FINAL

Total Maximum Daily Load of Mercury for Watersheds draining to Millington Wildlife Management Area Ponds Kent County, Maryland

FINAL

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List of Abbreviations

BIBI	Benthic Index of Biotic Integrity
^{o}C	Degrees Celcius
CAA	Clean Air Act
CAIR	Clean Air Interstate Rule
CWA	Clean Water Act
DNR	Maryland Department of Natural Resources
EGU	Electrical Generating Unit
Eh	Oxidation Potential
EPA	U.S. Environmental Protection Agency
FIBI	Fish Index of Biotic Integrity
g	Gram
g/yr	Grams per year
g/day	Grams per day
g/km^2-yr	Grams per square kilometer per year
g/cm^3	Grams per centimeters cubed
HAA	Healthy Air Act
Hg	Mercury
kg	Kilogram
km^2	Square kilometer
L	Liter
LA	Load Allocation
μg/kg	Micrograms per kilogram
μg/L	Micrograms per liter
μm	Micrometer
mL	Milliliter
mm	Millimeter
MDL	Maximum Daily Load
MD 8-Digit	Maryland 8-digit watershed
MDE	Maryland Department of the Environment
MeHg	Methylmercury
mi^2	Square miles
Mol/L	Mols/Liter
MOS	Margin of Safety
N/A	Not Applicable
ng/L	Nanograms per liter
NEI	National Emissions Inventory
NADP-MDN	National Atmospheric Deposition Program – Mercury Deposition Network
NPDES	National Pollutant Discharge Elimination System
pH	Inverse logarithm of the hydrogen ion concentration
ppb	Parts per billion
PPRP	Power Plant Research Program
RfD	Reference Dose
SCS	Soil Conservation Service
TMDL	Total Maximum Daily Load
UMCES	University of Maryland Center for Environmental Science
USDA	United States Department of Agriculture
WLA	Waste Load Allocation
WMA	Wildlife Management Area
WQLS	Water Quality Limited Segments
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

This document, upon approval by the U.S. Environmental Protection Agency (EPA), establishes a Total Maximum Daily Load (TMDL) for mercury (Hg) in the Millington Wildlife Management Area (WMA) Ponds located in the Maryland 8-digit (MD 8-digit) Upper Chester River Watershed (basin number 02130510) (2008 *Integrated Report of Surface Water Quality in Maryland Assessment Unit ID*: MD-02130510-Millington Wildlife Ponds). Section 303(d) of the federal Clean Water Act (CWA) and the EPA's implementing regulations direct each state to identify and list waters, known as water quality limited segments (WQLSs), in which current required controls of a specified substance are inadequate to achieve water quality standards. For each WQLS, the State is required to either establish a TMDL of the specified substance that the waterbody can receive without violating water quality standards, or demonstrate that water quality standards are being met (CFR 2010b).

The Maryland Department of the Environment (MDE) has identified the waters of the MD 8-digit Upper Chester River watershed on the State's 2008 Integrated Report as impaired by sediments (tidal portion: Chester River Tidal Fresh Chesapeake Bay Segment - 1996), nutrients – nitrogen and phosphorus (tidal portion: Chester River Tidal Fresh Chesapeake Bay Segment - 1996), bacteria (tidal beach: Duck Neck Beach - 1996), methylmercury (MeHg) in fish tissue (impoundments: Millington WMA Ponds - 2002), and impacts to biological communities (nontidal portion - 2006) (MDE 2008). The designated use of the tidal portion of the MD 8-digit Upper Chester River and its tributaries is Use II (Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting), and the designated use of the nontidal portion of the MD 8-digit Upper Chester River and its tributaries, including the Millington WMA Ponds and their tributaries, is Use I (Water Contact Recreation and Protection of Aquatic Life) (COMAR 2010a,b,c,d).

A TMDL of nitrogen and phosphorus was approved by the EPA in 2006 to address the nutrients listings (nitrogen and phosphorus) for the tidal portion of the MD 8-digit Upper Chester River (Chester River Tidal Fresh Chesapeake Bay Segment), and a TMDL of Enterococci was submitted to the EPA in 2009 to address the bacteria listing for Duck Neck Beach. In the future, the listing for impacts to biological communities for the nontidal portion of the watershed will include the results of a stressor identification analysis within the Integrated Report, and the sediment listing for the tidal portion of the watershed (Chester River Tidal Fresh Chesapeake Bay Segment) will be addressed via the Chesapeake Bay TMDL, which is scheduled for completion in 2010.

