219	321	21.24	49.85	95% Chebyshev (Mean, SD) UCL	--	49.9
NR Upper	13	13	1.113	5.39	2.69	3.26	95% Student's-t UCL	--	3.3
RRM 1.7 to 2.7	1	1	96.8	96.8	96.8	--	--	1	96.8
RRM 16.7 to 20.9	81	81	1.383	708	186	257.2	95% Chebyshev (Mean, SD) UCL	--	257

Notes:

THg, Total mercury; RRM, Relative river mile; SR, South River; MR, Middle River; NR, North River; ww, Wet weight.

Min, Max, and Mean - Minimum, Maximum, and Mean of the detected concentrations.

95% UCL, 95% Upper confidence level of the mean concentrations.

EPC, Exposure point concentration; Max or the 95% UCL, whichever is lower.

--, Not applicable.

a, Outside of the 62-year floodplain (considered reference area).

*UCL Notes:

1, Data set is too small to compute reliable and meaningful statistics and estimates.

2, For highly negative-skewed data, confidence limits (e.g., (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable.

3, Sample size is small (e.g., <10).

4, H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide. It is therefore recommended to avoid the use of H-statistic based 95% UCLs.

Table E-16
Aquatic Plant Tissue Mercury Exposure Point Concentrations (EPCs) for Dose Rate Modeling
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	IHg (mg/kg ww)									MeHg (mg/kg ww)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC ^a	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Note*	EPC ^a
RRM -2.7 to -0.7	5	5	0.0001	0.029	0.014	0.0276	95% Student's-t UCL	3	0.028	5	5	0.0002	0.001	0.001	0.00149	95% Student's-t UCL	2, 3	0.001
RRM -0.7 to 0.0	--	--	--	--	--	--	--	--	0.028	--	--	--	--	--	--	--	--	0.001
RRM 0.0 to 0.8	34	34	0.003	1.414	0.154	0.244	95% H-UCL	5	0.244	34	34	0.0001	0.009	0.002	0.00361	95% Chebyshev (Mean, SD) UCL	--	0.004
RRM 0.8 to 1.7	60	60	0.002	2.043	0.368	0.486	95% Approximate Gamma UCL	--	0.486	60	60	0.00001	0.011	0.003	0.0035	95% Approximate Gamma UCL	--	0.004
RRM 1.7 to 2.7	64	64	0.001	1.569	0.456	0.564	95% Approximate Gamma UCL	--	0.564	64	64	0.00003	0.067	0.007	0.0124	95% Chebyshev (Mean, SD) UCL	--	0.012
RRM 2.7 to 4.4	22	22	0.076	3.472	1.013	1.54	95% Adjusted Gamma UCL	--	1.540	22	22	0.0020	0.053	0.017	0.025	95% Adjusted Gamma UCL	--	0.025
RRM 4.4 to 5.2	3	3	3.797	4.526	4.148	4.763	95% Student's-t UCL	3, 4	4.526	3	3	0.0063	0.012	0.009	0.014	95% Student's-t UCL	3, 4	0.012
RRM 5.2 to 7.9	31	31	0.007	2.126	0.466	0.673	95% Adjusted Gamma UCL	--	0.673	31	31	0.0002	0.043	0.009	0.0122	95% Adjusted Gamma UCL	--	0.012
RRM 7.9 to 9.2	7	7	0.075	1.694	0.667	1.105	95% Student's-t UCL	3	1.105	7	7	0.0013	0.070	0.025	0.0466	95% Student's-t UCL	3	0.047
RRM 9.2 to 11.3	12	12	0.092	0.366	0.169	0.216	95% Student's-t UCL	--	0.216	12	12	0.0005	0.004	0.002	0.00396	95% Chebyshev (Mean, SD) UCL	1	0.004
RRM 11.3 to 12.5	129	129	0.003	1.330	0.212	0.312	95% Chebyshev (Mean, SD) UCL	--	0.312	129	129	0.00004	0.163	0.020	0.0306	95% Chebyshev (Mean, SD) UCL	--	0.031
RRM 12.5 to 13.5	5	5	0.015	0.476	0.235	0.453	95% Student's-t UCL	3	0.453	5	5	0.0010	0.070	0.018	0.0464	95% Student's-t UCL	3	0.046
RRM 13.5 to 16.7	5	5	0.033	0.452	0.219	0.367	95% Student's-t UCL	3	0.367	5	5	0.0011	0.011	0.005	0.00983	95% Student's-t UCL	3	0.010
RRM 16.7 to 20.9	5	5	0.004	0.256	0.099	0.195	95% Student's-t UCL	3	0.195	5	5	0.0010	0.012	0.004	0.00891	95% Student's-t UCL	--	0.009
RRM 20.9 to 24.0	45	45	0.009	1.974	0.457	0.822	95% Chebyshev (Mean, SD) UCL	--	0.822	45	45	0.0001	0.076	0.010	0.0138	95% Adjusted Gamma UCL	--	0.014
SFSR	5	5	0.003	1.595	0.385	9.188	95% Adjusted Gamma UCL	3,4	1.595	5	5	0.0004	0.009	0.003	0.00661	95% Student's-t UCL	3	0.007

Notes:
IHg, Inorganic mercury; MeHg, Methylmercury; RRM, Relative river mile; SFSR, South Fork Shenandoah River; ww, Wet weight.
Min, Max, and Mean - Minimum, Maximum, and Mean of the detected concentrations.
95% UCL, 95% Upper confidence level of the mean concentrations.
EPC, Exposure point concentration; Max or the 95% UCL, whichever is lower; For N < 5, data set is too small to compute reliable and meaningful statistics and estimates.
--, Not applicable.
a, EPCs in ***bold and italics*** are extrapolations based on the Reference Reach (RRM -2.7 to -0.7).

*UCL Notes:
1, There are only 3 Distinct Values in this data.
2, For highly negative-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable.
3, Sample size is small (e.g., <10).
4, Recommended UCL exceeds the maximum observation.
5, H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide. It is therefore recommended to avoid the use of H-statistic based 95% UCLs.

Table E-17
Terrestrial Plant Tissue Mercury Exposure Point Concentrations (EPCs) for Dose Rate Modeling
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Assessment Reach	IHg (mg/kg ww)									MeHg (mg/kg ww)								
	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC ^a	Sample Size (n)	Detects (n)	Min	Max	Mean	95% UCL	95% UCL Method	UCL Notes*	EPC ^a
RRM -2.7 to -0.7	--	--	--	--	--	--	--	--	<i>0.019</i>	--	--	--	--	--	--	--	--	<i>0.0012</i>
RRM -0.7 to 0.0	--	--	--	--	--	--	--	--	<i>0.019</i>	--	--	--	--	--	--	--	--	<i>0.0012</i>
RRM 0.0 to 0.8	--	--	--	--	--	--	--	--	<i>0.019</i>	--	--	--	--	--	--	--	--	<i>0.0012</i>
RRM 0.8 to 1.7	--	--	--	--	--	--	--	--	<i>0.019</i>	--	--	--	--	--	--	--	--	<i>0.0012</i>
RRM 1.7 to 2.7	9	9	0.003	0.037	0.012	0.0191	95% Student's-t UCL	1	0.019	9	9	0.0003	0.002	0.001	0.00124	95% Chebyshev (Mean, SD) UCL	1	0.0012
RRM 2.7 to 4.4	--	--	--	--	--	--	--	--	<i>0.022</i>	--	--	--	--	--	--	--	--	<i>0.0012</i>
RRM 4.4 to 5.2	--	--	--	--	--	--	--	--	<i>0.022</i>	--	--	--	--	--	--	--	--	<i>0.0012</i>
RRM 5.2 to 7.9	--	--	--	--	--	--	--	--	<i>0.022</i>	--	--	--	--	--	--	--	--	<i>0.0012</i>
RRM 7.9 to 9.2	--	--	--	--	--	--	--	--	<i>0.022</i>	--	--	--	--	--	--	--	--	<i>0.0012</i>
RRM 9.2 to 11.3	--	--	--	--	--	--	--	--	<i>0.022</i>	--	--	--	--	--	--	--	--	<i>0.0012</i>
RRM 11.3 to 12.5	9	9	0.002	0.040	0.015	0.0219	95% Student's-t UCL	1	0.022	9	9	0.0002	0.001	0.0003	0.00039817	95% Student's-t UCL	1	0.0004
RRM 12.5 to 13.5	--	--	--	--	--	--	--	--	<i>0.040</i>	--	--	--	--	--	--	--	--	<i>0.0004</i>
RRM 13.5 to 16.7	--	--	--	--	--	--	--	--	<i>0.040</i>	--	--	--	--	--	--	--	--	<i>0.0004</i>
RRM 16.7 to 20.9	9	9	0.005	0.085	0.024	0.0397	95% Student's-t UCL	1	0.040	9	9	0.0002	0.0005	0.0003	0.00037192	95% Student's-t UCL	1	0.0004
RRM 20.9 to 24.0	9	9	0.003	0.011	0.006	0.00769	95% Student's-t UCL	1	0.008	9	9	0.0001	0.0002	0.0002	0.00018043	95% Student's-t UCL	1	0.0002
SFSR	--	--	--	--	--	--	--	--	<i>0.008</i>	--	--	--	--	--	--	--	--	<i>0.0002</i>

Notes:
IHg, Inorganic mercury; MeHg, Methylmercury; RRM, Relative river mile; SFSR, South Fork Shenandoah River; ww, Wet weight.
Min, Max, and Mean - Minimum, Maximum, and Mean of the detected concentrations.
95% UCL, 95% Upper confidence level of the mean concentrations.
EPC, Exposure point concentration; Max or the 95% UCL, whichever is lower; For N < 5, data set is too small to compute reliable and meaningful statistics and estimates.
--, Not applicable.
a, EPCs in ***bold and italics*** are extrapolations based on the next highest EPC for adjacent Reach.

*UCL Notes:
1, Sample size is small (e.g., <10).

Appendix F

Dose Rate Modeling

Dose Rate Modeling (DRM)

AOC 4 Ecological Risk Assessment Report

Former DuPont Waynesboro Plant, Waynesboro, Virginia

1.0 Introduction

In the exposure analysis, dietary exposures to mercury within AOC 4 are characterized using dose rate models (DRMs) for nine representative wildlife receptors (below) identified in the ECSM (see Section 3.5).

Wildlife Receptor Category	Focal Wildlife Species
Semi-aquatic piscivorous birds	Belted kingfisher (<i>Megaceryle alcyon</i>)
Semi-aquatic invertivorous/omnivorous birds	Mallard (<i>Anas platyrhynchos</i>)
Terrestrial carnivorous birds	Eastern screech owl (<i>Megascops asio</i>)
Terrestrial aerial insectivorous birds	Tree swallow (<i>Tachycineta bicolor</i>)
Terrestrial invertivorous songbirds	American robin (<i>Turdus migratorius</i>)
Semi-aquatic piscivorous mammals	River otter (<i>Lontra canadensis</i>)
Terrestrial invertivorous mammals	Short-tailed shrew (<i>Blarina brevicauda</i>)
Terrestrial herbivorous mammals	White-tailed deer (<i>Odocoileus virginianus</i>)
Aerial insectivorous mammals	Big brown bat (<i>Eptesicus fuscus</i>)

The DRMs estimate the dietary doses obtained by the focal species through the direct ingestion of mercury (IHg and MeHg, separately) in dietary items and drinking water, and for select receptors, through the incidental or indirect ingestion of soil or sediment. In doing so a deterministic approach is used where point estimates of daily mercury intake rates (DMIRs), in milligrams (mg) of mercury per kilogram body weight per day (mg Hg/kg BW/day), are calculated using average or typical exposure factors for the focal species and reasonable maximum exposure point concentrations (EPCs) in the applicable biotic and abiotic media. The following sections describe the model structures, model parameters, and the exposure areas (Assessment Reaches) in greater detail.

2.0 Dose Rate Model Structure

For each focal species, the dietary exposure models consider the typical dietary preference and composition in terms of representative dietary items in AOC 4. The models incorporate site-specific measurements or estimates of IHg and MeHg concentrations in representative dietary items, drinking water (surface water), sediment, and soil. Area use factors (AUFs) are included in the model, as appropriate, to account for the proportion of the dietary exposure that a receptor is likely to experience from foraging within an exposure area (Assessment Reach) of AOC 4 relative to the total exposure experienced while foraging within its entire foraging range (home range).

Based on these components, the DMIR for each receptor is estimated as follows:

$$DMIR = \frac{1}{BW} \sum_{i=1}^N (FIR_{ww} \times \sum_{j=1}^M (f_j \times C_j) + SIR \times C_S + WIR \times C_{SW})_i \times AUF_i \quad (1)$$

where:

- i = Number of exposure areas where N is the total number of areas, representing the 16 Assessment Reaches and other applicable Reference Reaches
- j = Receptor-specific dietary items (where M is the total number of dietary items)
- BW = Receptor-specific mean body weight
- FIR_{ww} = Receptor-specific mean daily food ingestion rate (wet weight)
- f = Proportion of dietary item j to total dietary composition
- C_j = Exposure point concentrations (EPCs) of IHg or MeHg in dietary item j
- SIR = Receptor-specific incidental sediment or soil ingestion rate
- C_s = EPCs of IHg or MeHg in sediment or soil
- WIR = Receptor-specific daily drinking-water ingestion rate
- C_{sw} = EPCs of IHg or MeHg in unfiltered surface water
- AUF = Area use factor

As indicated above the dietary exposure models include parameters relating to receptor-specific exposure factors, EPCs, and AUFs. Exposure factors refer to receptor-specific variables (e.g., BW , FIR_{ww} , SIR , WIR , etc.), which are typically derived from literature sources. EPCs refer to exposure concentrations based on site-specific measurements or estimates, namely mercury concentrations measured or estimated in exposure media. AUFs refer to relative contribution of an exposure area (Assessment Reach) towards the total dose to which a receptor may be exposed. The following sections describe the estimation of these parameters and the major assumptions of model parameterization.

3.0 Exposure Factors

The primary data source of exposure factors for the focal wildlife species is the EPA Wildlife Exposure Factors Handbook [“the Handbook” (EPA, 1993)]. Additional receptor-specific literature sources are also used to supplement exposure data compiled in the Handbook.

Exposure factors that are representative of typical or average (e.g., mean parameter) exposure conditions are used in the DRMs (see Table D-1, Appendix D). Receptor profiles (Tables D-2a through 2i, Appendix D) provides the basis for exposure factors included in the evaluation. These factors include the following:

- Body Weight (BW)
- Food Ingestion Rate (FIR)
- Sediment or Soil Ingestion Rate (SIR)
- Drinking Water Ingestion Rate (WIR)
- Dietary Preference/Composition

These factors are described in detail in Appendix D.

4.0 Exposure Concentrations

Exposure point concentrations (EPCs) are concentrations to which wildlife receptors are expected to be exposed through dietary ingestion pathways. As discussed in Appendices A and D, historical investigations included site-specific analyses of THg and MeHg in biotic exposure media that are consumed by wildlife receptors. In addition to mercury analyses in biotic exposure media, THg and MeHg concentrations are characterized in soil, sediment, and surface water within AOC 4. These biotic and abiotic datasets collected historically provide the basis for estimating mercury exposure in the dietary models.

Exposure models calculate a point estimate of dietary exposure based on a single EPC for each relevant exposure medium for a given receptor. EPCs are calculated or estimated (where data is not available for an Assessment Reach) as indicated in Appendix E.

5.0 Exposure Areas- Assessment Reaches

Figure 3-1 shows the areal extent of AOC 4, covering approximately 27 river miles, including a Reference Reach within about three miles upstream of the outfall from the site. Datasets for AOC 4 are partitioned spatially based on the Assessment Reach breaks defined by intersecting the 2-foot LiDAR contours with the channel centerline, resulting in 16 Assessment Reaches (14 Assessment Study Reaches including SFSR and an Upstream Reference Reach and Buffer Reach, see Section 3.2 and Table 3-1). Table 3-1 also provides the Assessment Reach lengths and the areas within the 0.3-year flood plain within each Assessment Reach to represent the foraging ranges available within each Assessment Reach.

Each Assessment Reach (in Table 3-1) is considered an independent, discrete exposure area and thus DMIRs for a receptor are calculated for each Assessment Reach. Wildlife receptors, particularly those with home ranges larger than each Assessment Reach, are not necessarily limited to forage within a given Assessment Reach. In all likelihood, the receptor home ranges will not coincide with Assessment Reach boundaries and that the receptors will move among the Assessment Reaches for foraging. Nonetheless, these Assessment Reach boundaries allow systematic evaluation of potential exposures. Additionally, by considering these Assessment Reaches within AOC 4 separately, their relative contribution to total exposures and, therefore, spatial heterogeneity in exposures to mercury within AOC 4 are captured.

The AUF in DRMs reflects the proportion of the dose that a receptor may obtain as a result of foraging activities within an Assessment Reach relative to the receptor's typical home range. The AUF is simply the ratio of the size of the Assessment Reach to the receptor home range or territory size. Species with relatively small home ranges (e.g., American robin and short-tailed shrew) may forage entirely within one exposure area (Assessment Reach) and hence their exposures to mercury can originate entirely within an Assessment Reach. However, species with larger home ranges (e.g., river otter) may forage in multiple Assessment Reaches and thus their exposures to mercury may represent relative contributions from different Assessment Reaches.

Home ranges are reported using various metrics: feeding or foraging radius, feeding or foraging distance, and home range or territory size, etc. In most cases, home ranges are reported in hectares or acres and are referred to as the home range or territory. For the focal receptors, AUFs are defined either in terms of the shoreline length (belted kingfisher) or the area within the 0.3-year floodplain (for the rest of the receptors) because the source of mercury in the food web originates primarily within this area, including the river channel.

6.0 Results

The results of the DMIR calculations are shown in Tables F-1 through F-9 for IHg and Tables F-10 through F-18 for MeHg. The results are discussed in the context of risk characterizations in Section 6 of the ERA Report.

7.0 References

EPA. 1993. *Wildlife Exposure Factors Handbook. Volumes I and II*. EPA/600/R-93/187. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment and Office of Research and Development, Washington, DC. December.