The TMDL established herein by MDE will address the 2002 methylmercury in fish tissue listing for the Millington WMA Ponds, for which a data solicitation was conducted, and all readily available data from the past five years have been considered. The objective of the TMDL is to ensure that the "fishing" designated use in the ponds is supported to allow for the consumption of fish that is protective of human health (COMAR 2010e). Currently, MDE's public fish consumption advisory to eat limited amounts of fish from the Millington WMA Ponds, due to elevated mercury concentrations found in fish tissue, is not supportive of this use.

Data and accessibility constraints to Millington WMA impoundments limit the analysis described herein solely to "Pond Two" (Millington WMA Identification) of the WMA. In the other Millington WMA ponds, MDE has either determined it to be unlikely that trophic-level four fish can develop to edible size or was unable to determine if largemouth bass populations could be supported. However, if the other ponds did support largemouth bass populations, since: 1) the entirety of mercury delivered to the impoundments is assumed to be from atmospheric deposition (either directly to the surface of the impoundments or to the watershed areas draining to the impoundments); 2) the WMA is relatively small and therefore the other ponds are in exceptionally close proximity to "Pond Two"; and 3) a watershed approach has been applied, the TMDL and proportionate reductions, which are calculated based on Pond Two data and described herein, will apply to all other impoundments within the Millington WMA. This approach is valid since the Millington WMA ponds are all in close geographic proximity of one another and the principle source of mercury to the ponds is from atmospheric deposition.

The methodology used to calculate this TMDL consists of two general steps. First, trophic-level four fish (sport fish) are sampled to assess the mercury concentration in their muscle (filet) tissue. Then, this fish tissue concentration is compared with the TMDL endpoint of 235 micrograms per kilogram (µg/kg) (MDE fish consumption advisory threshold) to determine the degree of impairment. The second step is to determine the maximum allowable mercury loading to the impoundment, assuming that the entirety of the fish tissue mercury is resultant from atmospheric deposition loadings.

As part of this analysis, the only nonpoint source of mercury to Millington WMA Pond Two has been identified as atmospheric deposition, either directly to the surface of the impoundment or to the watershed area draining to the impoundment. No point sources, individual municipal wastewater treatment plant (WWTP) discharges, individual industrial discharges, and/or National Pollutant Discharge Elimination System (NPDES) regulated stormwater discharges, have been identified. This source identification for Pond Two and its associated drainage area is consistent with that which has been identified for all other impoundments within the Millington WMA (i.e., the only source of mercury is from atmospheric deposition), and as a result, the individual source sector allocations, in addition to the total TMDL, will apply to all other impoundments within the Millington WMA.

EPA's regulations require TMDLs to take into account seasonality and critical conditions for stream flow, loading, and water quality parameters (CFR 2010b). The intent of this requirement is to ensure that the water quality of the waterbody is protected during times when it is most vulnerable. Thus, since fish tissue concentrations at the time of sampling are the result of the long-term accumulation of mercury in fish over their lifespan, and the allowable concentrations of mercury are based on human fish consumption over a long time period, which averages out critical events, seasonality and critical conditions are inherently addressed.

All TMDLs need to be presented as a sum of waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources generated within the assessment unit, accounting for natural background, tributary, and upstream segment loads. Furthermore, all TMDLs must include a margin of safety (MOS) to account for any lack of knowledge and uncertainty concerning the relationship between loads and water quality (CFR 2010a,b). It is proposed that the following components of this analysis already account for such uncertainty, and therefore the MOS is implicitly included: 1) the use of trophic-level four fish, which typically have higher fish tissue mercury concentrations than other lower trophic-level fish; 2) the use of a TMDL endpoint of 235 µg/kg (MDE's fish consumption advisory threshold), as compared to EPA's recommended criteria (protective of human health via fish consumption) of 300 µg/kg (COMAR 2010f); 3) the use of total mercury rather than methylmercury (methylmercury, the form that represents a human health risk, comprises 90 to 95% of total mercury found in fish tissue); and 4) the assumption within the baseline loading calculations (see Section 4.3 and Appendix A) that the entirety of the atmospheric deposition mercury loading to Pond Two's watershed area actually reaches the impoundment. The TMDL includes a LA and a MOS. There is no WLA, as no point sources were identified within the watershed. The TMDL methodology considers all sources, but atmospheric deposition to the surface of the impoundment and to the watershed draining to the impoundment is the only source identified.