Tables

Table F-1
Dose Rate Modeling Calculations - Belted Kingfisher (*Megaceryle alcyon*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	0.148	kg	Powdermill Nature Center [as cited in EPA (1993)]
Food Ingestion Rate (FIR)	0.085	kg ww/day	Equation #64 in Nagy (2001)
Water Ingestion Rate (WIR)	0.016	L/day	Calder and Braun (1983)
Sediment Ingestion Rate (SIR)	2.33E-04	kg dw/day	Assumed 1% of dry FIR using Equation #63 in Nagy (2001)
Home Range (HR)	1.5-20.8	acre	EPA (2003)

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Crayfish (CF)	5	%	0.004	kg ww/day
Frogs	5	%	0.004	kg ww/day
Fish TL < 130 mm (SF)	90	%	0.076	kg ww/day

Toxicity Reference Values (TRVs) ^f	Value	Unit
No Observed Adverse Effects Level (NOAEL)	0.45	mg IHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	0.9	mg IHg/kg BW/day

Assessment Reach	Shoreline ^c (miles)	AUF ^c	EPC ^d (ng/L, mg/kg dw, or mg/kg ww)					DMIR ^e (mg IHg/kg BW/day)						HQ ^g		AUF-Adjusted HQ ^h	
			Water	Sediment	CF	Frogs	SF	Water	Sediment	CF	Frogs	SF	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	2.0	0.40	2.1	0.05	0.007	0.024	0.06	2.28E-07	8.10E-05	1.97E-04	6.87E-04	2.98E-02	0.03	0.1	0.0	0.0	0.0
RRM -0.7 to 0.0	0.7	0.14	27.6	4.86	0.007	0.025	0.06	3.05E-06	7.66E-03	1.97E-04	7.16E-04	2.98E-02	0.04	0.1	0.0	0.0	0.0
RRM 0.0 to 0.8	0.8	0.16	24.2	4.68	0.12	0.110	0.49	2.68E-06	7.38E-03	3.51E-03	3.15E-03	2.49E-01	0.26	0.6	0.3	0.1	0.0
RRM 0.8 to 1.7	0.9	0.18	40.1	7.81	0.06	0.18	0.07	4.45E-06	1.23E-02	1.71E-03	5.00E-03	3.77E-02	0.06	0.1	0.1	0.0	0.0
RRM 1.7 to 2.7	1.0	0.20	53.2	35.11	0.14	0.18	0.09	5.89E-06	5.53E-02	4.00E-03	5.00E-03	4.87E-02	0.11	0.3	0.1	0.1	0.0
RRM 2.7 to 4.4	1.7	0.34	71.0	41.65	0.25	0.30	0.21	7.87E-06	6.56E-02	7.26E-03	8.65E-03	1.06E-01	0.19	0.4	0.2	0.1	0.1
RRM 4.4 to 5.2	0.8	0.16	84.9	199.95	0.25	0.30	0.32	9.41E-06	3.15E-01	7.26E-03	8.65E-03	1.66E-01	0.50	1.1	0.6	0.2	0.1
RRM 5.2 to 7.9	2.7	0.54	114.7	27.72	0.25	0.34	0.32	1.27E-05	4.37E-02	7.00E-03	9.59E-03	1.66E-01	0.23	0.5	0.3	0.3	0.1
RRM 7.9 to 9.2	1.3	0.26	386.0	84.29	0.17	0.27	0.22	4.28E-05	1.33E-01	4.77E-03	7.70E-03	1.11E-01	0.26	0.6	0.3	0.1	0.1
RRM 9.2 to 11.3	2.1	0.42	119.9	27.55	0.11	0.27	0.09	1.33E-05	4.34E-02	3.23E-03	7.82E-03	4.53E-02	0.10	0.2	0.1	0.1	0.0
RRM 11.3 to 12.5	1.2	0.24	96.4	13.54	0.10	0.27	0.32	1.07E-05	2.13E-02	2.81E-03	7.76E-03	1.65E-01	0.20	0.4	0.2	0.1	0.1
RRM 12.5 to 13.5	1.0	0.20	142.4	14.03	0.19	0.30	0.16	1.58E-05	2.21E-02	5.37E-03	8.57E-03	8.43E-02	0.12	0.3	0.1	0.1	0.0
RRM 13.5 to 16.7	3.2	0.64	88.0	14.63	0.10	0.30	0.20	9.75E-06	2.31E-02	2.97E-03	8.57E-03	1.04E-01	0.14	0.3	0.2	0.2	0.1
RRM 16.7 to 20.9	4.2	0.84	78.5	12.81	0.10	0.30	0.12	8.70E-06	2.02E-02	2.97E-03	8.54E-03	6.33E-02	0.09	0.2	0.1	0.2	0.1
RRM 20.9 to 24.0	3.1	0.62	50.4	14.25	0.15	0.24	0.23	5.59E-06	2.25E-02	4.37E-03	6.78E-03	1.18E-01	0.15	0.3	0.2	0.2	0.1
SFSR	--	1.00	17.9	0.74	0.07	0.14	0.04	1.99E-06	1.17E-03	1.91E-03	3.87E-03	1.95E-02	0.03	0.1	0.0	0.1	0.0
Minimum HQ ^{i,j} :														0.1	0.0	0.0	0.0
Maximum HQ ^{i,j} :														1.1	0.6	0.3	0.1
Cumulative HQ ^{i,j} :														0.3	0.1		

Notes:

- , Not applicable or not evaluated; ww - Wet weight ; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.
- a, More details are provided in Appendix D (Table D-2a).
- b, Intake rates = Dietary Composition (%) x FIR.
- c, AUF - Area use factor; Estimated based on the ratio of the shoreline length within the reach relative to the home range of five linear miles from a nest.
- d, EPC - Exposure point concentration; Values from Appendix E; units in ng/L for water, mg/kg dw for sediment, and mg/kg ww for dietary items.
- e, DMIR - Daily mercury intake rate (or estimated daily dose).
- f, Values from Section 4.7.3 (or Appendix C).
- g, HQ - Hazard quotient; $HQ_{NOAEL} = DMIR_{Total}/NOAEL$; $HQ_{LOAEL} = DMIR_{Total}/LOAEL$.
- h, Weighted HQs based on AUFs.
- i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0.
- j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. $SHQ_i \times AUF_i$, where i = Exposure Areas and $SAUF_i = 1$).

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Table F-2
Dose Rate Modeling Calculations - Mallard Duck (*Anas platyrhynchos*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	1.171	kg	Delnicki & Reinecke (1986) [as cited in EPA (1993)]
Food Ingestion Rate (FIR)	0.176	kg ww/day	Equation #62 in Nagy (2001)
Water Ingestion Rate (WIR)	0.066	L/day	Calder and Braun (1983)
Sediment Ingestion Rate (SIR)	1.86E-03	kg dw/day	Assumed 3.3% of dry FIR using Equation #61 in Nagy (2001)
Home Range (HR)	94-3560	acre	EPA (2003)

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Aquatic Vegetation (AV)	5	%	0.009	kg ww/day
Aquatic Invertebrates - Larval (AIL)	45	%	0.079	kg ww/day
Crayfish (CF)	45	%	0.079	kg ww/day
Fish < 130 mm TL (SF)	5	%	0.009	kg ww/day

Toxicity Reference Values (TRVs) ^f	Value	Unit
No Observed Adverse Effects Level (NOAEL)	0.45	mg IHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	0.9	mg IHg/kg BW/day

Assessment Reach	Area ^c (acre)	AUF ^c	EPC ^d (ng/L, mg/kg dw, or mg/kg ww)						DMIR ^e (mg IHg/kg BW/day)							HQ ^g		AUF-Adjusted HQ	
			Water	Sediment	AV	AIL	CF	SF	Water	Sediment	AV	AIL	CF	SF	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	47	0.50	2.06	0.05	0.028	0.007	0.007	0.06	1.15E-07	8.15E-05	2.07E-04	5.05E-04	4.67E-04	4.35E-04	0.00	0.0	0.0	0.0	0.0
RRM -0.7 to 0.0	8	0.08	27.6	4.86	0.028	0.007	0.007	0.06	1.54E-06	7.70E-03	2.07E-04	5.05E-04	4.67E-04	4.35E-04	0.01	0.0	0.0	0.0	0.0
RRM 0.0 to 0.8	12	0.13	24.2	4.68	0.24	0.318	0.123	0.49	1.36E-06	7.42E-03	1.83E-03	2.15E-02	8.31E-03	3.64E-03	0.04	0.1	0.0	0.0	0.0
RRM 0.8 to 1.7	12	0.13	40.1	7.81	0.49	0.34	0.06	0.07	2.25E-06	1.24E-02	3.65E-03	2.28E-02	4.04E-03	5.51E-04	0.04	0.1	0.0	0.0	0.0
RRM 1.7 to 2.7	24	0.26	53.2	35.1	0.56	0.10	0.14	0.09	2.98E-06	5.56E-02	4.23E-03	6.42E-03	9.46E-03	7.11E-04	0.08	0.2	0.1	0.0	0.0
RRM 2.7 to 4.4	88	0.93	71.0	41.7	1.54	1.32	0.25	0.21	3.98E-06	6.60E-02	1.16E-02	8.94E-02	1.72E-02	1.55E-03	0.19	0.4	0.2	0.4	0.2
RRM 4.4 to 5.2	15	0.15	84.9	200	4.53	1.32	0.25	0.32	4.76E-06	3.17E-01	3.40E-02	8.94E-02	1.72E-02	2.42E-03	0.46	1.0	0.5	0.2	0.1
RRM 5.2 to 7.9	77	0.81	115	27.7	0.67	0.40	0.25	0.32	6.42E-06	4.39E-02	5.05E-03	2.72E-02	1.65E-02	2.42E-03	0.10	0.2	0.1	0.2	0.1
RRM 7.9 to 9.2	33	0.35	386	84.3	1.11	0.43	0.17	0.22	2.16E-05	1.34E-01	8.29E-03	2.91E-02	1.13E-02	1.62E-03	0.18	0.4	0.2	0.1	0.1
RRM 9.2 to 11.3	34	0.37	120	27.6	0.22	0.94	0.11	0.09	6.71E-06	4.37E-02	1.62E-03	6.36E-02	7.63E-03	6.61E-04	0.12	0.3	0.1	0.1	0.0
RRM 11.3 to 12.5	26	0.28	96.4	13.5	0.31	0.37	0.10	0.32	5.40E-06	2.15E-02	2.34E-03	2.52E-02	6.64E-03	2.41E-03	0.06	0.1	0.1	0.0	0.0
RRM 12.5 to 13.5	28	0.30	142	14.0	0.45	1.49	0.19	0.16	7.98E-06	2.22E-02	3.40E-03	1.01E-01	1.27E-02	1.23E-03	0.14	0.3	0.2	0.1	0.0
RRM 13.5 to 16.7	70	0.74	88.0	14.6	0.37	0.20	0.10	0.20	4.93E-06	2.32E-02	2.75E-03	1.34E-02	7.03E-03	1.52E-03	0.05	0.1	0.1	0.1	0.0
RRM 16.7 to 20.9	72	0.76	78.5	12.8	0.20	0.17	0.10	0.12	4.40E-06	2.03E-02	1.46E-03	1.14E-02	7.03E-03	9.23E-04	0.04	0.1	0.0	0.1	0.0
RRM 20.9 to 24.0	81	0.86	50.4	14.2	0.82	0.21	0.15	0.23	2.82E-06	2.26E-02	6.17E-03	1.43E-02	1.03E-02	1.72E-03	0.06	0.1	0.1	0.1	0.1
SFSR	--	1.00	17.9	0.74	1.60	0.09	0.07	0.04	1.00E-06	1.18E-03	1.20E-02	5.89E-03	4.52E-03	2.84E-04	0.02	0.1	0.0	0.1	0.0
Minimum HQ ^{i,j} :																0.1	0.0	0.0	0.0
Maximum HQ ^{i,j} :																1.0	0.5	0.4	0.2
Cumulative HQ ^{i,j} :																0.2	0.1		

Notes:

- , Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.
- a, More details are provided in Appendix D (Table D-2a).
- b, Intake rates = Dietary Composition (%) x FIR.
- c, AUF - Area Use Factor; Estimated based on the ratio of the 0.3-year floodplain area (Area, in acres) within each reach to the lower end of the mallard home range (94 acres).
- d, EPC - Exposure point concentration; Values from Appendix E; units in ng/L for water, mg/kg dw for sediment, and mg/kg ww for dietary items.
- e, DMIR - Daily Mercury Intake Rate (or estimated daily dose).
- f, Values from Section 4.7.3 (or Appendix C).
- g, HQ - Hazard quotient; $HQ_{NOAEL} = DMIR_{Total}/NOAEL$; $HQ_{LOAEL} = DMIR_{Total}/LOAEL$.
- h, Weighted HQs based on AUFs.
- i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0.
- j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. $\sum HQ_i \times AUF_i$, where i = Exposure Areas and $\sum AUF_i = 1$).

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Table F-3
Dose Rate Modeling Calculations - Eastern Screech Owl (*Megascops asio*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	0.164	kg	ADW (2014)
Food Ingestion Rate (FIR)	0.091	kg ww/day	Equation #64 in Nagy (2001)
Water Ingestion Rate (WIR)	0.018	L/day	Calder and Braun (1983)
Sediment Ingestion Rate (SIR1)	2.50E-04	kg dw/day	Assumed 1% of dry FIR using Equation #63 in Nagy (2001)
Soil Ingestion Rate (SIR2)	2.50E-04	kg dw/day	Assumed 1% of dry FIR using Equation #63 in Nagy (2001)
Home Range (HR)	150	acre	Hayward and Garton (1988)

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Crayfish (CF)	13	%	0.012	kg ww/day
Earthworms (EW)	10	%	0.009	kg ww/day
Wolf spiders (WS)	7	%	0.006	kg ww/day
Small birds (SB)	22	%	0.020	kg ww/day
Small mammals (SM)	48	%	0.043	kg ww/day

Toxicity Reference Values (TRVs) ^f	Value	Unit
No Observed Adverse Effects Level (NOAEL)	0.45	mg IHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	0.9	mg IHg/kg BW/day

Assessment Reach	Area ^c (acre)	AUF ^c	EPC ^d (ng/L, mg/kg dw, or mg/kg ww)								DMIR ^e (mg IHg/kg BW/day)									HQ ^g		AUF-Adjusted HQ	
			Water	Sediment	Soil ^k	CF	EW	WS	SB	SM	Water	Sediment	Soil	CF	EM	WS	SB	SM	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	47	0.31	2.1	0.05	0.16	0.01	0.17	0.02	0.04	0.04	2.20E-07	7.83E-05	2.40E-04	4.96E-04	9.44E-03	7.88E-04	5.17E-03	1.06E-02	0.03	0.1	0.0	0.0	0.0
RRM -0.7 to 0.0	8	0.05	27.6	4.86	0.16	0.01	0.17	0.02	0.04	0.04	2.95E-06	7.40E-03	2.40E-04	4.96E-04	9.44E-03	7.88E-04	5.17E-03	1.06E-02	0.03	0.1	0.0	0.0	0.0
RRM 0.0 to 0.8	12	0.08	24.2	4.68	35.6	0.12	1.56	0.20	0.18	0.04	2.59E-06	7.13E-03	5.41E-02	8.83E-03	8.60E-02	7.88E-03	2.17E-02	1.06E-02	0.20	0.4	0.2	0.0	0.0
RRM 0.8 to 1.7	12	0.08	40.1	7.81	46.2	0.06	1.57	0.20	0.18	0.04	4.30E-06	1.19E-02	7.04E-02	4.29E-03	8.64E-02	7.88E-03	2.17E-02	1.06E-02	0.21	0.5	0.2	0.0	0.0
RRM 1.7 to 2.7	24	0.16	53.2	35.1	23.3	0.14	3.58	0.20	0.24	0.04	5.70E-06	5.34E-02	3.55E-02	1.00E-02	1.98E-01	7.88E-03	2.87E-02	1.06E-02	0.34	0.8	0.4	0.1	0.1
RRM 2.7 to 4.4	88	0.59	71.0	41.7	21.6	0.25	4.28	0.70	0.26	0.08	7.61E-06	6.34E-02	3.29E-02	1.82E-02	2.36E-01	2.72E-02	3.21E-02	2.05E-02	0.43	1.0	0.5	0.6	0.3
RRM 4.4 to 5.2	15	0.10	84.9	200	41.2	0.25	4.28	0.70	0.32	0.08	9.10E-06	3.04E-01	6.27E-02	1.82E-02	2.36E-01	2.72E-02	3.86E-02	2.05E-02	0.71	1.6	0.8	0.2	0.1
RRM 5.2 to 7.9	77	0.51	114.7	27.7	16.7	0.25	4.21	0.70	0.34	0.08	1.23E-05	4.22E-02	2.54E-02	1.76E-02	2.32E-01	2.72E-02	4.15E-02	2.05E-02	0.41	0.9	0.5	0.5	0.2
RRM 7.9 to 9.2	33	0.22	386.0	84.3	14.2	0.17	4.21	0.70	0.35	0.08	4.14E-05	1.28E-01	2.16E-02	1.20E-02	2.32E-01	2.72E-02	4.19E-02	2.05E-02	0.48	1.1	0.5	0.2	0.1
RRM 9.2 to 11.3	34	0.23	119.9	27.6	25.1	0.11	3.55	0.70	0.39	0.08	1.28E-05	4.19E-02	3.82E-02	8.11E-03	1.96E-01	2.72E-02	4.70E-02	2.05E-02	0.38	0.8	0.4	0.2	0.1
RRM 11.3 to 12.5	26	0.17	96.4	13.54	14.8	0.10	4.65	0.70	0.34	0.08	1.03E-05	2.06E-02	2.26E-02	7.06E-03	2.57E-01	2.72E-02	4.11E-02	2.05E-02	0.40	0.9	0.4	0.2	0.1
RRM 12.5 to 13.5	28	0.19	142.4	14.03	8.1	0.19	4.65	0.70	0.40	0.08	1.53E-05	2.14E-02	1.24E-02	1.35E-02	2.57E-01	2.72E-02	4.82E-02	2.05E-02	0.40	0.9	0.4	0.2	0.1
RRM 13.5 to 16.7	70	0.46	88.0	14.63	7.3	0.10	2.96	0.70	0.39	0.08	9.43E-06	2.23E-02	1.11E-02	7.46E-03	1.64E-01	2.72E-02	4.79E-02	2.05E-02	0.30	0.7	0.3	0.3	0.2
RRM 16.7 to 20.9	72	0.48	78.5	12.81	7.06	0.10	2.62	0.25	0.38	0.02	8.41E-06	1.95E-02	1.08E-02	7.46E-03	1.44E-01	9.50E-03	4.57E-02	6.12E-03	0.24	0.5	0.3	0.3	0.1
RRM 20.9 to 24.0	81	0.54	50.4	14.25	12.4	0.15	1.40	0.14	0.41	0.06	5.40E-06	2.17E-02	1.89E-02	1.10E-02	7.72E-02	5.32E-03	4.96E-02	1.53E-02	0.20	0.4	0.2	0.2	0.1
SFSR	--	1.00	17.9	0.74	0.00	0.07	1.40	0.14	0.23	0.06	1.92E-06	1.13E-03	0.00E+00	4.80E-03	7.72E-02	5.32E-03	2.73E-02	1.53E-02	0.13	0.3	0.1	0.3	0.1
Minimum HQ ^{i,j} :																		0.3	0.1	0.0	0.0		
Maximum HQ ^{i,j} :																		1.6	0.8	0.6	0.3		
Cumulative HQ ^{i,j} :																		0.7	0.3				

Notes:
--, Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.

Notes:
--, Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.
a, More details are provided in Appendix D (Table D-2a).
b, Intake rates = Dietary Composition (%) x FIR.
c, AUF - Area Use Factor; Estimated based on the ratio of the 0.3-year floodplain area (Area, in acres) within each reach to the Eastern screech owl home range (150 acres).
d, EPC - Exposure Point Concentration; Values from Appendix E; units in ng/L for water, mg/kg dw for sediment and soil, and mg/kg ww for dietary items.
e, DMIR - Daily mercury intake rate (or estimated daily dose).
f, Values from Section 4.7.3 (or Appendix C).
g, HQ - Hazard quotient; HQ_{NOAEL} = DMIR_{Total}/NOAEL; HQ_{LOAEL} = DMIR_{Total}/LOAEL.
h, Weighted HQs based on AUFs.
i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0.
j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. ΣHQ_i x AUF_i, where i = Exposure Areas and ΣAUF_i = 1).
k, Soil IHg and MeHg EPCs for Dose Rate Modeling are estimated as 98% and 2% of the THg EPCs (AOC 4 ERA Report, Appendix E, Table E-6), respectively, for the surficial soil in the 0.3 Year Floodplain.