The Millington WMA Pond Two Total Mercury Baseline Load is an average annual load of 21.70 grams per year (g/yr). The Millington WMA Pond Two Average Annual Mercury TMDL is 15.22 g/yr, which translates to a Maximum Daily Load (MDL) of 0.0417 grams per day (g/day) (see Table ES-1). This is the total amount of mercury that can be assimilated by the Millington WMA Ponds without significantly increasing the risk to human health, due to the consumption of fish, from mercury concentrations in fish tissue. It represents a 29.86% reduction from baseline conditions (see Table ES-1). The LA is apportioned between loadings from atmospheric deposition to the actual water surface of Pond Two as well as the watershed area draining to the pond. The water surface loading is 0.58947 g/yr and 0.00161 g/day, and the remainder of the LA is apportioned to the pond's watershed area. The MOS is implicit.

Table ES-1: Millington WMA Pond Two Mercury Baseline Load, TMDL, and Total Reduction Percentage

Baseline Load (g/yr)	TMDL (g/yr)	Total Reduction (%)
21.70	15.22	29.86

Due to this TMDL, immediate public health benefits will be derived from the enhanced public awareness that will be generated via the TMDL process. The TMDL will increase public awareness of the need for upgrading controls on the atmospheric emissions of mercury. Maryland has already passed legislation requiring such controls, such as the Healthy Air Act (HAA), the implementation of which (full implementation supposed to occur by 2013) is anticipated to result in water quality improvements. Thus, TMDL implementation, via a reduction in the atmospheric deposition of mercury, is expected to be accomplished over time through existing and proposed regulatory controls such as the Clean Air Interstate Rule (CAIR), which will be replaced by the Clean Air Transport Rule (once the latter is finalized), and Maryland's HAA, which will curb current sources of atmospheric mercury emissions (See Appendix A) (COMAR 2010h,i). These controls are expected to be implemented in phases.

1.0 INTRODUCTION

This document, upon approval by the U.S. Environmental Protection Agency (EPA), establishes a Total Maximum Daily Load (TMDL) for mercury (Hg) in the Millington Wildlife Management Area (WMA) Ponds located in the Maryland 8-digit (MD 8-digit) Upper Chester River Watershed (basin number 02130510) (2008 *Integrated Report of Surface Water Quality in Maryland Assessment Unit ID*: MD-02130510-Millington Wildlife Ponds). Section 303(d)(1)(C) of the federal Clean Water Act (CWA) and the EPA's implementing regulations direct each state to develop a TMDL for each impaired water quality limited segment (WQLS) on the State's Integrated Report, taking into account seasonal variations, critical conditions, and a protective margin of safety (MOS) to account for uncertainty (CFR 2010b). A TMDL reflects the total pollutant loading of the impairing substance a waterbody can receive and still meet water quality standards.

TMDLs are established to determine the pollutant load reductions needed to achieve and maintain water quality standards. A water quality standard is the combination of a designated use for a particular body of water and the water quality criteria designed to protect that use. Designated uses include activities such as swimming, drinking water supply, protection of aquatic life, shellfish propagation and harvest, and fishing, including the protection of human health associated with the consumption of fish. Water quality criteria consist of narrative statements and numeric values designed to protect the designated uses. Criteria may differ among waters with different designated uses.

The Maryland Department of the Environment (MDE) has identified the waters of the MD 8-digit Upper Chester River watershed on the State's 2008 Integrated Report as impaired by sediments (tidal portion: Chester River Tidal Fresh Chesapeake Bay Segment - 1996), nutrients – nitrogen and phosphorus (tidal portion: Chester River Tidal Fresh Chesapeake Bay Segment - 1996), bacteria (tidal beach: Duck Neck Beach - 1996), methylmercury (MeHg) in fish tissue (impoundments: Millington WMA Ponds - 2002), and impacts to biological communities (nontidal portion - 2006) (MDE 2008). The designated use of the tidal portion of the MD 8-digit Upper Chester River and its tributaries is Use II (Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting), and the designated use of the nontidal portion of the MD 8-digit Upper Chester River and its tributaries, including the Millington WMA Ponds and their tributaries, is Use I (Water Contact Recreation and Protection of Aquatic Life) (COMAR 2010a,b,c,d).

A TMDL of nitrogen and phosphorus was approved by the EPA in 2006 to address the nutrients listings (nitrogen and phosphorus) for the tidal portion of the MD 8-digit Upper Chester River (Chester River Tidal Fresh Chesapeake Bay Segment), and a TMDL of Enterococci was submitted to the EPA in 2009 to address the bacteria listing for Duck Neck Beach. In the future, the listing for impacts to biological communities for the nontidal portion of the watershed will include the results of a stressor identification analysis within the Integrated Report, and the sediment listing for the tidal portion of the watershed (Chester River Tidal Fresh Chesapeake Bay Segment) will be addressed via the Chesapeake Bay TMDL, which is scheduled for completion in 2010.

The TMDL established herein by MDE will address the 2002 methylmercury in fish tissue listing for the Millington WMA Ponds, for which a data solicitation was conducted, and all readily available data from the past five years have been considered. The federal CWA and Maryland's State regulations require the State to maintain water quality that supports fish and aquatic life, and fishing as a recreational activity (COMAR 2010c,e). The EPA interprets the "fishable" use under section 101(a) of the CWA to include, at a minimum, the protection of aquatic communities and human health related to the consumption of fish and shellfish. Thus, "fishable" implies that not only can fish and shellfish survive in a water body, but when harvested, can also be safely eaten by humans and terrestrial wildlife (US EPA 2000a). Based on the recommended EPA criterion, a fish tissue concentration of 300 micrograms per kilogram (µg/kg) is considered the highest possible concentration (i.e., threshold concentration) that still supports this "fishable" use (US EPA 2001). This water quality criterion describes the maximum advisable concentration of mercury in freshwater and estuarine fish and shellfish tissue to protect consumers of fish and shellfish among the general population. The EPA expects the recommended criterion to be used as guidance by States and authorized Tribes in establishing or updating water quality standards for waters of the United States. Water bodies with fish tissue concentrations above this level are thus considered to be impaired. Therefore, the objective of the TMDL is to ensure that the "fishing" designated use in the Millington WMA ponds is supported to allow for the consumption of fish that is protective of human health (COMAR 2010e).

MDE measures fish tissue concentrations of total mercury. Methylmercury, which is the form that represents a human health risk, comprises 90 to 95% of total mercury found in fish tissue. Thus, as a conservative assumption, total mercury as measured by MDE in fish tissue is assumed to consist entirely of its methylated form. Therefore, for the purpose of this TMDL, the terms "total mercury", "methylmercury", and "mercury" are used interchangeably to refer to the impairing substance, except when a distinction is made for computational purposes.

Within the Millington WMA, there are four individual and distinct ponds. Three of the ponds are intermittent, occasionally drying up completely, and two of the ponds are too small to appear on certain maps. Furthermore, it cannot be determined if the intermittent ponds support largemouth bass populations, and if they do, it is unclear under what conditions this occurs. MDE field staff attempted to obtain fish samples from one of these intermittent ponds in March, 2010. They determined it is unlikely that trophic-level four (sport fish) fish can develop to edible size, as electrofishing produced insufficient fish for a composite sample. Thus, the pond will not be used in the calculation of the TMDL. Only data from "Pond Two" (Millington WMA Identification) of the WMA will be used. However, if the intermittent ponds did support largemouth bass populations and remained full long enough for the fish to grow to a size at which they could bioaccumulate sufficient mercury to pose a public health threat, this TMDL will prevent mercury from reaching concentrations at which the water bodies would be deemed impaired. The physical characteristics of all four ponds are similar, and the environmental conditions governing mercury chemistry among the ponds are similar as well. All four ponds are located within an extremely small area (less than six square miles (mi^2)) and the resolution of the atmospheric deposition model is similar to the geographic scope of the planned implementation (i.e., to reduce atmospheric deposition of mercury) (see Section 5). Thus, the modeled deposition will be uniform throughout the implementation area.

2.0 SETTING AND WATER QUALITY DESCRIPTION

2.1 General Setting

The Millington WMA Ponds are located in rural, northeastern Kent County on Maryland's Eastern Shore within the MD 8-digit Upper Chester River watershed. Millington WMA covers 3,800 acres in Kent County, Maryland and adjacent New Castle County, DE (see Figure 1). The total population in the MD 8-digit Upper Chester River watershed is approximately 11,800 (US Census Bureau 2000). Millington WMA fulfills several important roles, such as protecting several endangered species of animals and providing hunting and outdoor recreation opportunities (DNR 2010a). The impoundments are owned by the Maryland Department of Natural Resources (DNR). There are four individual and distinct farm ponds within the WMA. As mentioned in Section 1.0, however, three of the ponds (old borrow pits) are intermittent, occasionally drying up completely, and two of the ponds are too small to appear on certain maps. Furthermore, it has been determined by MDE field staff to be unlikely that trophic-level four fish can develop to edible size in one of the intermittent ponds, since an attempt to obtain fish samples from the pond via electrofishing produced insufficient fish for a composite sample. It cannot be determined if the other intermittent ponds support largemouth bass populations. The intermittent ponds therefore could not be applied within this analysis, and the TMDL was calculated using solely Pond Two (impounded via the damming of an unnamed tributary to Cypress Branch) data. Since all four ponds are located within an extremely small area and share very similar physical and environmental characteristics, however, the TMDL established herein will apply to all four ponds. A small portion of Pond Two’s watershed is in Delaware.