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Table F-4
Dose Rate Modeling Calculations - Tree Swallow (*Tachycineta bicolor*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	0.020	kg	Robertson et al. (1992) ^c and Dunning (1993) ^c
Food Ingestion Rate (FIR)	0.015	kg ww/day	Equation #38 in Nagy (2001)
Water Ingestion Rate (WIR)	0.004	L/day	Calder and Braun (1983)
Substratet Ingestion Rate (SIR)	0.00	kg dw/day	Assumed to be negligible
Home Range (HR)	5-148	acre	EPA (2003)

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Aquatic Invertebrates - Emergent (AIE)	95	%	0.014	kg ww/day
Wolf spiders (WS)	5	%	0.001	kg ww/day

Toxicity Reference Values (TRVs) ^f	Value	Unit
No Observed Adverse Effects Level (NOAEL)	0.45	mg IHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	0.9	mg IHg/kg BW/day

Assessment Reach	Area ^c (acre)	AUF ^c	EPC ^d (ng/L or mg/kg ww)			DMIR ^e (mg IHg/kg BW/day)				HQ ^g		AUF-Adjusted HQ	
			Water	AIE	WS	Water	AIE	WS	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	47	0.61	2.06	0.02	0.02	4.40E-07	1.40E-02	7.64E-04	0.015	0.0	0.0	0.0	0.0
RRM -0.7 to 0.0	8	0.10	27.6	0.02	0.02	5.90E-06	1.40E-02	7.64E-04	0.015	0.0	0.0	0.0	0.0
RRM 0.0 to 0.8	12	0.16	24.2	0.26	0.20	5.18E-06	1.82E-01	7.64E-03	0.189	0.4	0.2	0.1	0.0
RRM 0.8 to 1.7	12	0.16	40.1	0.26	0.20	8.59E-06	1.82E-01	7.64E-03	0.189	0.4	0.2	0.1	0.0
RRM 1.7 to 2.7	24	0.32	53.2	0.26	0.20	1.14E-05	1.82E-01	7.64E-03	0.189	0.4	0.2	0.1	0.1
RRM 2.7 to 4.4	88	1.00	71.0	1.21	0.70	1.52E-05	8.65E-01	2.64E-02	0.891	2.0	1.0	2.0	1.0
RRM 4.4 to 5.2	15	0.19	84.9	1.21	0.70	1.82E-05	8.65E-01	2.64E-02	0.891	2.0	1.0	0.4	0.2
RRM 5.2 to 7.9	77	0.99	114.7	1.21	0.70	2.46E-05	8.65E-01	2.64E-02	0.891	2.0	1.0	2.0	1.0
RRM 7.9 to 9.2	33	0.43	386	0.85	0.70	8.27E-05	6.04E-01	2.64E-02	0.630	1.4	0.7	0.6	0.3
RRM 9.2 to 11.3	34	0.45	119.9	0.85	0.70	2.57E-05	6.04E-01	2.64E-02	0.630	1.4	0.7	0.6	0.3
RRM 11.3 to 12.5	26	0.34	96.4	0.20	0.70	2.07E-05	1.45E-01	2.64E-02	0.172	0.4	0.2	0.1	0.1
RRM 12.5 to 13.5	28	0.37	142.4	1.01	0.70	3.05E-05	7.21E-01	2.64E-02	0.748	1.7	0.8	0.6	0.3
RRM 13.5 to 16.7	70	0.91	88.0	1.01	0.70	1.88E-05	7.21E-01	2.64E-02	0.748	1.7	0.8	1.5	0.8
RRM 16.7 to 20.9	72	0.93	78.5	1.01	0.25	1.68E-05	7.21E-01	9.22E-03	0.731	1.6	0.8	1.5	0.8
RRM 20.9 to 24.0	81	1.00	50.4	0.30	0.14	1.08E-05	2.17E-01	5.16E-03	0.222	0.5	0.2	0.5	0.2
SFSR	--	1.00	17.92	0.30	0.14	3.84E-06	2.17E-01	5.16E-03	0.222	0.5	0.2	0.5	0.2
Minimum HQ ⁱ :										0.4	0.2	0.1	0.0
Maximum HQ ⁱ :										2.0	1.0	2.0	1.0
Cumulative HQ ^{ij} :										2.0	1.0		

Notes:

- , Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.
- a, More details are provided in Appendix D (Table D-2a).
- b, Intake rates = Dietary Composition (%) x FIR.
- c, AUF - Area Use Factor; Estimated based on the ratio of the 0.3-year floodplain area (Area, in acres) within each reach to the mid range of the Tree swallow home range (77 acres).
- d, EPC - Exposure point concentration; Values from Appendix E; units in ng/L for water and mg/kg ww for dietary items.
- e, DMIR - Daily mercury intake rate (or estimated daily dose).
- f, Values from Section 4.7.3 (or Appendix C).
- g, HQ - Hazard quotient; $HQ_{NOAEL} = DMIR_{Total}/NOAEL$; $HQ_{LOAEL} = DMIR_{Total}/LOAEL$.
- h, Weighted HQs based on AUFs.
- i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0.
- j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. $\sum HQ_i \times AUF_i$, where i = Exposure Areas and $\sum AUF_i = 1$).

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Table F-5
Dose Rate Modeling Calculations - American Robin (*Turdus migratorius*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	0.081	kg	USACHPPM (2004)
Food Ingestion Rate (FIR)	0.035	kg ww/day	Equation #38 in Nagy (2001)
Water Ingestion Rate (WIR)	0.011	L/day	Calder and Braun (1983)
Soil Ingestion Rate (SIR)	2.63E-04	kg dw/day	Assumed 2.1 % of dry FIR using Equation #37 in Nagy (2001)
Home Range (HR)	0.27-2.07	acre	EPA (2003)

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Earthworms (EW)	70	%	0.025	kg ww/day
Wolf spiders (WS)	20	%	0.007	kg ww/day
Terrestrial Plants (TP)	10	%	0.004	kg ww/day

Toxicity Reference Values (TRVs) ^f	Value	Unit
No Observed Adverse Effects Level (NOAEL)	0.45	mg IHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	0.9	mg IHg/kg BW/day

Assessment Reach	Area ^c (acre)	AUF ^c	EPC ^d (ng/L, mg/kg dw, or mg/kg ww)					DMIR ^e (mg IHg/kg BW/day)						HQ ^g		AUF-Adjusted HQ	
			Water	Soil ^k	EW	WS	TP	Water	Soil	EW	WS	TP	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	47	1.00	2.06	0.16	0.17	0.02	0.02	2.78E-07	5.12E-04	5.19E-02	1.77E-03	8.28E-04	0.05	0.1	0.1	0.1	0.1
RRM -0.7 to 0.0	8	1.00	27.6	0.16	0.17	0.02	0.02	3.73E-06	5.12E-04	5.19E-02	1.77E-03	8.28E-04	0.06	0.1	0.1	0.1	0.1
RRM 0.0 to 0.8	12	1.00	24.2	35.6	1.56	0.20	0.02	3.27E-06	1.15E-01	4.72E-01	1.77E-02	8.28E-04	0.61	1.3	0.7	1.3	0.7
RRM 0.8 to 1.7	12	1.00	40.1	46.2	1.57	0.20	0.02	5.42E-06	1.50E-01	4.75E-01	1.77E-02	8.28E-04	0.64	1.4	0.7	1.4	0.7
RRM 1.7 to 2.7	24	1.00	53.2	23.3	3.58	0.20	0.02	7.19E-06	7.55E-02	1.09E+00	1.77E-02	8.28E-04	1.18	2.6	1.3	2.6	1.3
RRM 2.7 to 4.4	88	1.00	71.0	21.6	4.28	0.70	0.02	9.60E-06	7.01E-02	1.30E+00	6.10E-02	9.49E-04	1.43	3.2	1.6	3.2	1.6
RRM 4.4 to 5.2	15	1.00	84.9	41.2	4.28	0.70	0.02	1.15E-05	1.34E-01	1.30E+00	6.10E-02	9.49E-04	1.49	3.3	1.7	3.3	1.7
RRM 5.2 to 7.9	77	1.00	115	16.7	4.21	0.70	0.02	1.55E-05	5.41E-02	1.28E+00	6.10E-02	9.49E-04	1.39	3.1	1.5	3.1	1.5
RRM 7.9 to 9.2	33	1.00	386	14.2	4.21	0.70	0.02	5.22E-05	4.60E-02	1.28E+00	6.10E-02	9.49E-04	1.38	3.1	1.5	3.1	1.5
RRM 9.2 to 11.3	34	1.00	120	25.1	3.55	0.70	0.02	1.62E-05	8.14E-02	1.08E+00	6.10E-02	9.49E-04	1.22	2.7	1.4	2.7	1.4
RRM 11.3 to 12.5	26	1.00	96.4	14.8	4.65	0.70	0.02	1.30E-05	4.80E-02	1.41E+00	6.10E-02	9.49E-04	1.52	3.4	1.7	3.4	1.7
RRM 12.5 to 13.5	28	1.00	142	8.12	4.65	0.70	0.04	1.93E-05	2.63E-02	1.41E+00	6.10E-02	1.72E-03	1.50	3.3	1.7	3.3	1.7
RRM 13.5 to 16.7	70	1.00	88.0	7.29	2.96	0.70	0.04	1.19E-05	2.36E-02	8.99E-01	6.10E-02	1.72E-03	0.99	2.2	1.1	2.2	1.1
RRM 16.7 to 20.9	72	1.00	78.5	7.06	2.62	0.25	0.04	1.06E-05	2.29E-02	7.94E-01	2.13E-02	1.72E-03	0.84	1.9	0.9	1.9	0.9
RRM 20.9 to 24.0	81	1.00	50.4	12.4	1.40	0.14	0.01	6.81E-06	4.02E-02	4.25E-01	1.19E-02	3.33E-04	0.48	1.1	0.5	1.1	0.5
SFSR	--	1.00	17.9	0.00	1.40	0.14	0.01	2.42E-06	0.00E+00	4.25E-01	1.19E-02	3.33E-04	0.44	1.0	0.5	1.0	0.5
												Minimum HQ ⁱ :	1.0	0.5	1.0	0.5	
												Maximum HQ ⁱ :	3.4	1.7	3.4	1.7	
												Cumulative HQ ^{i,j} :	3.4	1.7			

Notes:

Notes:

- , Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.
- a, More details are provided in Appendix D (Table D-2a).
- b, Intake rates = Dietary Composition (%) x FIR.
- c, AUF - Area use factor; Estimated based on the ratio of the 0.3-year floodplain area (Area, in acres) within each reach to the American robin home range (0.27-2.07 acres).
- d, EPC - Exposure point concentration; Values from Appendix E; units in ng/L for water, mg/kg dw for soil, and mg/kg ww for dietary items.
- e, DMIR - Daily mercury intake rate (or estimated daily dose).
- f, Values from Section 4.7.3 (or Appendix C).
- g, HQ - Hazard quotient; $HQ_{NOAEL} = DMIR_{Total}/NOAEL$; $HQ_{LOAEL} = DMIR_{Total}/LOAEL$.
- h, Weighted HQs based on AUFs.
- i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0.
- j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. $\sum HQ_i \times AUF_i$, where i = Exposure Areas and $\sum AUF_i = 1$).
- k, Soil IHg and MeHg EPCs for Dose Rate Modeling are estimated as 98% and 2% of the THg EPCs (AOC 4 ERA Report, Appendix E, Table E-6), respectively, for the surficial soil in the 0.3 Year Floodplain.

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Table F-6
Dose Rate Modeling Calculations - River Otter (*Lontra canadensis*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	7.430	kg	Lauhachinda (1978) [as cited in EPA (1993)]
Food Ingestion Rate (FIR)	0.899	kg ww/day	Equation #26 in Nagy (2001)
Water Ingestion Rate (WIR)	0.602	L/day	Calder and Braun (1983)
Sediment Ingestion Rate (SIR)	2.59E-03	kg dw/day	Assumed 1% of dry FIR using Equation #25 in Nagy (2001)
Home Range (HR)	>729	acre	EPA (2003)

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Crayfish (CF)	5	%	0.045	kg ww/day
Frogs	5	%	0.045	kg ww/day
Fish TL < 130 mm (SF)	45	%	0.405	kg ww/day
Fish TL > 130 mm (LF)	45	%	0.405	kg ww/day

Toxicity Reference Values (TRVs) ^f	Value	Unit
No Observed Adverse Effects Level (NOAEL)	1.01	mg IHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	--	mg IHg/kg BW/day

Assessment Reach	Area ^c (acre)	AUF ^c	EPC ^d (ng/L, mg/kg dw, or mg/kg ww)						DMIR ^e (mg IHg/kg BW/day)							HQ ^g		AUF-Adjusted HQ	
			Water	Sediment	CF	Frogs	SF	LF	Water	Sediment	CF	Frogs	SF	LF	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	47	0.06	2.06	0.05	0.01	0.02	0.06	0.01	1.67E-07	1.79E-05	4.18E-05	1.45E-04	3.15E-03	6.81E-04	0.00	0.0	--	0.0	--
RRM -0.7 to 0.0	8	0.01	27.6	4.86	0.01	0.03	0.06	0.01	2.23E-06	1.69E-03	4.18E-05	1.52E-04	3.15E-03	6.81E-04	0.01	0.0	--	0.0	--
RRM 0.0 to 0.8	12	0.02	24.2	4.68	0.12	0.110	0.485	0.05	1.96E-06	1.63E-03	7.44E-04	6.67E-04	2.64E-02	2.64E-03	0.03	0.0	--	0.0	--
RRM 0.8 to 1.7	12	0.02	40.1	7.81	0.06	0.18	0.07	0.07	3.25E-06	2.72E-03	3.62E-04	1.06E-03	4.00E-03	3.60E-03	0.01	0.0	--	0.0	--
RRM 1.7 to 2.7	24	0.03	53.2	35.1	0.14	0.18	0.09	0.09	4.31E-06	1.22E-02	8.47E-04	1.06E-03	5.16E-03	4.89E-03	0.02	0.0	--	0.0	--
RRM 2.7 to 4.4	88	0.12	71.0	41.7	0.25	0.30	0.21	0.11	5.75E-06	1.45E-02	1.54E-03	1.83E-03	1.12E-02	6.04E-03	0.03	0.0	--	0.0	--
RRM 4.4 to 5.2	15	0.02	84.9	200	0.25	0.30	0.32	0.13	6.88E-06	6.97E-02	1.54E-03	1.83E-03	1.75E-02	6.81E-03	0.09	0.1	--	0.0	--
RRM 5.2 to 7.9	77	0.11	114.7	27.7	0.25	0.34	0.32	0.17	9.29E-06	9.66E-03	1.48E-03	2.03E-03	1.75E-02	9.15E-03	0.03	0.0	--	0.0	--
RRM 7.9 to 9.2	33	0.05	386	84.3	0.17	0.27	0.22	0.17	3.13E-05	2.94E-02	1.01E-03	1.63E-03	1.18E-02	9.15E-03	0.04	0.0	--	0.0	--
RRM 9.2 to 11.3	34	0.05	119.9	27.6	0.11	0.27	0.09	0.16	9.71E-06	9.60E-03	6.84E-04	1.66E-03	4.80E-03	8.82E-03	0.02	0.0	--	0.0	--
RRM 11.3 to 12.5	26	0.04	96.4	13.54	0.10	0.27	0.32	0.12	7.81E-06	4.72E-03	5.95E-04	1.64E-03	1.75E-02	6.59E-03	0.02	0.0	--	0.0	--
RRM 12.5 to 13.5	28	0.04	142.4	14.03	0.19	0.30	0.16	0.13	1.15E-05	4.89E-03	1.14E-03	1.81E-03	8.93E-03	6.81E-03	0.02	0.0	--	0.0	--
RRM 13.5 to 16.7	70	0.10	88.0	14.63	0.10	0.30	0.20	0.13	7.13E-06	5.10E-03	6.29E-04	1.81E-03	1.11E-02	6.81E-03	0.02	0.0	--	0.0	--
RRM 16.7 to 20.9	72	0.10	78.5	12.81	0.10	0.30	0.12	0.13	6.36E-06	4.46E-03	6.29E-04	1.81E-03	6.70E-03	7.02E-03	0.01	0.0	--	0.0	--
RRM 20.9 to 24.0	81	0.11	50.4	14.25	0.15	0.24	0.23	0.10	4.08E-06	4.96E-03	9.26E-04	1.44E-03	1.25E-02	5.55E-03	0.02	0.0	--	0.0	--
SFSR	--	1.00	17.92	0.74	0.07	0.14	0.04	0.04	1.45E-06	2.59E-04	4.05E-04	8.19E-04	2.06E-03	2.37E-03	0.00	0.0	--	0.0	--
Minimum HQ ⁱ :																0.0	--	0.0	--
Maximum HQ ⁱ :																0.1	--	0.0	--
Cumulative HQ ^{i,j} :																0.0	--		

Notes:

- , Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.
- a, More details are provided in Appendix D (Table D-2a).
- b, Intake rates = Dietary Composition (%) x FIR.
- c, AUF - Area use factor; Estimated based on the ratio of the 0.3-year floodplain area (Area, in acres) within each reach to the River otter home range (729 acres).
- d, EPC - Exposure point concentration; Values from Appendix E; units in ng/L for water, mg/kg dw for sediment, and mg/kg ww for dietary items.
- e, DMIR - Daily mercury intake rate (or estimated daily dose).
- f, Values from Section 4.7.3 (or Appendix C).
- g, HQ - Hazard quotient; $HQ_{NOAEL} = DMIR_{Total}/NOAEL$; $HQ_{LOAEL} = DMIR_{Total}/LOAEL$.
- h, Weighted HQs based on AUFs.
- i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0.
- j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. $\sum HQ_i \times AUF_i$, where i = Exposure Areas and $\sum AUF_i = 1$).