There are two “high quality”, or Tier II, stream segments (Benthic Index of Biotic Integrity (BIBI) and Fish Index of Biotic Integrity (FIBI) aquatic life assessment scores > 4 (scale 1 – 5)) located within the Millington WMA, which are: 1) Cypress Branch directly above Mill Pond; and 2) Cypress Branch extending from the stream’s confluence with Black Bottom Branch upstream to the Maryland – Delaware state line, requiring the implementation of Maryland’s antidegradation policy (COMAR 2010g; MDE 2010b).

Millington WMA lies in the Coastal Plain geologic province of Maryland. Broad upland areas with low slopes, gentle drainage, and deep sedimentary soil complexes that support broad meandering streams characterize the Coastal Plain geologic province (DNR 2010b; MGS 2010; MDE 2000). The soils immediately surrounding the ponds lie in the Woodstown-Fallsington-Sassafras association. This association consists of nearly level to strongly sloping and poorly-drained to well-drained soils that were formed in loamy materials (USDA 1982).

Soil type for the Millington WMA is also categorized by the United States Department of Agriculture (USDA) Soil Conservation Service (SCS) into four hydrologic soil groups: Group A soils have high infiltration rates and are typically deep well-drained to excessively drained sands or gravels; Group B soils have moderate infiltration rates and consist of moderately deep to deep and moderately well to well drained soils, with moderately fine to moderately coarse textures; Group C soils have slow infiltration rates and a layer that impedes downward water movement and consist of moderately fine to fine textured soils; Group D soils have very slow infiltration rates and consist of clay soils with a permanently high water table that are shallow and often over nearly impervious material. The Millington WMA is comprised of primarily Group C soils (62%) with smaller amounts of and Group B (20%), Group A (9%), and Group D (9%) soils (USDA 2006).

Inflow to the ponds within Millington WMA is primarily from direct runoff during rain events or from snowmelt. Pond Two discharges into Cypress Branch. Figure 2 shows that land use in the area draining to the Pond Two is predominately forest/herbaceous (99.43%) (see Figure 3) (MDP 2002; DOLP 2007). Table 1 lists the physical characteristics for Pond Two.

Table 1: Physical Characteristics for Millington WMA Pond Two[1]

Location:	Kent County, Maryland
Surface Area:	0.0445 km^2
Drainage Area to Lake:	1.105 km^2

Notes: [1] Sources: Maryland Inventory of Dams.
[2] km^2: square kilometers.

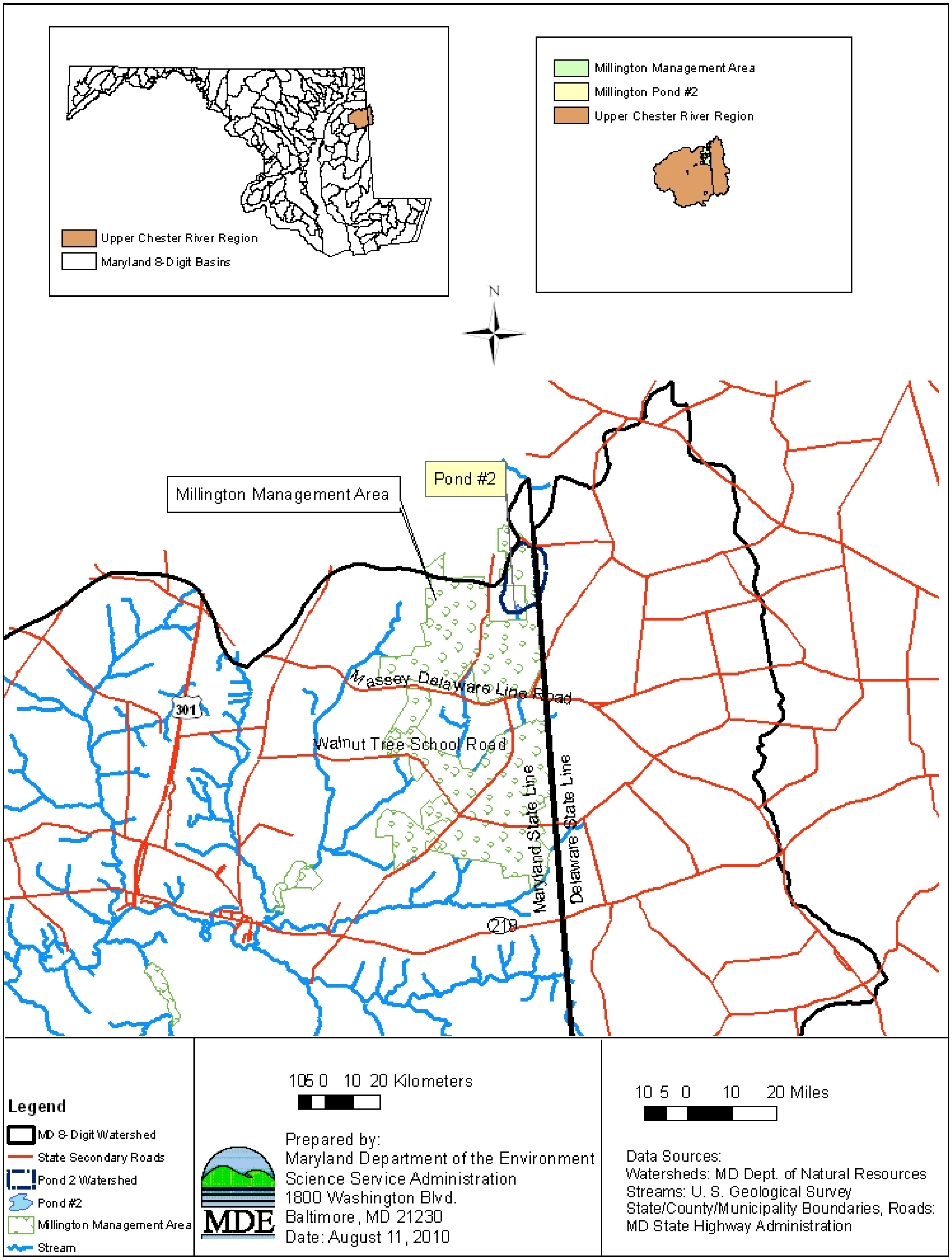

Figure 1: Location Map of the Millington WMA Pond Two Watershed in Kent County, Maryland and New Castle County, Delaware