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Table F-7
Dose Rate Modeling Calculations - Short-Tailed Shrew (*Blarina brevicauda*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	0.017	kg	Guilday (1957) [as cited in EPA (1993)]
Food Ingestion Rate (FIR)	0.007	kg ww/day	Equation #32 in Nagy (2001)
Water Ingestion Rate (WIR)	0.003	L/day	Calder and Braun (1983)
Soil Ingestion Rate (SIR)	5.27E-05	kg dw/day	Assumed 2.4 % of dry FIR using Equation #31 in Nagy (2001)
Home Range (HR)	0.07-4.45	acre	EPA (2003)

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Earthworms (EW)	60	%	0.004	kg ww/day
Wolf spiders (WS)	35	%	0.002	kg ww/day
Terrestrial Plants (TP)	5	%	0.000	kg ww/day

Toxicity Reference Values (TRVs) ^f	Value	Unit
No Observed Adverse Effects Level (NOAEL)	1.01	mg IHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	--	mg IHg/kg BW/day

Assessment Reach	Area ^c (acre)	AUF ^c	EPC ^d (ng/L, mg/kg dw, or mg/kg ww)					DMIR ^e (mg IHg/kg BW/day)						HQ ^g		AUF-Adjusted HQ	
			Water	Soil ^k	EW	WS	TP	Water	Soil	EW	WS	TP	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	47	1.00	2.06	0.16	0.17	0.02	0.02	3.05E-07	4.81E-04	3.95E-02	2.75E-03	3.67E-04	0.04	0.0	--	0.0	--
RRM -0.7 to 0.0	8	1.00	27.6	0.16	0.17	0.02	0.02	4.09E-06	4.81E-04	3.95E-02	2.75E-03	3.67E-04	0.04	0.0	--	0.0	--
RRM 0.0 to 0.8	12	1.00	24.2	35.6	1.56	0.204	0.02	3.59E-06	1.08E-01	3.59E-01	2.75E-02	3.67E-04	0.50	0.5	--	0.5	--
RRM 0.8 to 1.7	12	1.00	40.1	46.2	1.57	0.20	0.02	5.96E-06	1.41E-01	3.61E-01	2.75E-02	3.67E-04	0.53	0.5	--	0.5	--
RRM 1.7 to 2.7	24	1.00	53.2	23.3	3.58	0.20	0.02	7.90E-06	7.10E-02	8.26E-01	2.75E-02	3.67E-04	0.92	0.9	--	0.9	--
RRM 2.7 to 4.4	88	1.00	71.0	21.6	4.28	0.70	0.02	1.05E-05	6.59E-02	9.87E-01	9.47E-02	4.21E-04	1.15	1.1	--	1.1	--
RRM 4.4 to 5.2	15	1.00	84.9	41.2	4.28	0.70	0.02	1.26E-05	1.26E-01	9.87E-01	9.47E-02	4.21E-04	1.21	1.2	--	1.2	--
RRM 5.2 to 7.9	77	1.00	114.7	16.7	4.21	0.70	0.02	1.70E-05	5.08E-02	9.71E-01	9.47E-02	4.21E-04	1.12	1.1	--	1.1	--
RRM 7.9 to 9.2	33	1.00	386	14.2	4.21	0.70	0.02	5.73E-05	4.32E-02	9.71E-01	9.47E-02	4.21E-04	1.11	1.1	--	1.1	--
RRM 9.2 to 11.3	34	1.00	119.9	25.1	3.55	0.70	0.02	1.78E-05	7.65E-02	8.20E-01	9.47E-02	4.21E-04	0.99	1.0	--	1.0	--
RRM 11.3 to 12.5	26	1.00	96.4	14.8	4.65	0.70	0.02	1.43E-05	4.52E-02	1.07E+00	9.47E-02	4.21E-04	1.21	1.2	--	1.2	--
RRM 12.5 to 13.5	28	1.00	142.4	8.1	4.65	0.70	0.04	2.12E-05	2.48E-02	1.07E+00	9.47E-02	7.64E-04	1.19	1.2	--	1.2	--
RRM 13.5 to 16.7	70	1.00	88.0	7.3	2.96	0.70	0.04	1.31E-05	2.22E-02	6.84E-01	9.47E-02	7.64E-04	0.80	0.8	--	0.8	--
RRM 16.7 to 20.9	72	1.00	78.5	7.1	2.62	0.25	0.04	1.17E-05	2.15E-02	6.04E-01	3.31E-02	7.64E-04	0.66	0.7	--	0.7	--
RRM 20.9 to 24.0	81	1.00	50.4	12.4	1.40	0.14	0.01	7.49E-06	3.77E-02	3.23E-01	1.85E-02	1.48E-04	0.38	0.4	--	0.4	--
SFSR	--	1.00	17.9	0.0	1.40	0.14	0.01	2.66E-06	0.00E+00	3.23E-01	1.85E-02	1.48E-04	0.34	0.3	--	0.3	--
Minimum HQ ⁱ :														0.3	--	0.3	--
Maximum HQ ⁱ :														1.2	--	1.2	--
Cumulative HQ ^{i,j} :														1.2	--		

Notes:

- , Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.
- a, More details are provided in Appendix D (Table D-2a).
- b, Intake rates = Dietary Composition (%) x FIR.
- c, AUF - Area use factor; Estimated based on the ratio of the 0.3-year floodplain area (Area, in acres) within each reach to the Short-tailed shrew home range (0.07-4.45 acres).
- d, EPC - Exposure point concentration; Values from Appendix E; units in ng/L for water, mg/kg dw for soil, and mg/kg ww for dietary items.
- e, DMIR - Daily mercury intake rate (or estimated daily dose).
- f, Values from Section 4.7.3 (or Appendix C).
- g, HQ - Hazard quotient; $HQ_{NOAEL} = DMIR_{Total}/NOAEL$; $HQ_{LOAEL} = DMIR_{Total}/LOAEL$.
- h, Weighted HQs based on AUFs.
- i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0.
- j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. $\sum HQ_i \times AUF_i$, where i = Exposure Areas and $\sum AUF_i = 1$).
- k, Soil IHg and MeHg EPCs for Dose Rate Modeling are estimated as 98% and 2% of the THg EPCs (AOC 4 ERA Report, Appendix E, Table E-6), respectively, for the surficial soil in the 0.3 Year Floodplain.

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Table F-8
Dose Rate Modeling Calculations - White-Tailed Deer (*Odocoileus virginianus*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	56.500	kg	Smith (1991) [as cited in Sample and Suter (1994)]
Food Ingestion Rate (FIR)	2.513	kg ww/day	Equation #30 in Nagy (2001)
Water Ingestion Rate (WIR)	3.737	L/day	Calder and Braun (1983)
Soil Ingestion Rate (SIR)	7.44E-03	kg dw/day	Assumed 2.0 % of dry FIR using Equation #29 in Nagy (2001)
Home Range (HR)	>146	acre	EPA (2003)

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Aquatic Vegetation (AV)	10	%	0.251	kg ww/day
Terrestrial Plants (TP)	90	%	2.262	kg ww/day

Toxicity Reference Values (TRVs) ^f	Value	Unit
No Observed Adverse Effects Level (NOAEL)	1.01	mg IHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	--	mg IHg/kg BW/day

Assessment Reach	Area ^c (acre)	AUF ^c	EPC ^d (ng/L, mg/kg dw, or mg/kg ww)				DMIR ^e (mg MeHg/kg BW/day)					HQ ^g		AUF-Adjusted HQ	
			Water	Soil ^k	AV	TP	Water	Soil	AV	TP	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	47	0.32	2.06	0.16	0.03	0.02	1.36E-07	2.08E-05	1.23E-04	7.65E-04	0.00	0.0	--	0.0	--
RRM -0.7 to 0.0	8	0.05	27.6	0.16	0.03	0.02	1.82E-06	2.08E-05	1.23E-04	7.65E-04	0.00	0.0	--	0.0	--
RRM 0.0 to 0.8	12	0.08	24.2	35.6	0.24	0.02	1.60E-06	4.69E-03	1.09E-03	7.65E-04	0.01	0.0	--	0.0	--
RRM 0.8 to 1.7	12	0.08	40.1	46.2	0.49	0.02	2.65E-06	6.09E-03	2.16E-03	7.65E-04	0.01	0.0	--	0.0	--
RRM 1.7 to 2.7	24	0.17	53.2	23.3	0.56	0.02	3.52E-06	3.07E-03	2.51E-03	7.65E-04	0.01	0.0	--	0.0	--
RRM 2.7 to 4.4	88	0.60	71.0	21.6	1.54	0.02	4.69E-06	2.85E-03	6.85E-03	8.77E-04	0.01	0.0	--	0.0	--
RRM 4.4 to 5.2	15	0.10	84.9	41.2	4.53	0.02	5.62E-06	5.43E-03	2.01E-02	8.77E-04	0.03	0.0	--	0.0	--
RRM 5.2 to 7.9	77	0.52	115	16.7	0.67	0.02	7.59E-06	2.20E-03	2.99E-03	8.77E-04	0.01	0.0	--	0.0	--
RRM 7.9 to 9.2	33	0.23	386	14.2	1.11	0.02	2.55E-05	1.87E-03	4.92E-03	8.77E-04	0.01	0.0	--	0.0	--
RRM 9.2 to 11.3	34	0.24	120	25.1	0.22	0.02	7.93E-06	3.31E-03	9.61E-04	8.77E-04	0.01	0.0	--	0.0	--
RRM 11.3 to 12.5	26	0.18	96.4	14.8	0.31	0.02	6.38E-06	1.95E-03	1.39E-03	8.77E-04	0.00	0.0	--	0.0	--
RRM 12.5 to 13.5	28	0.19	142	8.12	0.45	0.04	9.42E-06	1.07E-03	2.02E-03	1.59E-03	0.00	0.0	--	0.0	--
RRM 13.5 to 16.7	70	0.48	88.0	7.29	0.37	0.04	5.82E-06	9.60E-04	1.63E-03	1.59E-03	0.00	0.0	--	0.0	--
RRM 16.7 to 20.9	72	0.49	78.5	7.06	0.20	0.04	5.19E-06	9.31E-04	8.67E-04	1.59E-03	0.00	0.0	--	0.0	--
RRM 20.9 to 24.0	81	0.55	50.4	12.4	0.82	0.01	3.33E-06	1.63E-03	3.66E-03	3.08E-04	0.01	0.0	--	0.0	--
SFSR	--	1.00	17.9	0.00	1.60	0.01	1.18E-06	0.00E+00	7.10E-03	3.08E-04	0.01	0.0	--	0.0	--
Minimum HQ ⁱ :												0.0	--	0.0	--
Maximum HQ ⁱ :												0.0	--	0.0	--
Cumulative HQ ^{i,j} :												0.0	--		

Notes:

- , Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.
- a, More details are provided in Appendix D (Table D-2a).
- b, Intake rates = Dietary Composition (%) x FIR.
- c, AUF - Area use factor; Estimated based on the ratio of the 0.3-year floodplain area (Area, in acres) within each reach to the White-tailed deer home range (146 acres).
- d, EPC - Exposure point concentration; Values from Appendix E; units in ng/L for water, mg/kg dw for soil, and mg/kg ww for dietary items.
- e, DMIR - Daily mercury intake rate (or estimated daily dose).
- f, Values from Section 4.7.3 (or Appendix C).
- g, HQ - Hazard quotient; $HQ_{NOAEL} = DMIR_{Total}/NOAEL$; $HQ_{LOAEL} = DMIR_{Total}/LOAEL$.
- h, Weighted HQs based on AUFs.
- i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0.
- j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. $\sum HQ_i \times AUF_i$, where i = Exposure Areas and $\sum AUF_i = 1$)
- k, Soil IHg and MeHg EPCs for Dose Rate Modeling are estimated as 98% and 2% of the THg EPCs (AOC 4 ERA Report, Appendix E, Table E-6), respectively, for the surficial soil in the 0.3 Year Floodplain.

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Table F-9
Dose Rate Modeling Calculations - Big Brown Bat (*Eptesicus fuscus*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	0.021	kg	Nagy (2001)
Food Ingestion Rate (FIR)	0.009	kg ww/day	Equation #8 in Nagy (2001)
Water Ingestion Rate (WIR)	0.003	L/day	Calder and Braun (1983)
Substrate Ingestion Rate (SIR)	0.00	kg dw/day	Assumed to be negligible
Home Range (HR)	>776	acre	Kurta and Baker (1990) [as cited in Sample and Suter (1994)]

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Aquatic Invertebrates - Emergent (AIE)	100	%	0.009	kg ww/day

Toxicity Reference Values (TRVs) ^f	Value	Unit
No Observed Adverse Effects Level (NOAEL)	1.01	mg IHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	--	mg IHg/kg BW/day

Assessment Reach	Area ^c (acre)	AUF ^c	EPC ^d (ng/L or mg/kg ww)		DMIR ^e (mg IHg/kg BW/day)			HQ ^g		AUF-Adjusted HQ	
			Water	AIE	Water	AIE	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	47	0.06	2.06	0.02	3.00E-07	8.32E-03	0.01	0.0	--	0.0	--
RRM -0.7 to 0.0	8	0.01	27.6	0.02	4.02E-06	8.32E-03	0.01	0.0	--	0.0	--
RRM 0.0 to 0.8	12	0.02	24.2	0.26	3.53E-06	1.08E-01	0.11	0.1	--	0.0	--
RRM 0.8 to 1.7	12	0.02	40.1	0.26	5.85E-06	1.08E-01	0.11	0.1	--	0.0	--
RRM 1.7 to 2.7	24	0.03	53.2	0.26	7.75E-06	1.08E-01	0.11	0.1	--	0.0	--
RRM 2.7 to 4.4	88	0.11	71.0	1.21	1.04E-05	5.15E-01	0.51	0.5	--	0.1	--
RRM 4.4 to 5.2	15	0.02	84.9	1.21	1.24E-05	5.15E-01	0.51	0.5	--	0.0	--
RRM 5.2 to 7.9	77	0.10	114.7	1.21	1.67E-05	5.15E-01	0.51	0.5	--	0.1	--
RRM 7.9 to 9.2	33	0.04	386	0.85	5.63E-05	3.60E-01	0.36	0.4	--	0.0	--
RRM 9.2 to 11.3	34	0.04	119.9	0.85	1.75E-05	3.60E-01	0.36	0.4	--	0.0	--
RRM 11.3 to 12.5	26	0.03	96.4	0.20	1.41E-05	8.65E-02	0.09	0.1	--	0.0	--
RRM 12.5 to 13.5	28	0.04	142.4	1.01	2.08E-05	4.29E-01	0.43	0.4	--	0.0	--
RRM 13.5 to 16.7	70	0.09	88.0	1.01	1.28E-05	4.29E-01	0.43	0.4	--	0.0	--
RRM 16.7 to 20.9	72	0.09	78.5	1.01	1.14E-05	4.29E-01	0.43	0.4	--	0.0	--
RRM 20.9 to 24.0	81	0.10	50.4	0.30	7.35E-06	1.29E-01	0.13	0.1	--	0.0	--
SFSR	--	1.00	17.9	0.30	2.61E-06	1.29E-01	0.13	0.1	--	0.1	--
Minimum HQ ⁱ :								0.1	--	0.0	--
Maximum HQ ⁱ :								0.5	--	0.1	--
Cumulative HQ ^{i,j} :								0.3	--		

Notes:

--, Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.

a, More details are provided in Appendix D (Table D-2a).

b, Intake rates = Dietary Composition (%) x FIR.

c, AUF - Area use factor; Estimated based on the ratio of the 0.3-year floodplain area (Area, in acres) within each reach to the Big brown bat home range (776 acres).

d, EPC - Exposure point concentration; Values from Appendix E; units in ng/L for water and mg/kg ww for dietary items.

e, DMIR - Daily mercury intake rate (or estimated daily dose).

f, Values from Section 4.7.3 (or Appendix C).

g, HQ - Hazard quotient; $HQ_{NOAEL} = DMIR_{Total}/NOAEL$; $HQ_{LOAEL} = DMIR_{Total}/LOAEL$.

h, Weighted HQs based on AUFs.

i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0.

j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. $\sum HQ_i \times AUF_i$, where i = Exposure Areas and $\sum AUF_i = 1$).

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Table F-10
Dose Rate Modeling Calculations - Belted Kingfisher (*Megasceryle alcyon*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	0.148	kg	Powdermill Nature Center [as cited in EPA (1993)]
Food Ingestion Rate (FIR)	0.085	kg ww/day	Equation #64 in Nagy (2001)
Water Ingestion Rate (WIR)	0.016	L/day	Calder and Braun (1983)
Sediment Ingestion Rate (SIR)	2.33E-04	kg dw/day	Assumed 1% of dry FIR using Equation #63 in Nagy (2001)
Home Range (HR)	1.5-20.8	acre	EPA (2003)

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Crayfish (CF)	5	%	0.004	kg ww/day
Frogs	5	%	0.004	kg ww/day
Fish TL < 130 mm (SF)	90	%	0.076	kg ww/day

Toxicity Reference Values (TRVs) ^f	Value	Unit
No Observed Adverse Effects Level (NOAEL)	0.017	mg MeHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	0.055	mg MeHg/kg BW/day

Assessment Reach	Shoreline ^c (miles)	AUF ^c	EPC ^d (ng/L, mg/kg dw, or mg/kg ww)					DMIR ^e (mg MeHg/kg BW/day)						HQ ^g		AUF-Adjusted HQ ^h	
			Water	Sediment	CF	Frogs	SF	Water	Sediment	CF	Frogs	SF	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	2	0.40	0.04	0.00	0.01	0.03	0.12	4.08E-09	3.42E-06	3.57E-04	7.67E-04	5.97E-02	0.061	3.6	1.1	1.4	0.4
RRM -0.7 to 0.0	0.7	0.14	0.05	0.03	0.01	0.03	0.12	5.66E-09	4.65E-05	3.57E-04	7.86E-04	5.97E-02	0.061	3.6	1.1	0.5	0.2
RRM 0.0 to 0.8	0.8	0.16	0.13	0.03	0.07	0.12	0.22	1.44E-08	4.65E-05	1.95E-03	3.52E-03	1.14E-01	0.120	7.0	2.2	1.1	0.3
RRM 0.8 to 1.7	0.9	0.18	0.40	0.01	0.09	0.20	0.37	4.48E-08	9.09E-06	2.70E-03	5.60E-03	1.89E-01	0.198	12	3.6	2.1	0.6
RRM 1.7 to 2.7	1	0.20	0.58	0.33	0.17	0.20	0.49	6.43E-08	5.26E-04	4.74E-03	5.60E-03	2.54E-01	0.265	16	4.8	3.1	1.0
RRM 2.7 to 4.4	1.7	0.34	1.06	0.08	0.35	0.34	0.69	1.17E-07	1.18E-04	1.00E-02	9.72E-03	3.52E-01	0.372	22	6.8	7.4	2.3
RRM 4.4 to 5.2	0.8	0.16	1.57	0.05	0.37	0.34	1.18	1.74E-07	7.19E-05	1.05E-02	9.72E-03	6.06E-01	0.626	37	11	5.9	1.8
RRM 5.2 to 7.9	2.7	0.54	1.20	0.06	0.37	0.38	1.18	1.33E-07	8.92E-05	1.05E-02	1.09E-02	6.06E-01	0.627	37	11	20	6.2
RRM 7.9 to 9.2	1.3	0.26	2.06	0.05	0.42	0.31	1.50	2.28E-07	7.25E-05	1.21E-02	8.76E-03	7.73E-01	0.794	47	14	12	3.8
RRM 9.2 to 11.3	2.1	0.42	1.12	0.06	0.27	0.32	0.79	1.24E-07	8.70E-05	7.69E-03	9.24E-03	4.04E-01	0.421	25	7.7	10	3.2
RRM 11.3 to 12.5	1.2	0.24	2.37	0.33	0.43	0.32	0.90	2.63E-07	5.20E-04	1.24E-02	9.16E-03	4.63E-01	0.485	29	8.8	6.8	2.1
RRM 12.5 to 13.5	1	0.20	3.26	0.05	0.46	0.35	1.45	3.61E-07	7.09E-05	1.33E-02	1.01E-02	7.46E-01	0.769	45	14	9.0	2.8
RRM 13.5 to 16.7	3.2	0.64	1.57	0.09	0.56	0.35	2.44	1.74E-07	1.40E-04	1.59E-02	1.01E-02	1.26E+00	1.283	75	23	48	15
RRM 16.7 to 20.9	4.2	0.84	2.15	0.09	0.48	0.35	1.20	2.39E-07	1.40E-04	1.37E-02	1.01E-02	6.19E-01	0.643	38	12	32	9.8
RRM 20.9 to 24.0	3.1	0.62	1.73	0.07	0.43	0.28	0.80	1.92E-07	1.13E-04	1.24E-02	8.07E-03	4.12E-01	0.433	25	7.9	16	4.9
SFSR	--	1	0.48	0.07	0.14	0.17	0.24	5.26E-08	1.13E-04	3.91E-03	4.78E-03	1.22E-01	0.131	7.7	2.4	7.7	2.4
												Minimum HQ ⁱ :		7.0	2.2	1.1	0.3
												Maximum HQ ⁱ :		75	23	48	15
												Cumulative HQ ^{j,l} :		63	20	--	--

Notes:

--, Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.