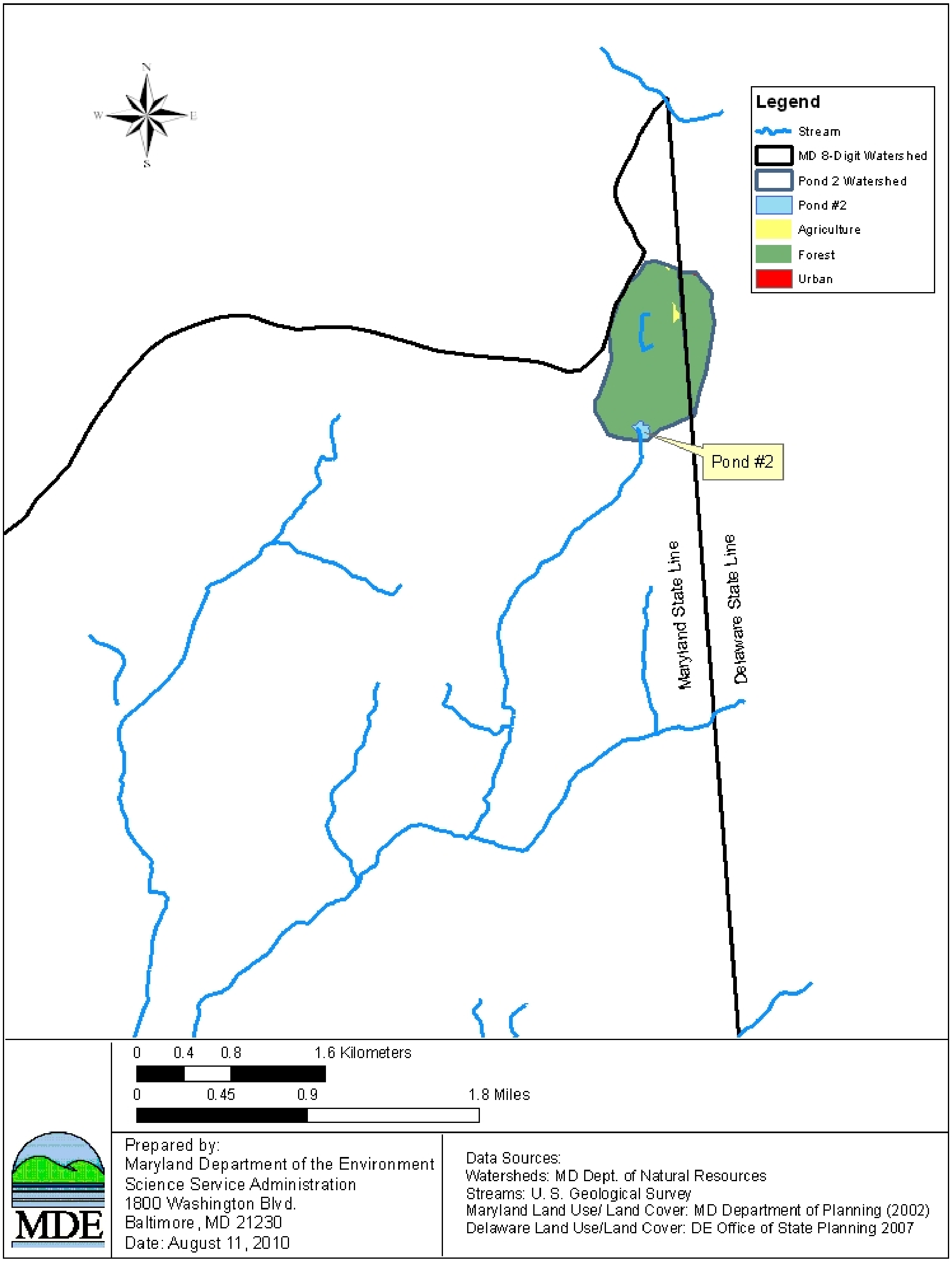

Figure 2: Predominant Land Use in the Millington WMA Pond Two Watershed

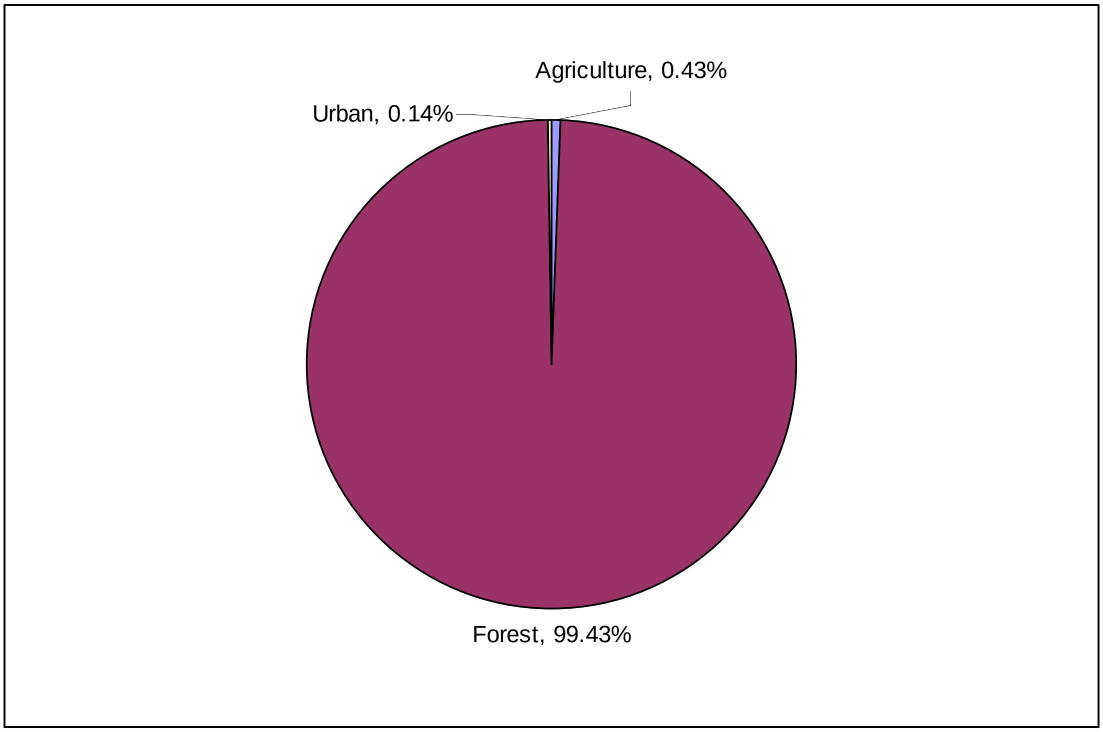

Figure 3: Land Use Distribution in the Pond Two Watershed

2.2 Source Assessment

The Millington WMA Ponds are located in a watershed in which the mercury impairment is caused entirely by nonpoint source contributions via atmospheric deposition. Therefore, essentially a one-to-one relationship between concentrations of mercury in fish tissue and atmospheric deposition of mercury is assumed. This assumption is explained in greater detail below.

To assess atmospheric deposition, the model CALPUFF was used. CALPUFF is an advanced, non-steady-state, time variable, Gaussian meteorological and air quality modeling system, approved by EPA for many atmospheric pollutant modeling purposes. Its use is made available to MDE via Maryland DNR's Power Plant Research Program (PPRP). A detailed description of CALPUFF and a link to the model itself can be found at www.src.com/calpuff/calpuff1.htm (Sherwell et al. 2006). Appendix A summarizes the use of CALPUFF in this TMDL analysis.

The EPA considers coal-fired electric power generating plants to be the largest anthropogenic source of mercury emissions in the nation (US EPA 2005). In Maryland as a whole, the major sources of atmospheric mercury deposition are as follows: 23.3% attributed to electrical generating units (EGUs) in the state; 34.0% attributed to out-of state EGUs; 3.4% and 10.6% attributed to non-EGU sources (e.g., Portland cement plants and medical waste incinerators) in-state and out-of-state, respectively; and the remaining 28.7% to global background sources, including natural emissions (PPRP 1994). The corresponding estimates for Pond Two and its watershed, as calculated using the

CALPUFF model, (only Pond Two is used in TMDL calculations: see Section 2.3 for details) are: 19.1% attributed to in-state EGUs; 27.3% attributed to out-of-state EGUs; 1.6% attributed to in-state non-EGU sources; 20.1% attributed to out-of-state non-EGU sources, and 32% to global background sources. These estimates represent modeled 2007 baseline conditions (Sherwell et al. 2006). There are no point sources in the Millington WMA (i.e., no individual municipal wastewater treatment plant (WWTP), individual industrial, or National Pollutant Discharge Elimination System (NPDES) regulated stormwater discharges have been identified). Therefore there is no current contribution