Notes:

- , Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.
- a, More details are provided in Appendix D (Table D-2a).
- b, Intake rates = Dietary Composition (%) x FIR.
- c, AUF - Area use factor; Estimated based on the ratio of the shoreline length within the reach relative to the home range of five linear miles from a nest.
- d, EPC - Exposure point concentration; Values from Appendix E; units in ng/L for water, mg/kg dw for sediment, and mg/kg ww for dietary items.
- e, DMIR - Daily mercury intake rate (or estimated daily dose).
- f, Values from Section 4.7.3 (or Appendix C).
- g, HQ - Hazard quotient; $HQ_{NOAEL} = DMIR_{Total}/NOAEL$; $HQ_{LOAEL} = DMIR_{Total}/LOAEL$.
- h, Weighted HQs based on AUFs.
- i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0 and SFSR.
- j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. $\sum HQ_i \times AUF_i$, where i = Exposure Areas and $\sum AUF_i = 1$).

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Table F-11
Dose Rate Modeling Calculations - Mallard Duck (*Anas platyrhynchos*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	1.171	kg	Delnicki & Reinecke (1986) [as cited in EPA (1993)]
Food Ingestion Rate (FIR)	0.176	kg ww/day	Equation #62 in Nagy (2001)
Water Ingestion Rate (WIR)	0.066	L/day	Calder and Braun (1983)
Sediment Ingestion Rate (SIR)	1.86E-03	kg dw/day	Assumed 3.3% of dry FIR using Equation #61 in Nagy (2001)
Home Range (HR)	94-3560	acre	EPA (2003)

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Aquatic Vegetation (AV)	5	%	0.009	kg ww/day
Aquatic Invertebrates - Larval (AIL)	45	%	0.079	kg ww/day
Crayfish (CF)	45	%	0.079	kg ww/day
Fish < 130 mm TL (SF)	5	%	0.009	kg ww/day

Toxicity Reference Values (TRVs) ⁱ	Value	Unit
No Observed Adverse Effects Level (NOAEL)	0.024	mg MeHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	0.078	mg MeHg/kg BW/day

Assessment Reach	Area ^c (acre)	AUF ^c	EPC ^d (ng/L, mg/kg dw, or mg/kg ww)						DMIR ^e (mg MeHg/kg BW/day)							HQ ^g		AUF-Adjusted HQ	
			Water	Sediment	AV	AIL	CF	SF	Water	Sediment	AV	AIL	CF	SF	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	47	0.5	0.037	0.00	0.00	0.013	0.013	0.12	2.06E-09	3.44E-06	1.08E-05	8.98E-04	8.44E-04	8.71E-04	0.003	0.1	0.0	0.1	0.0
RRM -0.7 to 0.0	8	0.1	0.051	0.03	0.00	0.013	0.013	0.12	2.86E-09	4.68E-05	1.08E-05	8.98E-04	8.44E-04	8.71E-04	0.003	0.1	0.0	0.0	0.0
RRM 0.0 to 0.8	12	0.1	0.13	0.03	0.00	0.180	0.068	0.22	7.28E-09	4.68E-05	2.71E-05	1.22E-02	4.62E-03	1.67E-03	0.019	0.8	0.2	0.1	0.0
RRM 0.8 to 1.7	12	0.1	0.40	0.01	0.00	0.16	0.09	0.37	2.26E-08	9.15E-06	2.63E-05	1.09E-02	6.38E-03	2.76E-03	0.020	0.8	0.3	0.1	0.0
RRM 1.7 to 2.7	24	0.3	0.58	0.33	0.01	0.07	0.17	0.49	3.25E-08	5.29E-04	9.31E-05	4.52E-03	1.12E-02	3.71E-03	0.020	0.8	0.3	0.2	0.1
RRM 2.7 to 4.4	88	0.9	1.06	0.08	0.03	0.16	0.35	0.69	5.93E-08	1.19E-04	1.88E-04	1.08E-02	2.37E-02	5.14E-03	0.040	1.7	0.5	1.6	0.5
RRM 4.4 to 5.2	15	0.2	1.57	0.05	0.01	0.19	0.37	1.18	8.81E-08	7.23E-05	9.08E-05	1.27E-02	2.48E-02	8.84E-03	0.046	1.9	0.6	0.3	0.1
RRM 5.2 to 7.9	77	0.8	1.20	0.06	0.01	0.19	0.37	1.18	6.73E-08	8.97E-05	9.16E-05	1.27E-02	2.48E-02	8.84E-03	0.047	1.9	0.6	1.6	0.5
RRM 7.9 to 9.2	33	0.4	2.06	0.05	0.05	0.21	0.42	1.50	1.15E-07	7.29E-05	3.50E-04	1.40E-02	2.86E-02	1.13E-02	0.054	2.3	0.7	0.8	0.2
RRM 9.2 to 11.3	34	0.4	1.12	0.06	0.00	0.22	0.27	0.79	6.27E-08	8.75E-05	2.97E-05	1.49E-02	1.82E-02	5.90E-03	0.039	1.6	0.5	0.6	0.2
RRM 11.3 to 12.5	26	0.3	2.37	0.33	0.03	0.42	0.43	0.90	1.33E-07	5.23E-04	2.30E-04	2.85E-02	2.92E-02	6.75E-03	0.065	2.7	0.8	0.7	0.2
RRM 12.5 to 13.5	28	0.3	3.26	0.05	0.05	4.04	0.46	1.45	1.82E-07	7.13E-05	3.48E-04	2.73E-01	3.13E-02	1.09E-02	0.316	13	4.0	3.9	1.2
RRM 13.5 to 16.7	70	0.7	1.57	0.09	0.01	0.27	0.56	2.44	8.79E-08	1.40E-04	7.38E-05	1.81E-02	3.75E-02	1.83E-02	0.074	3.1	1.0	2.3	0.7
RRM 16.7 to 20.9	72	0.8	2.15	0.09	0.01	0.33	0.48	1.20	1.21E-07	1.40E-04	6.69E-05	2.24E-02	3.24E-02	9.03E-03	0.064	2.7	0.8	2.0	0.6
RRM 20.9 to 24.0	81	0.9	1.73	0.07	0.01	0.22	0.43	0.80	9.68E-08	1.13E-04	1.04E-04	1.47E-02	2.92E-02	6.02E-03	0.050	2.1	0.6	1.8	0.6
SFSR	--	1.0	0.48	0.07	0.01	0.06	0.14	0.24	2.66E-08	1.13E-04	4.96E-05	3.94E-03	9.25E-03	1.79E-03	0.015	0.6	0.2	0.6	0.2
Minimum HQ ^{i,j} :																0.6	0.2	0.1	0.0
Maximum HQ ^{i,j} :																13	4.0	3.9	1.2
Cumulative HQ ^{i,j} :																5.9	1.8	--	--

Notes:

- , Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.
- a, More details are provided in Appendix D (Table D-2a).
- b, Intake rates = Dietary Composition (%) x FIR.
- c, AUF - Area use factor; Estimated based on the ratio of the 0.3-year floodplain area (Area, in acres) within each reach to the lower end of the mallard home range (94 acres).
- d, EPC - Exposure point concentration; Values from Appendix E; units in ng/L for water, mg/kg dw for sediment, and mg/kg ww for dietary items.
- e, DMIR - Daily mercury intake rate (or estimated daily dose).
- f, Values from Section 4.7.3 (or Appendix C).
- g, HQ - Hazard quotient; $HQ_{NOAEL} = DMIR_{Total}/NOAEL$; $HQ_{LOAEL} = DMIR_{Total}/LOAEL$.
- h, Weighted HQs based on AUFs.
- i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0 and SFSR.
- j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. $\sum HQ_i \times AUF_i$, where i = Exposure Areas and $\sum AUF_i = 1$).

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Table F-12
Dose Rate Modeling Calculations - Eastern Screech Owl (*Megascops asio*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	0.164	kg	ADW (2014)
Food Ingestion Rate (FIR)	0.091	kg ww/day	Equation #64 in Nagy (2001)
Water Ingestion Rate (WIR)	0.018	L/day	Calder and Braun (1983)
Sediment Ingestion Rate (SIR1)	2.50E-04	kg dw/day	Assumed 1% of dry FIR using Equation #63 in Nagy (2001)
Soil Ingestion Rate (SIR2)	2.50E-04	kg dw/day	Assumed 1% of dry FIR using Equation #63 in Nagy (2001)
Home Range (HR)	150	acre	Hayward and Garton (1988)

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Crayfish (CF)	13	%	0.012	kg ww/day
Earthworms (EW)	10	%	0.009	kg ww/day
Wolf spiders (WS)	7	%	0.006	kg ww/day
Small birds (SB)	22	%	0.020	kg ww/day
Small mammals (SM)	48	%	0.043	kg ww/day

Toxicity Reference Values (TRVs) ⁱ	Value	Unit
No Observed Adverse Effects Level (NOAEL)	0.017	mg MeHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	0.055	mg MeHg/kg BW/day

Assessment Reach	Area ^c (acre)	AUF ^c	EPC ^d (ng/L, mg/kg dw, or mg/kg ww)								DMIR ^e (mg MeHg/kg BW/day)								HQ ^g		AUF-Adjusted HQ		
			Water	Sediment	Soil ^k	CF	EW	WS	SB	SM	Water	Sediment	Soil	CF	EM	WS	SB	SM	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	47	0.31	0.04	0.00	0.00	0.01	0.00	0.01	0.37	0.05	3.94E-09	3.30E-06	4.90E-06	8.97E-04	1.67E-04	3.51E-04	4.49E-02	1.43E-02	0.061	3.6	1.1	1.1	0.3
RRM -0.7 to 0.0	8	0.05	0.05	0.03	0.00	0.01	0.00	0.01	0.37	0.05	5.47E-09	4.49E-05	4.90E-06	8.97E-04	1.67E-04	3.51E-04	4.49E-02	1.43E-02	0.061	3.6	1.1	0.2	0.1
RRM 0.0 to 0.8	12	0.08	0.13	0.03	0.73	0.07	0.06	0.66	1.70	0.05	1.39E-08	4.49E-05	1.10E-03	4.91E-03	3.47E-03	2.54E-02	2.07E-01	1.43E-02	0.256	15	4.7	1.2	0.4
RRM 0.8 to 1.7	12	0.08	0.40	0.01	0.94	0.09	0.19	0.66	1.70	0.05	4.33E-08	8.78E-06	1.44E-03	6.78E-03	1.03E-02	2.54E-02	2.07E-01	1.43E-02	0.265	16	4.8	1.2	0.4
RRM 1.7 to 2.7	24	0.16	0.58	0.33	0.48	0.17	0.18	0.66	2.01	0.05	6.21E-08	5.08E-04	7.24E-04	1.19E-02	1.01E-02	2.54E-02	2.44E-01	1.43E-02	0.307	18	5.6	2.9	0.9
RRM 2.7 to 4.4	88	0.59	1.06	0.08	0.44	0.35	0.24	0.66	2.30	0.05	1.13E-07	1.14E-04	6.72E-04	2.52E-02	1.33E-02	2.54E-02	2.80E-01	1.43E-02	0.359	21	6.5	12	3.8
RRM 4.4 to 5.2	15	0.10	1.57	0.05	0.84	0.37	0.24	0.66	2.74	0.05	1.69E-07	6.94E-05	1.28E-03	2.63E-02	1.33E-02	2.54E-02	3.32E-01	1.43E-02	0.413	24	7.5	2.3	0.7
RRM 5.2 to 7.9	77	0.51	1.20	0.06	0.34	0.37	0.09	0.66	2.69	0.05	1.29E-07	8.62E-05	5.18E-04	2.63E-02	4.73E-03	2.54E-02	3.26E-01	1.43E-02	0.398	23	7.2	12	3.7
RRM 7.9 to 9.2	33	0.22	2.06	0.05	0.29	0.42	0.09	0.66	4.30	0.05	2.20E-07	7.00E-05	4.41E-04	3.04E-02	4.73E-03	2.54E-02	5.23E-01	1.43E-02	0.598	35	11	7.8	2.4
RRM 9.2 to 11.3	34	0.23	1.12	0.06	0.51	0.27	0.02	0.66	3.03	0.05	1.20E-07	8.40E-05	7.80E-04	1.93E-02	1.07E-03	2.54E-02	3.68E-01	1.43E-02	0.429	25	7.8	5.8	1.8
RRM 11.3 to 12.5	26	0.17	2.37	0.33	0.30	0.43	0.07	0.33	2.83	0.02	2.54E-07	5.02E-04	4.60E-04	3.11E-02	4.05E-03	1.27E-02	3.43E-01	5.99E-03	0.398	23	7.2	4.0	1.3
RRM 12.5 to 13.5	28	0.19	3.26	0.05	0.17	0.46	0.07	1.03	4.57	0.41	3.49E-07	6.85E-05	2.52E-04	3.33E-02	4.05E-03	3.97E-02	5.55E-01	1.09E-01	0.741	44	13	8.2	2.5
RRM 13.5 to 16.7	70	0.46	1.57	0.09	0.15	0.56	0.03	1.03	3.54	0.41	1.68E-07	1.35E-04	2.26E-04	3.98E-02	1.76E-03	3.97E-02	4.30E-01	1.09E-01	0.621	37	11	17	5.2
RRM 16.7 to 20.9	72	0.48	2.15	0.09	0.14	0.48	0.05	1.03	3.66	0.41	2.31E-07	1.35E-04	2.19E-04	3.45E-02	2.94E-03	3.97E-02	4.45E-01	1.09E-01	0.631	37	11	18	5.5
RRM 20.9 to 24.0	81	0.54	1.73	0.07	0.25	0.43	0.10	0.09	3.75	0.02	1.85E-07	1.09E-04	3.85E-04	3.11E-02	5.48E-03	3.51E-03	4.56E-01	4.61E-03	0.501	29	9.1	16	4.9
SFSR	--	1.00	0.48	0.07	0.00	0.14	0.10	0.09	1.83	0.02	5.09E-08	1.09E-04	0.00E+00	9.83E-03	5.48E-03	3.51E-03	2.22E-01	4.61E-03	0.245	14	4.5	14	4.5
																		Minimum HQ ^l :	14	4.5	1.2	0.4	
																		Maximum HQ ^l :	44	13	18	5.5	
																		Cumulative HQ ^{m,n} :	38	12	--	--	

Notes:

--, Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.

Notes:
--, Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.
a, More details are provided in Appendix D (Table D-2a).
b, Intake rates = Dietary Composition (%) x FIR.
c, AUF - Area use factor; Estimated based on the ratio of the 0.3-year floodplain area (Area, in acres) within each reach to the Eastern screech owl home range (150 acres).
d, EPC - Exposure point concentration; Values from Appendix E; units in ng/L for water, mg/kg dw for sediment and soil, and mg/kg ww for dietary items.
e, DMIR - Daily mercury intake rate (or estimated daily dose).
f, Values from Section 4.7.3 (or Appendix C).
g, HQ - Hazard quotient; HQ_{NOAEL} = DMIR_{Total}/NOAEL; HQ_{LOAEL} = DMIR_{Total}/LOAEL.
h, Weighted HQs based on AUFs.
i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0 and SFSR.
j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. ΣHQ_i x AUF_i, where i = Exposure Areas and ΣAUF_i = 1).
k, Soil IHg and MeHg EPCs for Dose Rate Modeling are estimated as 98% and 2% of the THg EPCs (AOC 4 ERA Report, Appendix E, Table E-6), respectively, for the surficial soil in the 0.3 Year Floodplain.

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Table F-13
Dose Rate Modeling Calculations - Tree Swallow (*Tachycineta bicolor*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	0.020	kg	Robertson et al. (1992) ^c and Dunning (1993) ^c
Food Ingestion Rate (FIR)	0.015	kg ww/day	Equation #38 in Nagy (2001)
Water Ingestion Rate (WIR)	0.004	L/day	Calder and Braun (1983)
Substrate Ingestion Rate (SIR)	0.00	kg dw/day	Assumed to be negligible
Home Range (HR)	5-148	acre	EPA (2003)

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Aquatic Invertebrates - Emergent (AIE)	95	%	0.014	kg ww/day
Wolf spiders (WS)	5	%	0.001	kg ww/day

Toxicity Reference Values (TRVs) ^f	Value	Unit
No Observed Adverse Effects Level (NOAEL)	0.036	mg MeHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	0.078	mg MeHg/kg BW/day

Assessment Reach	Area ^c (acre)	AUF ^c	EPC ^d (ng/L or mg/kg ww)			DMIR ^e (mg MeHg/kg BW/day)				HQ ^g		AUF-Adjusted HQ	
			Water	AIE	WS	Water	AIE	WS	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	47	0.61	0.04	0.01	0.01	7.88E-09	8.46E-03	3.40E-04	0.009	0.2	0.1	0.1	0.1
RRM -0.7 to 0.0	8	0.10	0.05	0.01	0.01	1.09E-08	8.46E-03	3.40E-04	0.009	0.2	0.1	0.0	0.0
RRM 0.0 to 0.8	12	0.16	0.13	0.06	0.66	2.78E-08	4.23E-02	2.46E-02	0.067	1.9	0.9	0.3	0.1
RRM 0.8 to 1.7	12	0.16	0.40	0.06	0.66	8.65E-08	4.23E-02	2.46E-02	0.067	1.9	0.9	0.3	0.1
RRM 1.7 to 2.7	24	0.32	0.58	0.06	0.66	1.24E-07	4.23E-02	2.46E-02	0.067	1.9	0.9	0.6	0.3
RRM 2.7 to 4.4	88	1.00	1.06	0.73	0.66	2.27E-07	5.17E-01	2.46E-02	0.542	15	6.9	15	6.9
RRM 4.4 to 5.2	15	0.19	1.57	1.85	0.66	3.37E-07	1.32E+00	2.46E-02	1.343	37	17	7.0	3.2
RRM 5.2 to 7.9	77	0.99	1.20	1.85	0.66	2.57E-07	1.32E+00	2.46E-02	1.343	37	17	37	17
RRM 7.9 to 9.2	33	0.43	2.06	1.85	0.66	4.41E-07	1.32E+00	2.46E-02	1.343	37	17	16	7.4
RRM 9.2 to 11.3	34	0.45	1.12	1.85	0.66	2.40E-07	1.32E+00	2.46E-02	1.343	37	17	17	7.7
RRM 11.3 to 12.5	26	0.34	2.37	0.64	0.33	5.08E-07	4.57E-01	1.23E-02	0.469	13	6.0	4.4	2.0
RRM 12.5 to 13.5	28	0.37	3.26	0.64	1.03	6.97E-07	4.57E-01	3.85E-02	0.495	14	6.3	5.0	2.3
RRM 13.5 to 16.7	70	0.91	1.57	0.64	1.03	3.36E-07	4.57E-01	3.85E-02	0.495	14	6.3	12	5.7
RRM 16.7 to 20.9	72	0.93	2.15	0.31	1.03	4.61E-07	2.21E-01	3.85E-02	0.259	7.2	3.3	6.7	3.1
RRM 20.9 to 24.0	81	1.00	1.73	0.23	0.09	3.70E-07	1.67E-01	3.40E-03	0.170	4.7	2.2	4.7	2.2
SFSR	--	1.00	0.48	0.23	0.09	1.02E-07	1.67E-01	3.40E-03	0.170	4.7	2.2	4.7	2.2
Minimum HQ ⁱ :										1.9	0.9	0.3	0.1
Maximum HQ ⁱ :										37	17	37	17
Cumulative HQ ^{i,j} :										37	17	--	--

Notes:

- , Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.
- a, More details are provided in Appendix D (Table D-2a).
- b, Intake rates = Dietary Composition (%) x FIR.
- c, AUF - Area use factor; Estimated based on the ratio of the 0.3-year floodplain area (Area, in acres) within each reach to the mid range of the Tree swallow home range (77 acres).
- d, EPC - Exposure point concentration; Values from Appendix E; units in ng/L for water and mg/kg ww for dietary items.
- e, DMIR - Daily mercury intake rate (or estimated daily dose).
- f, Values from Section 4.7.3 (or Appendix C).
- g, HQ - Hazard quotient; $HQ_{NOAEL} = DMIR_{Total}/NOAEL$; $HQ_{LOAEL} = DMIR_{Total}/LOAEL$.
- h, Weighted HQs based on AUFs.
- i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0 and SFSR.
- j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. $\sum HQ_i \times AUF_i$, where i = Exposure Areas and $\sum AUF_i = 1$).

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Table F-14
Dose Rate Modeling Calculations - American Robin (*Turdus migratorius*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	0.081	kg	USACHPPM (2004)
Food Ingestion Rate (FIR)	0.035	kg ww/day	Equation #38 in Nagy (2001)
Water Ingestion Rate (WIR)	0.011	L/day	Calder and Braun (1983)
Soil Ingestion Rate (SIR)	2.63E-04	kg dw/day	Assumed 2.1 % of dry FIR using Equation #37 in Nagy (2001)
Home Range (HR)	0.27-2.07	acre	EPA (2003)

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Earthworms (EW)	70	%	0.025	kg ww/day
Wolf spiders (WS)	20	%	0.007	kg ww/day
Terrestrial Plants (TP)	10	%	0.004	kg ww/day

Toxicity Reference Values (TRVs) ^f	Value	Unit
No Observed Adverse Effects Level (NOAEL)	0.036	mg MeHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	0.078	mg MeHg/kg BW/day

Assessment Reach	Area ^c (acre)	AUF ^c	EPC ^d (ng/L, mg/kg dw, or mg/kg ww)					DMIR ^e (mg MeHg/kg BW/day)						HQ ^g		AUF-Adjusted HQ	
			Water	Soil ^k	EW	WS	TP	Water	Soil	EW	WS	TP	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	47	1.0	0.04	0.00	0.00	0.01	0.00	4.98E-09	1.04E-05	9.19E-04	7.87E-04	5.38E-05	0.002	0.0	0.0	0.0	0.0
RRM -0.7 to 0.0	8	1.0	0.05	0.00	0.00	0.01	0.00	6.91E-09	1.04E-05	9.19E-04	7.87E-04	5.38E-05	0.002	0.0	0.0	0.0	0.0
RRM 0.0 to 0.8	12	1.0	0.13	0.73	0.06	0.66	0.00	1.76E-08	2.35E-03	1.91E-02	5.70E-02	5.38E-05	0.078	2.2	1.0	2.2	1.0
RRM 0.8 to 1.7	12	1.0	0.40	0.94	0.19	0.66	0.00	5.46E-08	3.06E-03	5.64E-02	5.70E-02	5.38E-05	0.117	3.2	1.5	3.2	1.5
RRM 1.7 to 2.7	24	1.0	0.58	0.48	0.18	0.66	0.00	7.84E-08	1.54E-03	5.55E-02	5.70E-02	5.38E-05	0.114	3.2	1.5	3.2	1.5
RRM 2.7 to 4.4	88	1.0	1.06	0.44	0.24	0.66	0.00	1.43E-07	1.43E-03	7.30E-02	5.70E-02	5.38E-05	0.131	3.7	1.7	3.7	1.7
RRM 4.4 to 5.2	15	1.0	1.57	0.84	0.24	0.66	0.00	2.13E-07	2.73E-03	7.30E-02	5.70E-02	5.38E-05	0.133	3.7	1.7	3.7	1.7
RRM 5.2 to 7.9	77	1.0	1.20	0.34	0.09	0.66	0.00	1.63E-07	1.10E-03	2.60E-02	5.70E-02	5.38E-05	0.084	2.3	1.1	2.3	1.1
RRM 7.9 to 9.2	33	1.0	2.06	0.29	0.09	0.66	0.00	2.78E-07	9.38E-04	2.60E-02	5.70E-02	5.38E-05	0.084	2.3	1.1	2.3	1.1
RRM 9.2 to 11.3	34	1.0	1.12	0.51	0.02	0.66	0.00	1.51E-07	1.66E-03	5.86E-03	5.70E-02	5.38E-05	0.065	1.8	0.8	1.8	0.8
RRM 11.3 to 12.5	26	1.0	2.37	0.30	0.07	0.33	0.00	3.21E-07	9.80E-04	2.22E-02	2.85E-02	1.73E-05	0.052	1.4	0.7	1.4	0.7
RRM 12.5 to 13.5	28	1.0	3.26	0.17	0.07	1.03	0.00	4.40E-07	5.37E-04	2.22E-02	8.92E-02	1.73E-05	0.112	3.1	1.4	3.1	1.4
RRM 13.5 to 16.7	70	1.0	1.57	0.15	0.03	1.03	0.00	2.12E-07	4.82E-04	9.65E-03	8.92E-02	1.73E-05	0.099	2.8	1.3	2.8	1.3
RRM 16.7 to 20.9	72	1.0	2.15	0.14	0.05	1.03	0.00	2.91E-07	4.67E-04	1.62E-02	8.92E-02	1.61E-05	0.106	2.9	1.4	2.9	1.4
RRM 20.9 to 24.0	81	1.0	1.73	0.25	0.10	0.09	0.00	2.34E-07	8.20E-04	3.01E-02	7.87E-03	7.82E-06	0.039	1.1	0.5	1.1	0.5
SFSR	--	1.0	0.48	0.00	0.10	0.09	0.00	6.42E-08	0.00E+00	3.01E-02	7.87E-03	7.82E-06	0.038	1.1	0.5	1.1	0.5
Notes:												Minimum HQ ^l :		1.1	0.5	1.1	0.5
												Maximum HQ ^l :		3.7	1.7	3.7	1.7
												Cumulative HQ ^{l,j} :		3.7	1.7	--	--

Notes:

- , Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.
- a, More details are provided in Appendix D (Table D-2a).
- b, Intake rates = Dietary Composition (%) x FIR.
- c, AUF - Area use factor; Estimated based on the ratio of the 0.3-year floodplain area (Area, in acres) within each reach to the American robin home range (0.27-2.07 acres).
- d, EPC - Exposure point concentration; Values from Appendix E; units in ng/L for water, mg/kg dw for soil, and mg/kg ww for dietary items.
- e, DMIR - Daily mercury intake rate (or estimated daily dose).
- f, Values from Section 4.7.3 (or Appendix C).
- g, HQ - Hazard quotient; $HQ_{NOAEL} = DMIR_{Total}/NOAEL$; $HQ_{LOAEL} = DMIR_{Total}/LOAEL$.
- h, Weighted HQs based on AUFs.
- i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0 and SFSR.
- j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. $\sum HQ_i \times AUF_i$, where i = Exposure Areas and $\sum AUF_i = 1$).
- k, Soil IHg and MeHg EPCs for Dose Rate Modeling are estimated as 98% and 2% of the THg EPCs (AOC 4 ERA Report, Appendix E, Table E-6), respectively, for the surficial soil in the 0.3 Year Floodplain.

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Table F-15
Dose Rate Modeling Calculations - River Otter (*Lontra canadensis*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	7.430	kg	Lauhachinda (1978) [as cited in EPA (1993)]
Food Ingestion Rate (FIR)	0.899	kg ww/day	Equation #26 in Nagy (2001)
Water Ingestion Rate (WIR)	0.602	L/day	Calder and Braun (1983)
Sediment Ingestion Rate (SIR)	2.59E-03	kg dw/day	Assumed 1% of dry FIR using Equation #25 in Nagy (2001)
Home Range (HR)	>729	acre	EPA (2003)

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Crayfish (CF)	5	%	0.045	kg ww/day
Frogs	5	%	0.045	kg ww/day
Fish TL < 130 mm (SF)	45	%	0.405	kg ww/day
Fish TL > 130 mm (LF)	45	%	0.405	kg ww/day

Toxicity Reference Values (TRVs) ^f	Value	Unit
No Observed Adverse Effects Level (NOAEL)	0.053	mg MeHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	0.09	mg MeHg/kg BW/day

Assessment Reach	Area ^c (acre)	AUF ^c	EPC ^d (ng/L, mg/kg dw, or mg/kg ww)						DMIR ^e (mg MeHg/kg BW/day)							HQ ^g		AUF-Adjusted HQ	
			Water	Sediment	CF	Frogs	SF	LF	Water	Sediment	CF	Frogs	SF	LF	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	47	0.06	0.04	0.00	0.01	0.03	0.12	0.18	2.98E-09	7.56E-07	7.56E-05	1.62E-04	6.32E-03	9.96E-03	0.007	0.1	0.1	0.0	0.0
RRM -0.7 to 0.0	8	0.01	0.05	0.03	0.01	0.03	0.12	0.18	4.14E-09	1.03E-05	7.56E-05	1.66E-04	6.32E-03	9.96E-03	0.007	0.1	0.1	0.0	0.0
RRM 0.0 to 0.8	12	0.02	0.13	0.03	0.07	0.12	0.22	0.46	1.05E-08	1.03E-05	4.14E-04	7.46E-04	1.21E-02	2.52E-02	0.013	0.3	0.1	0.0	0.0
RRM 0.8 to 1.7	12	0.02	0.40	0.01	0.09	0.20	0.37	0.62	3.27E-08	2.01E-06	5.72E-04	1.19E-03	2.00E-02	3.38E-02	0.022	0.4	0.2	0.0	0.0
RRM 1.7 to 2.7	24	0.03	0.58	0.33	0.17	0.20	0.49	1.05	4.70E-08	1.16E-04	1.00E-03	1.19E-03	2.69E-02	5.70E-02	0.029	0.6	0.3	0.0	0.0
RRM 2.7 to 4.4	88	0.12	1.06	0.08	0.35	0.34	0.69	1.06	8.58E-08	2.62E-05	2.12E-03	2.06E-03	3.73E-02	5.75E-02	0.042	0.8	0.5	0.1	0.1
RRM 4.4 to 5.2	15	0.02	1.57	0.05	0.37	0.34	1.18	1.40	1.27E-07	1.59E-05	2.22E-03	2.06E-03	6.41E-02	7.61E-02	0.068	1.3	0.8	0.0	0.0
RRM 5.2 to 7.9	77	0.11	1.20	0.06	0.37	0.38	1.18	1.39	9.74E-08	1.97E-05	2.22E-03	2.31E-03	6.41E-02	7.55E-02	0.069	1.3	0.8	0.1	0.1
RRM 7.9 to 9.2	33	0.05	2.06	0.05	0.42	0.31	1.50	1.39	1.67E-07	1.60E-05	2.57E-03	1.86E-03	8.18E-02	7.55E-02	0.086	1.6	1.0	0.1	0.0
RRM 9.2 to 11.3	34	0.05	1.12	0.06	0.27	0.32	0.79	1.30	9.06E-08	1.92E-05	1.63E-03	1.96E-03	4.28E-02	7.08E-02	0.046	0.9	0.5	0.0	0.0
RRM 11.3 to 12.5	26	0.04	2.37	0.33	0.43	0.32	0.90	1.41	1.92E-07	1.15E-04	2.62E-03	1.94E-03	4.90E-02	7.68E-02	0.054	1.0	0.6	0.0	0.0
RRM 12.5 to 13.5	28	0.04	3.26	0.05	0.46	0.35	1.45	1.47	2.64E-07	1.57E-05	2.81E-03	2.14E-03	7.90E-02	8.03E-02	0.084	1.6	0.9	0.1	0.0
RRM 13.5 to 16.7	70	0.10	1.57	0.09	0.56	0.35	2.44	1.47	1.27E-07	3.09E-05	3.36E-03	2.14E-03	1.33E-01	8.03E-02	0.139	2.6	1.5	0.3	0.1
RRM 16.7 to 20.9	72	0.10	2.15	0.09	0.48	0.35	1.20	0.82	1.74E-07	3.09E-05	2.90E-03	2.13E-03	6.55E-02	4.46E-02	0.071	1.3	0.8	0.1	0.1
RRM 20.9 to 24.0	81	0.11	1.73	0.07	0.43	0.28	0.80	1.17	1.40E-07	2.49E-05	2.62E-03	1.71E-03	4.37E-02	6.37E-02	0.048	0.9	0.5	0.1	0.1
SFSR	--	1.00	0.48	0.07	0.14	0.17	0.24	0.52	3.85E-08	2.49E-05	8.29E-04	1.01E-03	1.30E-02	2.81E-02	0.015	0.3	0.2	0.3	0.2
Minimum HQ ^j :																0.3	0.1	0.0	0.0
Maximum HQ ^j :																2.6	1.5	0.3	0.2
Cumulative HQ ^{i,j} :																1.0	0.6	--	--

Notes:

- , Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.
- a, More details are provided in Appendix D (Table D-2a).
- b, Intake rates = Dietary Composition (%) x FIR.
- c, AUF - Area use factor; Estimated based on the ratio of the 0.3-year floodplain area (Area, in acres) within each reach to the River otter home range (729 acres).
- d, EPC - Exposure point concentration; Values from Appendix E; units in ng/L for water, mg/kg dw for sediment, and mg/kg ww for dietary items.
- e, DMIR - Daily mercury intake rate (or estimated daily dose).
- f, Values from Section 4.7.3 (or Appendix C).
- g, HQ - Hazard quotient; $HQ_{NOAEL} = DMIR_{Total}/NOAEL$; $HQ_{LOAEL} = DMIR_{Total}/LOAEL$.
- h, Weighted HQs based on AUFs.
- i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0 and SFSR.
- j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. $\sum HQ_i \times AUF_i$, where i = Exposure Areas and $\sum AUF_i = 1$).

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Table F-16
Dose Rate Modeling Calculations - Short-Tailed Shrew (*Blarina brevicauda*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	0.017	kg	Guilday (1957) [as cited in EPA (1993)]
Food Ingestion Rate (FIR)	0.007	kg ww/day	Equation #32 in Nagy (2001)
Water Ingestion Rate (WIR)	0.003	L/day	Calder and Braun (1983)
Soil Ingestion Rate (SIR)	5.27E-05	kg dw/day	Assumed 2.4 % of dry FIR using Equation #31 in Nagy (2001)
Home Range (HR)	0.07-4.45	acre	EPA (2003)

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Earthworms (EW)	60	%	0.004	kg ww/day
Wolf spiders (WS)	35	%	0.002	kg ww/day
Terrestrial Plants (TP)	5	%	0.000	kg ww/day

Toxicity Reference Values (TRVs) ^c	Value	Unit
No Observed Adverse Effects Level (NOAEL)	0.09	mg MeHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	0.42	mg MeHg/kg BW/day

Assessment Reach	Area ^c (acre)	AUF ^c	EPC ^d (ng/L, mg/kg dw, or mg/kg ww)					DMIR ^e (mg MeHg/kg BW/day)						HQ ^g		AUF-Adjusted HQ	
			Water	Soil ^k	EW	WS	TP	Water	Soil	EW	WS	TP	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	47	1.0	0.04	0.00	0.00	0.01	0.00	5.47E-09	9.81E-06	6.99E-04	1.22E-03	2.39E-05	0.002	0.0	0.0	0.0	0.0
RRM -0.7 to 0.0	8	1.0	0.05	0.00	0.00	0.01	0.00	7.59E-09	9.81E-06	6.99E-04	1.22E-03	2.39E-05	0.002	0.0	0.0	0.0	0.0
RRM 0.0 to 0.8	12	1.0	0.13	0.73	0.06	0.66	0.00	1.93E-08	2.21E-03	1.45E-02	8.84E-02	2.39E-05	0.105	1.2	0.3	1.2	0.3
RRM 0.8 to 1.7	12	1.0	0.40	0.94	0.19	0.66	0.00	6.00E-08	2.88E-03	4.29E-02	8.84E-02	2.39E-05	0.134	1.5	0.3	1.5	0.3
RRM 1.7 to 2.7	24	1.0	0.58	0.48	0.18	0.66	0.00	8.62E-08	1.45E-03	4.22E-02	8.84E-02	2.39E-05	0.132	1.5	0.3	1.5	0.3
RRM 2.7 to 4.4	88	1.0	1.06	0.44	0.24	0.66	0.00	1.57E-07	1.35E-03	5.56E-02	8.84E-02	2.39E-05	0.145	1.6	0.3	1.6	0.3
RRM 4.4 to 5.2	15	1.0	1.57	0.84	0.24	0.66	0.00	2.34E-07	2.56E-03	5.56E-02	8.84E-02	2.39E-05	0.147	1.6	0.3	1.6	0.3
RRM 5.2 to 7.9	77	1.0	1.20	0.34	0.09	0.66	0.00	1.79E-07	1.04E-03	1.98E-02	8.84E-02	2.39E-05	0.109	1.2	0.3	1.2	0.3
RRM 7.9 to 9.2	33	1.0	2.06	0.29	0.09	0.66	0.00	3.06E-07	8.82E-04	1.98E-02	8.84E-02	2.39E-05	0.109	1.2	0.3	1.2	0.3
RRM 9.2 to 11.3	34	1.0	1.12	0.51	0.02	0.66	0.00	1.66E-07	1.56E-03	4.45E-03	8.84E-02	2.39E-05	0.094	1.0	0.2	1.0	0.2
RRM 11.3 to 12.5	26	1.0	2.37	0.30	0.07	0.33	0.00	3.53E-07	9.22E-04	1.69E-02	4.43E-02	7.66E-06	0.062	0.7	0.1	0.7	0.1
RRM 12.5 to 13.5	28	1.0	3.26	0.17	0.07	1.03	0.00	4.83E-07	5.05E-04	1.69E-02	1.38E-01	7.66E-06	0.156	1.7	0.4	1.7	0.4
RRM 13.5 to 16.7	70	1.0	1.57	0.15	0.03	1.03	0.00	2.33E-07	4.53E-04	7.34E-03	1.38E-01	7.66E-06	0.146	1.6	0.3	1.6	0.3
RRM 16.7 to 20.9	72	1.0	2.15	0.14	0.05	1.03	0.00	3.20E-07	4.39E-04	1.23E-02	1.38E-01	7.15E-06	0.151	1.7	0.4	1.7	0.4
RRM 20.9 to 24.0	81	1.0	1.73	0.25	0.10	0.09	0.00	2.57E-07	7.70E-04	2.29E-02	1.22E-02	3.47E-06	0.036	0.4	0.1	0.4	0.1
SFSR	--	1.0	0.48	0.00	0.10	0.09	0.00	7.06E-08	0.00E+00	2.29E-02	1.22E-02	3.47E-06	0.035	0.4	0.1	0.4	0.1
Notes:												Minimum HQ ⁱ :	0.4	0.1	0.4	0.1	
												Maximum HQ ⁱ :	1.7	0.4	1.7	0.4	
												Cumulative HQ ^{i,j} :	1.7	0.4	--	--	

Notes:

- , Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.
- a, More details are provided in Appendix D (Table D-2a).
- b, Intake rates = Dietary Composition (%) x FIR.
- c, AUF - Area use factor; Estimated based on the ratio of the 0.3-year floodplain area (Area, in acres) within each reach to the Short-tailed shrew home range (0.07-4.45 acres).
- d, EPC - Exposure point concentration; Values from Appendix E; units in ng/L for water, mg/kg dw for soil, and mg/kg ww for dietary items.
- e, DMIR - Daily mercury intake rate (or estimated daily dose).
- f, Values from Section 4.7.3 (or Appendix C).
- g, HQ - Hazard quotient; $HQ_{NOAEL} = DMIR_{Total}/NOAEL$; $HQ_{LOAEL} = DMIR_{Total}/LOAEL$.
- h, Weighted HQs based on AUFs.
- i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0 and SFSR.
- j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. $\sum HQ_i \times AUF_i$, where i = Exposure Areas and $\sum AUF_i = 1$).
- k, Soil IHg and MeHg EPCs for Dose Rate Modeling are estimated as 98% and 2% of the THg EPCs (AOC 4 ERA Report, Appendix E, Table E-6), respectively, for the surficial soil in the 0.3 Year Floodplain.

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Table F-17
Dose Rate Modeling Calculations - White-Tailed Deer (*Odocoileus virginianus*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	56.50	kg	Smith (1991) [as cited in Sample and Suter (1994)]
Food Ingestion Rate (FIR)	2.51	kg ww/day	Equation #30 in Nagy (2001)
Water Ingestion Rate (WIR)	3.74	L/day	Calder and Braun (1983)
Soil Ingestion Rate (SIR)	7.44E-03	kg dw/day	Assumed 2.0 % of dry FIR using Equation #29 in Nagy (2001)
Home Range (HR)	>146	acre	EPA (2003)

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Aquatic Vegetation (AV)	10	%	0.251	kg ww/day
Terrestrial Plants (TP)	90	%	2.262	kg ww/day

Toxicity Reference Values (TRVs) ^f	Value	Unit
No Observed Adverse Effects Level (NOAEL)	0.09	mg MeHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	0.42	mg MeHg/kg BW/day

Assessment Reach	Area ^c (acre)	AUF ^c	EPC ^d (ng/L, mg/kg dw, or mg/kg ww)				DMIR ^e (mg MeHg/kg BW/day)					HQ ^g		AUF-Adjusted HQ	
			Water	Soil ^k	AV	TP	Water	Soil	AV	TP	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	47	0.32	0.04	0.00	0.00	0.00	2.43E-09	4.24E-07	6.37E-06	4.96E-05	0.000	0.0	0.0	0.0	0.0
RRM -0.7 to 0.0	8	0.05	0.05	0.00	0.00	0.00	3.38E-09	4.24E-07	6.37E-06	4.96E-05	0.000	0.0	0.0	0.0	0.0
RRM 0.0 to 0.8	12	0.08	0.13	0.73	0.00	0.00	8.60E-09	9.56E-05	1.61E-05	4.96E-05	0.000	0.0	0.0	0.0	0.0
RRM 0.8 to 1.7	12	0.08	0.40	0.94	0.00	0.00	2.67E-08	1.24E-04	1.56E-05	4.96E-05	0.000	0.0	0.0	0.0	0.0
RRM 1.7 to 2.7	24	0.17	0.58	0.48	0.01	0.00	3.84E-08	6.26E-05	5.52E-05	4.96E-05	0.000	0.0	0.0	0.0	0.0
RRM 2.7 to 4.4	88	0.60	1.06	0.44	0.03	0.00	7.00E-08	5.82E-05	1.11E-04	4.96E-05	0.000	0.0	0.0	0.0	0.0
RRM 4.4 to 5.2	15	0.10	1.57	0.84	0.01	0.00	1.04E-07	1.11E-04	5.38E-05	4.96E-05	0.000	0.0	0.0	0.0	0.0
RRM 5.2 to 7.9	77	0.52	1.20	0.34	0.01	0.00	7.95E-08	4.48E-05	5.43E-05	4.96E-05	0.000	0.0	0.0	0.0	0.0
RRM 7.9 to 9.2	33	0.23	2.06	0.29	0.05	0.00	1.36E-07	3.81E-05	2.07E-04	4.96E-05	0.000	0.0	0.0	0.0	0.0
RRM 9.2 to 11.3	34	0.24	1.12	0.51	0.00	0.00	7.40E-08	6.75E-05	1.76E-05	4.96E-05	0.000	0.0	0.0	0.0	0.0
RRM 11.3 to 12.5	26	0.18	2.37	0.30	0.03	0.00	1.57E-07	3.98E-05	1.36E-04	1.59E-05	0.000	0.0	0.0	0.0	0.0
RRM 12.5 to 13.5	28	0.19	3.26	0.17	0.05	0.00	2.15E-07	2.18E-05	2.06E-04	1.59E-05	0.000	0.0	0.0	0.0	0.0
RRM 13.5 to 16.7	70	0.48	1.57	0.15	0.01	0.00	1.04E-07	1.96E-05	4.37E-05	1.59E-05	0.000	0.0	0.0	0.0	0.0
RRM 16.7 to 20.9	72	0.49	2.15	0.14	0.01	0.00	1.42E-07	1.90E-05	3.96E-05	1.49E-05	0.000	0.0	0.0	0.0	0.0
RRM 20.9 to 24.0	81	0.55	1.73	0.25	0.01	0.00	1.14E-07	3.33E-05	6.14E-05	7.22E-06	0.000	0.0	0.0	0.0	0.0
SFSR	--	1.00	0.48	0.00	0.01	0.00	3.14E-08	0.00E+00	2.94E-05	7.22E-06	0.000	0.0	0.0	0.0	0.0
Minimum HQ ⁱ :												0.0	0.0	0.0	0.0
Maximum HQ ^j :												0.0	0.0	0.0	0.0
Cumulative HQ ^{j,l} :												0.0	0.0	--	--

Notes:

- , Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.
- a, More details are provided in Appendix D (Table D-2a).
- b, Intake rates = Dietary Composition (%) x FIR.
- c, AUF - Area use factor; Estimated based on the ratio of the 0.3-year floodplain area (Area, in acres) within each reach to the White-tailed deer home range (146 acres).
- d, EPC - Exposure point concentration; Values from Appendix E; units in ng/L for water, mg/kg dw for soil, and mg/kg ww for dietary items.
- e, DMIR - Daily mercury intake rate (or estimated daily dose).
- f, Values from Section 4.7.3 (or Appendix C).
- g, HQ - Hazard quotient; $HQ_{NOAEL} = DMIR_{Total}/NOAEL$; $HQ_{LOAEL} = DMIR_{Total}/LOAEL$.
- h, Weighted HQs based on AUFs.
- i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0 and SFSR.
- j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. $\sum HQ_i \times AUF_i$, where i = Exposure Areas and $\sum AUF_i = 1$).
- k, Soil IHg and MeHg EPCs for Dose Rate Modeling are estimated as 98% and 2% of the THg EPCs (AOC 4 ERA Report, Appendix E, Table E-6), respectively, for the surficial soil in the 0.3 Year Floodplain.

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Table F-18
Dose Rate Modeling Calculations - Big Brown Bat (*Eptesicus fuscus*)
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Exposure Factors ^a	Value	Unit	Notes/References
Mean Body Weight (BW)	0.021	kg	Nagy (2001)
Food Ingestion Rate (FIR)	0.009	kg ww/day	Equation #8 in Nagy (2001)
Water Ingestion Rate (WIR)	0.003	L/day	Calder and Braun (1983)
Substratet Ingestion Rate (SIR)	0.00	kg dw/day	Assumed to be negligible
Home Range (HR)	>776	acre	Kurta and Baker (1990) [as cited in Sample and Suter (1994)]

Dietary Composition/Intake ^a	Value	Unit	Intake Rates ^b	Units
Aquatic Invertebrates - Emergent (AIE)	100	%	0.009	kg ww/day

Toxicity Reference Values (TRVs) ^f	Value	Unit
No Observed Adverse Effects Level (NOAEL)	0.027	mg MeHg/kg BW/day
Lowest Observed Adverse Effects Level (LOAEL)	0.045	mg MeHg/kg BW/day

Assessment Reach	Area ^c (acre)	AUF ^c	EPC ^d (ng/L or mg/kg ww)		DMIR ^e (mg MeHg/kg BW/day)			HQ ^g		AUF-Adjusted HQ	
			Water	AIE	Water	AIE	Total	HQ _{NOAEL}	HQ _{LOAEL}	HQ _{NOAEL}	HQ _{LOAEL}
RRM -2.7 to -0.7	47	0.06	0.04	0.01	5.37E-09	5.04E-03	0.005	0.2	0.1	0.0	0.0
RRM -0.7 to 0.0	8	0.01	0.05	0.01	7.45E-09	5.04E-03	0.005	0.2	0.1	0.0	0.0
RRM 0.0 to 0.8	12	0.02	0.13	0.06	1.90E-08	2.52E-02	0.025	0.9	0.6	0.0	0.0
RRM 0.8 to 1.7	12	0.02	0.40	0.06	5.89E-08	2.52E-02	0.025	0.9	0.6	0.0	0.0
RRM 1.7 to 2.7	24	0.03	0.58	0.06	8.46E-08	2.52E-02	0.025	0.9	0.6	0.0	0.0
RRM 2.7 to 4.4	88	0.11	1.06	0.73	1.54E-07	3.08E-01	0.308	11	6.8	1.3	0.8
RRM 4.4 to 5.2	15	0.02	1.57	1.85	2.29E-07	7.85E-01	0.785	29	17	0.5	0.3
RRM 5.2 to 7.9	77	0.10	1.20	1.85	1.75E-07	7.85E-01	0.785	29	17	2.9	1.7
RRM 7.9 to 9.2	33	0.04	2.06	1.85	3.00E-07	7.85E-01	0.785	29	17	1.2	0.7
RRM 9.2 to 11.3	34	0.04	1.12	1.85	1.63E-07	7.85E-01	0.785	29	17	1.3	0.8
RRM 11.3 to 12.5	26	0.03	2.37	0.64	3.46E-07	2.72E-01	0.272	10	6.0	0.3	0.2
RRM 12.5 to 13.5	28	0.04	3.26	0.64	4.75E-07	2.72E-01	0.272	10	6.0	0.4	0.2
RRM 13.5 to 16.7	70	0.09	1.57	0.64	2.29E-07	2.72E-01	0.272	10	6.0	0.9	0.5
RRM 16.7 to 20.9	72	0.09	2.15	0.31	3.14E-07	1.31E-01	0.131	4.9	2.9	0.5	0.3
RRM 20.9 to 24.0	81	0.10	1.73	0.23	2.52E-07	9.92E-02	0.099	3.7	2.2	0.4	0.2
SFSR	--	1.00	0.48	0.23	6.93E-08	9.92E-02	0.099	3.7	2.2	3.7	2.2
Minimum HQ ⁱ :								0.9	0.6	0.0	0.0
Maximum HQ ⁱ :								29	17	3.7	2.2
Cumulative HQ ^{i,j} :								9.7	5.8	--	--

Notes:

- , Not applicable or not evaluated; ww - Wet weight; dw - Dry weight; TL - Total length; RRM - Relative river mile; SFSR - South Fork Shenandoah River.
- a, More details are provided in Appendix D (Table D-2a).
- b, Intake rates = Dietary Composition (%) x FIR.
- c, AUF - Area use factor; Estimated based on the ratio of the 0.3-year floodplain area (Area, in acres) within each reach to the Big brown bat home range (776 acres).
- d, EPC - Exposure point concentration; Values from Appendix E; units in ng/L for water and mg/kg ww for dietary items.
- e, DMIR - Daily mercury intake rate (or estimated daily dose).
- f, Values from Section 4.7.3 (or Appendix C).
- g, HQ - Hazard quotient; $HQ_{NOAEL} = DMIR_{Total}/NOAEL$; $HQ_{LOAEL} = DMIR_{Total}/LOAEL$.
- h, Weighted HQs based on AUFs.
- i, Ranges and representing only the Assessment Reaches between RRM 0.00 and RRM 24.0 and SFSR.
- j, Maximum possible HQ; Cumulative AUF-weighted HQs within one or more contiguous reaches representing a total area equal to the receptors home range (i.e. $\sum HQ_i \times AUF_i$, where i = Exposure Areas and $\sum AUF_i = 1$).

Upstream Reference Reach	RRM -2.7 to -0.7
Buffer Reach	RRM -0.7 to 0.0

Appendix G

Weight of Evidence Evaluation Approach

TO: Vince Maiden, VADEQ **DATE:** September 5, 2014

FROM: JR Flanders, URS **PROJECT:** AOC 4
Ecological Risk Assessment

Cc: Ralph Stahl, DuPont CRG
Mike Liberati, DuPont CRG
Cecilia Mancini, URS

SUBJECT: WEIGHT OF EVIDENCE RANKING METHODOLOGY
AREA OF CONCERN 4 (AOC) ECOLOGICAL RISK ASSESSMENT

INTRODUCTION

The Area of Concern (AOC 4) Ecological Risk Assessment (ERA) will use a quantitative weight of evidence (WOE) evaluation to evaluate the potential for risk, following the approach proposed by Menzie et al. (1996). This memorandum supports the site-specific process developed for AOC 4, in the context of existing widely applied and accepted paradigms.

Two types of endpoints are used in the ERA process to assess the potential for risk to receptors. An assessment endpoint (AE) is an environmental attribute requiring protection, such as reproductive success of a particular ecological receptor. A measurement endpoint (ME) is a measureable or quantifiable ecological characteristic that relates to a particular AE, such as the number of fledglings produced by a passerine bird. In an ERA, multiple MEs may be evaluated for a particular AE. A method is required to evaluate the relative strengths and weaknesses of each ME to determine whether a specific stressor (e.g., mercury) is responsible for potential site-related ecological risk.

The WOE approach is the process by which multiple MEs are related to one AE to assess the potential for risk to a community, system, or other receptor being evaluated. Since the different MEs likely have different importance with respect to the receptor, the ME is weighted. The value of the WOE is that it provides additional information for consideration in a deterministic risk assessment based on a comparison of a potential exposure to a single benchmark. There are three components of the WOE that contribute to the weighting of an ME, as it relates to the AE:

- The weight assigned to each ME
- The magnitude of potential risk represented by the ME
- The concurrence among the outcome of multiple ME

The application of these attributes is further considered in the proposed WOE evaluation briefly discussed in the following three steps.

STEP 1: ASSIGNING WEIGHTS TO THE LINES-OF-EVIDENCE

Measurement endpoints may vary in several respects, such as the extent to which they relate to the AE. Eleven specific attributes within four general attribute groups were considered in the

proposed WOE approach (Table 1). Detailed definitions of the above attributes are provided in Menzie et al. (1996).

In the WOE approach for AOC 4, weights are assigned to MEs based upon ten attributes related to the degree of association between MEs and AEs and study design and execution. The data quality attribute is not considered because a Retrospective Data Quality Assessment (RDQA) will be used to determine if the data used in the ERA are of adequate quality. Exclusion of the data quality attribute is consistent with Menzie et al. (1996), which provides WOE frameworks with and without the inclusion of the data quality attribute. For AEs with a single ME, the ME was not weighted. ME are weighted based on the relative importance of the attributes and the variability of the attributes of an ME, as follows:

- *Scaling Relative Importance of Attributes*: Based on a survey of ten experienced ecological risk assessors, Menzie et al. (1996) developed scaling values to represent the relative importance of the attributes in Table 1. The scaling values (without the inclusion of the data quality attribute) range from 0.2 to 1.0 and sum to 4.0.
- *Scoring Variability of Attributes*: Evaluating ME using the specific attributes in Table 1, each ME will confirm with the attributes to varying degrees. Hence a range of scores from one (low) to five (high) is selected to quantify this variability. The criteria for assigning numeric scores to each ME based on the most relevant considerations for each attribute are provided in Menzie et al. (1996), and described in step 3 below.

The final weight of an ME (ME_w) is obtained as follows:

$$ME_w = \left(\sum_{i=1}^{10} \text{scaling value} * \text{score} \right) / 4$$

The resultant ME_w ranges from one (low importance) to five (high importance). The weights for the ME proposed in the AOC 4 ERA are shown in Table 2.

STEP 2: ASSIGNING THE MAGNITUDE OF POTENTIAL RISK

The magnitude of the response represented by an ME is considered together with the ME_w in assessing the overall contribution of the ME to the WOE. In this regard, the following questions are addressed:

1. Does the ME indicate greater incremental risk over background/reference that can be attributed to the site?
2. Is the potential risk high, medium, or low?

Assigning Potential for Site-Related Incremental Risk

Before determining the magnitude of response associated with each ME, the level at which a response would indicate a greater incremental site-related risk over background or reference was assigned to each ME. As discussed by Menzie et al. (1996), one or more of the following metrics are included to evaluate potential risk:

1. A change or difference in the response variable that is considered potentially ecologically relevant, e.g., % survival, change in abundance or biomass;
2. Spatial scale of the change or difference, as related to the AE; and
3. Temporal scale of the change or difference, as related to the AE.

Of these metrics, the spatial and temporal scales are accounted for in the application of Area Use Factors (AUFs) and through the calculation of Exposure Point Concentrations (EPCs), respectively. Spatial differences are accounted for in the exposure estimate by the application of AUFs, as applicable. Temporal differences are accounted for in the EPC estimation, because the duration of the underlying study for effects benchmarks is consistent with the time of exposure estimated by the EPC. As a result, incremental increase in risk greater than reference or background that is attributable to the site can be related to metric 1, as shown in Table 3.

Assigning Magnitude of Site-Related Incremental Risk

“No effects” benchmarks represent threshold levels below which ecological harm is not observed. “Low effects” benchmarks [Lowest Observed Effects Concentrations (LOECs), Low Effect Critical Body Residues (CBR_{LOEC}), Lowest Observed Adverse Effect Levels or Doses (LOAELs)] represent threshold levels above which individual-level effects have been demonstrated in other studies.

Established standards are not available for determining the level of risk based on the magnitude of the exceedance of a benchmark. The AOC 4 deterministic ERA will evaluate potential risk based on EPCs calculated either as the maximum exposures or 95th percentile upper confidence level on the mean exposures (95% UCL). Two sets of criteria are provided in Table 4. Criteria A apply to MEs for which both “no effects” and “low effects” benchmarks are available; Criteria B apply to cases where only “no effects” benchmarks are available. In cases where only “no effects” benchmarks are available, it is conservatively assumed that the “low effects” benchmarks are twice that of the corresponding “no effects” benchmark values. This is a conservative value compared to a typical “no effects” to “low effects” extrapolation factor of 10 used in ecological risk assessments (e.g., USFDA, 1998; ECB, 2003).

Using hazard quotients to estimate the magnitude of risk is a common tool employed in baseline risk assessments, but the approach must be used with caution. Given that the relation between EPCs/doses and measures of effects is typically non-linear, the magnitude of exceedance of a single benchmark does not necessarily predict the potential for or magnitude of toxic effects (Benjamin and Belluck, 2001). In the absence of defined concentration/dose-response relationships for each ME, the hazard quotient approach is applied in the WOE as an estimate of the potential magnitude of effects based on multiples of the “no effects” or “low effects” benchmarks (Table 4). However, it is important to note that many of the MEs for the AOC 4 ERA may also be evaluated using site-specific effects data, thereby mitigating the uncertainty regarding the use of hazard quotients to estimate magnitude of risk. These site-specific effects data will be incorporated in the AOC 4 ERA to provide additional context regarding the potential magnitude of effects estimated using the hazard quotient approach.

STEP 3: CONCURRENCE AMONG LINES-OF-EVIDENCE

The final step of the WOE approach involves risk characterization; the MEs for an AE are integrated using a transparent and logical method of combining results. Typical methods place the MEs on a matrix that displays graphically or in a table the weight and magnitude of potential incremental, site-related risk of each ME. The displays can then be used to evaluate concurrence among the MEs, which then serves as the basis for a narrative description of risk to the associated AE.

SCORING LINES OF EVIDENCE ATTRIBUTES

Scoring the ME attributes was based on the criteria specified in Table 2 of Menzie et al. (1996). The scores assigned to each ME within each of the ten specific attributes are discussed below, with notable deviations described in more detail.

Degree of Association

With few exceptions, MEs were assigned a score of three as ME represented direct links to the corresponding AEs, but differed in the level of ecological organization, because AEs were assessed on an individual level. The exceptions to this were the biological surveys (benthic community structure, fish community structure, and fish body condition), which were assigned a score of five as the AEs (community structure, growth) are directly measured.

Sediment chemistry received a score of one, because there is ample evidence that ecological exposure to mercury has no measureable impact on benthic populations and communities. For example, a long-term and comprehensive series of studies conducted in Clear Lake California (e.g., Suchanek et al. 1995) found no effects on benthic communities at concentrations of THg in surficial sediments that exceeded 450 µg/g, and were up to 7,000 time the sediment quality guidelines (MacDonald, et al., 2000).

Stressor/Response

- Tissue Chemistry: Measures of tissue mercury concentrations received scores of four because tissue concentrations as measures of exposure are, in general, correlated with effects, but the data in most ecological receptor categories have not been statistically linked to effects. The exception is fish tissue mercury concentrations, which received a score of five because fish tissue mercury concentrations have been statistically correlated with effects [e.g., Dillon et al., (2010)].
- Abiotic Chemistry: Abiotic chemistry refers to mercury concentrations in soil, sediment, surface water and pore water. Studies linking mercury concentrations in soil, surface water and pore water to effects are available, and effects are quantitatively correlated with the degree of exposure. However, sediment, received a score of two because although many studies have proposed that concentrations in sediment should cause effects in ecological receptors, a dose – response relationship has not been established. As a result, sediment quality guidelines are poor predictors of the probability of mercury effects. These studies are described in detail in Section 4 and Appendix C of the ERA.
- Dose rate models (DRM) were assigned a score of four for all receptors based on the use of TRVs and exposure factors. The TRVs and exposure factors were in many cases

developed for representative species, with a few exceptions, such as the mallard. Although certain species show differing sensitivities to mercury (Heinz et al., 2009; Heinz et al., 2010), the dose-response relationship would be expected to occur in birds and mammals.

- Sediment toxicity was assigned a score of two because the assessment endpoint does not correlate with the mercury concentration in sediment. This finding is based on toxicity data from the USEPA ECOTOX database, which is detailed in Appendix C of the ERA. In summary, there was no correlation between mercury concentration and control-adjusted survival of *Hyallela azteca* in toxicity studies conducted in freshwater sediment with no other co-occurring COPECs above Probable Effects Concentrations (MacDonald et al. 2000). However, this is likely due to a lack of sediment-associated toxicity for mercury rather than a fault of the measure.

Utility of Measure:

All MEs selected for this assessment are well accepted, developed by third parties with a strong scientific basis. However, different MEs merit different scores based on their sensitivity. Mammalian and avian tissue chemistry were assigned a score of four based on moderately sensitive benchmarks. Other MEs (including the remaining categories) were assigned score of three based on relatively insensitive benchmarks. For example, in fish tissue, although the magnitude of effects generally increases with the response, responses can range from 0% injury, to greater than 80% at approximately 1 mg/kg (Dillon et al. 2010).

Site-Specificity

Site specificity is scored based on representativeness of the biological or chemical data, environmental media, species in question, benchmark used for comparison, and the habitats considered to compare to the site. Biological surveys were entirely site derived and were assigned a score of five. For sediment, pore water, soil, tissue chemistry, DRM and toxicity, these ME were assigned a score of four, as five of the six factors were site-specific. The sixth factor involving the relevant benchmarks (i.e., CBRs and TRVs) for tissue chemistry and DRMs, were not site-specific.

Sensitivity

The sensitivity of each ME was scored based on the ratio of available low effect vs. no effect concentrations. All ME received scores of four, with the exception of sediment chemistry, biological surveys and sediment toxicity. Biological and sediment toxicity were assigned scores of three because both approaches are potentially affected by other factors (e.g., substrate condition). Sediment chemistry, based on the analysis of the SEDTOX database discussed in Appendix C, is unable to determine effects over a concentration range of at least four orders of magnitude <1 mg/kg to approximately 1,000 mg/kg. Similarly for fish condition, a study found an inverse correlation between condition and mercury concentrations, but mercury only explained 11% of the variance (Suns and Hitchin, 1990).

Spatial Representativeness

All ME were assigned scores of five for spatial representativeness. There is good spatial overlap of the study area and sampling locations. Receptors are generally assumed to be common

throughout AOC 4, although habitat suitability, for some ecological receptors, may not be uniform. For some MEs that had relatively few sampling locations (for example sediment toxicity), those locations were selected because they had physical and chemical characteristics that were broadly representative of large river reaches.

Temporal Representativeness

The majority of the MEs were assigned scores of five because the data collection spanned multiple sampling during periods of greatest expected effects. The exceptions are shrew and robin tissue, which were sampled once (Newman et al. 2011) and were assigned a score of three, and screech owl blood assigned a score of four based on two sampling events. Dose rate models and sediment toxicity were assigned scores of four based on at least two sampling events.

Quantitativeness and Standard Methods

The majority of MEs were assigned scores of four as quantitative measures, because most of the ME are quantitative and can be compared or evaluated statistically; however, because most do not measure the assessment endpoints directly, their biological significance in the ERA context is uncertain. The exceptions are for DRMs, which received scores of three due to lack of an ability to test for significance. All ME in this assessment were assigned a score of five since they are based on a Standard Method that is widely applied and accepted by the scientific community.

RESULTS

The results of the ranking indicate each ME selected for the ERA is relatively strong, with most MEs having a final score of four. The exceptions are pore water chemistry for SAV; sediment chemistry for invertebrates; surface water chemistry for fish, SAV and amphibians; and sediment toxicity, which received scores of three.

REFERENCES

- Dillon, T., Beckvar, N., Kern, J. 2010. Residue-based mercury dose-response in fish: An analysis using lethality-equivalent test endpoints. *Environmental Toxicology and Chemistry* 29: 2559-2565.
- Benjamin, S.L., and Belluck, D.A. (2001). *A Practical Guide to Understanding, Managing, and Reviewing Environmental Risk Assessment Reports* (CRC Press).
- ECB (European Chemicals Bureau). 2003. *Technical Guidance Document on Risk Assessment. Part II, Chapter 3: Environmental Risk Assessment.*
- Heinz, G., Hoffman, D., Klimstra, J., Stebbins, K., Kondrad, S., Erwin, C. 2009. Species differences in the sensitivity of avian embryos to methylmercury. *Archives of Environmental Contamination and Toxicology*. 56(1): 129–138.
- Heinz, G., Hoffman, D., Klimstra, J., Stebbins, K. 2010. Reproduction in mallards exposed to dietary concentrations of methylmercury. *Ecotoxicology*. 19(5): 977– 982.

Menzie, C., Henning, M.H., Cura, J., Finkelstein, K., Gentile, J., Maughan, J., Mitchell, D., Petron, S., Potocki, B., Svirsky, S., Tyler, P. 1996. Special Report of the Massachusetts Weight-of-Evidence Workgroup: A Weight-of-Evidence Approach for Evaluating Ecological Risks. Human and Ecological Risk Assessment 2(2):277-304.

Newman, M. C., L. Liang, and X. Xu. 2011. South River Trophic Studies. Prepared for E.I. duPont de Nemours and Company.

Sample, B.E., Opersko, D.M., Suter, G.W. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. June 1996, Prepared by the Risk Assessment Program Health Sciences Research Division Oak Ridge, Tennessee 37831, ES/ER/TM-86/R3.

Suchanek, T., Richerson, P., Holts, L., Lamphere, B., Woodmansee, C., Slotton, D., Harner, E., and Woodward, L. 1995. Impacts of mercury on benthic invertebrate populations and communities within the aquatic ecosystem of Clear Lake, California. Water Air and Soil Pollution 80: 951-960.

Suns, K., and Hitchin, G. 1990. Interrelationships between mercury levels in yearling yellow perch, fish condition and water quality. Water Air Soil Pollution 50, 255–265.

USFDA (U.S. Department of Health and Human Services Food and Drug Administration). 1998. Guidance for Industry: Environmental Assessment of Human Drug and Biologics Applications. July, 1998. Revision 1.

Table 1
Weight Assignments to the Measurement Endpoints[a]
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

General Attribute	Specific Attribute
Degree of 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 measurement endpoint
	Spatial representativeness
	Temporal representativeness
	Quantitative properties
	Standard methods
Measure of Environmental Harm	Availability of an objective measure for judging environmental harm

Notes:

Based on Menzie et al. (1996)

Table 2
Weight Assignments to the Measurement Endpoints[a]
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Receptors Groups	Receptors ^[b]	Measurement Endpoint Summary	Effects Benchmarks ^[c]	Measurement Endpoint Attributes and Associated Scores ^[d]								Final ME Weights (ME _w) ^[f]	
				Degree of Association	Stressor/Response	Utility of Measure	Site Specificity	Sensitivity	Representativeness		Quantitative Measure		Standard Measure
									Spatial	Temporal			
1	0.6	0.4	0.5	0.5	0.4	0.2	0.2						
Aquatic Receptors	Benthic invertebrates	Porewater chemistry (relative to PW benchmarks)	NOEC, LOEC	3	4	3	4	4	5	5	4	5	4
		Sediment chemistry	NOEC	1	2	3	4	1	5	5	4	5	3
		Benthic community analysis ^[a]	Reference	5	3	3	5	3	5	5	5	5	4
		Sediment toxicity ^[a]	Reference	3	2	3	4	3	5	4	4	5	3
		Larval Aquatic Invertebrate tissue chemistry (relative to CBRs for whole body)	CBR _{NOEC} , CBR _{LOEC} (MeHg Only)	3	4	3	4	4	5	5	4	5	4
		Emergent Aquatic Invertebrate tissue chemistry (relative to CBRs for whole body)	CBR _{NOEC} , CBR _{LOEC} (MeHg Only)	3	4	3	4	4	5	5	4	5	4
		Crayfish tissue chemistry (relative to CBRs for whole body)	CBR _{NOEC} , CBR _{LOEC} (MeHg Only)	3	4	3	4	4	5	5	4	5	4
	Fish	Surface water chemistry (relative to SW benchmarks)	NOEC	3	4	3	1	4	5	5	4	5	3
		Fish tissue chemistry - Bass Species (TL < 130 mm) (relative to CBRs)	CBR _{NOEC} , CBR _{LOEC}	3	5	3	4	4	5	5	4	5	4
		Fish tissue chemistry - Bass Species (TL > 130 mm) (relative to CBRs)	CBR _{NOEC} , CBR _{LOEC}	3	5	3	4	4	5	5	4	5	4
		Community structure ^[a]	Reference	5	2	3	5	3	5	5	4	5	4
		Field survey of demography and condition ^[a]	Reference	5	2	3	5	3	5	5	4	5	4
	Submerged aquatic vegetation (SAV)	Porewater chemistry (relative to PW benchmarks)	NOEC, LOEC	3	4	3	2	1	5	5	4	5	3
Surface water chemistry (relative to SW benchmarks)		NOEC, LOEC	3	4	3	1	4	5	5	4	5	3	
Semi-Aquatic Receptors	Amphibians	Surface water chemistry (relative to SW benchmarks)	NOEC, LOEC	3	4	3	1	4	5	5	4	5	3
	Piscivorous birds	Amphibian tissue chemistry (relative to CBRs)	CBR _{NOEC} , CBR _{LOEC}	3	4	3	4	4	5	5	4	5	4
		Kingfisher tissue chemistry - blood (relative to CBRs)	CBR _{NOEC} , CBR _{LOEC} (Only THg)	3	4	4	4	4	5	5	4	5	4
	Piscivorous Mammals	Estimated DMIR for Belted kingfisher (relative to TRVs)	NOAEL, LOAEL	3	4	3	4	4	5	4	3	5	4
Estimated DMIR - Otter (relative to TRVs)		NOAEL, LOAEL	3	4	3	4	4	5	4	3	5	4	
Terrestrial Receptors	Aerial Insectivorous Mammals	Little brown bat tissue chemistry (relative to CBRs for fur)	CBR _{NOEC}	3	4	4	4	4	5	5	4	5	4
		Big brown bat tissue chemistry (relative to CBRs for fur)	CBR _{NOEC}	3	4	4	4	4	5	5	4	5	4
		Estimated DMIR for Big brown bat (relative to TRVs)	NOAEL, LOAEL	3	4	3	4	4	5	4	3	5	4
	Invertivorous Birds	American robin tissue chemistry (relative to CBRs for blood)	CBR _{NOEC} , CBR _{LOEC} (MeHg Only)	3	4	4	4	4	5	3	4	5	4
		Estimated DMIR for American robin (relative to TRVs)	NOAEL, LOAEL	3	4	3	4	4	5	4	3	5	4
		Tree swallow tissue chemistry (relative to CBRs for blood)	CBR _{NOEC} , CBR _{LOEC} (MeHg Only)	3	4	4	4	4	5	5	4	5	4
		Estimated DMIR for Tree swallow (relative to TRVs)	NOAEL, LOAEL	3	4	3	4	4	5	4	3	5	4
		Short-tailed shrew tissue chemistry (relative to CBRs for fur)	CBR _{NOEC}	3	4	4	4	4	5	3	4	5	4
	Terrestrial Invertivorous Mammals	Estimated DMIR for short-tailed shrew (relative to TRVs)	NOAEL, LOAEL	3	4	3	4	4	5	4	3	5	4

Notes:
[a] Based on the Menzie et al. (1996).
[b] Assessment Endpoints are Survival, Growth and/or Reproduction.
[c] Benchmarks are presented in Section 4 and Appendix C of the ERA Report: NOEC - No Observed Effects Concentrations, LOEC - Lowest Observed Effects Concentration, No Effects Critical Body Residue (CBR_{NOEC}), Low Effects Critical Body Residue (CBR_{LOEC}), No Observed Adverse Effect Level or Dose (NOAEL), and Lowest Observed Effects Level or Dose (LOAEL); THg - Total Mercury, MeHg - Methylmercury.
[d] Attribute definitions and criteria for attribute scores are presented in Table 2 in Menzie et al. (1996) and justification for the selected attribute scores are presented in the text.
[e] Scaling values are based on the exclusion of Data Quality attribute because it is assumed that data used in the AOC 4 ERA are of adequate quality and usability based on a Retrospective Data Quality Assessment (see text).
[f] ME_w = S(scaling value * attribute score)/4
[g] MEs associated with Sediment Quality Triad (SQT) and other surveys; May include secondary level multiple LOEs.

Table 3
Criteria for Assigning Presence/Absence of Adverse Ecological Effects
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Criteria ^[a]	Potential for Site-Related Effects?
$HQ_{No\ Effects} \leq 1$ or $HQ_{EA} \leq HQ_{REF}$	No
$HQ_{Low\ Effects} > 1$ and $HQ_{EA} > HQ_{REF}$	Yes
$HQ_{No\ Effects} > 1$ but $HQ_{Low\ Effects} \leq 1$	Undetermined

Notes:

HQ, Area use adjusted Hazard Quotient

$HQ_{No\ Effects}$ = Exposure Point Concentration (EPC)/"No Effects" Benchmark

$HQ_{Low\ Effects}$ = Exposure Point Concentration (EPC)/"Low Effects" Benchmark

HQ_{EA} = HQ for an Exposure Area and HQ_{REF} = HQ for the Reference Area

[a] Criteria for LOEs associated with Sediment Quality Triad (SQT) and fish surveys will be based on the comparisons with corresponding reference conditions as in the Ecological Study Report (URS, 2012).

Table 4
Criteria for Assigning Magnitude of Ecological Effects[a]
AOC 4 Ecological Risk Assessment Report
Former DuPont Waynesboro Plant, Waynesboro, Virginia

Criteria A^[b]	Criteria B^[c]	Magnitude of Potential Ecological Risk
$HQ_{\text{Low Effects}} \leq 1$	$HQ_{\text{No Effects}} \leq 2$	Low
$1 < HQ_{\text{Low Effects}} \leq 2$	$2 < HQ_{\text{No Effects}} \leq 4$	Medium
$HQ_{\text{Low Effects}} > 2$	$HQ_{\text{No Effects}} > 4$	High

Notes:

HQ, Area - Use Adjusted Hazard Quotient

$HQ_{\text{Low Effects}}$ = Exposure Point Concentration (EPC)/"Low Effects" Benchmark

$HQ_{\text{No Effects}}$ = Exposure Point Concentration (EPC)/"No Effects" Benchmark

[a] Criteria for LOEs associated with Sediment Quality Triad (SQT) and fish surveys will be based on the comparisons with corresponding reference conditions as in the Ecological Study Report (URS, 2012).

[b] Applicable to LOEs for which Low Effects Benchmarks are available.

[c] Applicable to LOEs for which only the No Effects Benchmarks are available.