from point sources to the impairment. Additionally, despite the fact that a portion of the Millington WMA drainage area is located in Delaware, upstream loads from this Delaware portion are not characterized separately, since the sole source of mercury from the Delaware portion is still atmospheric deposition (at the same rate as the Maryland portion of the drainage area), thereby making this separation of loads irrelevant.

2.3 Water Quality Characterization

To characterize the water quality of the Millington WMA Ponds, two parameters were assessed: 1) mercury concentrations in fish tissue and 2) mercury concentrations in the water column.

2.3.1 General Discussion

In 2001, MDE announced a statewide fish consumption advisory for all lakes throughout Maryland, based on fish tissue mercury data from a subset of lakes across the State. The advisory was established statewide as a precautionary measure because the primary source of mercury is understood to be atmospheric deposition, which is widely dispersed (MDE 2001). Based on additional fish tissue data collected in 2002, 2003, and again now, in 2010, Maryland has verified that the Millington WMA Ponds are impaired due to elevated levels of mercury in fish tissue.

Fish tissue and water quality data were collected in the Millington WMA Ponds in 2002, but no TMDL was completed at that time. Additional data were collected in 2003. Since the data collected in 2002 and 2003, however, are now seven years old, and MDE has changed its analytical procedures for fish consumption advisories to assess total mercury rather than methylmercury, MDE collected new data in April of 2010 for use in this TMDL. All 2010 data were collected from Pond Two, which is also known as the Quillan Pond. In 2003, MDE field staff had attempted to obtain fish samples from one of the intermittent ponds as well, but electrofishing produced insufficient fish for a composite sample. During the 2010 sampling, the aforementioned intermittent pond was inaccessible by boat to field staff and nearly completely dried up. Based on these factors in combination with the prior inability to collect a sample, no sampling was conducted at the intermittent pond. As mentioned briefly in Sections 1 and 2.1, since all of the Millington WMA ponds are in close proximity to one another, and the source of mercury to the ponds is entirely from atmospheric deposition (thus being extremely unlikely to vary significantly from one pond to another), the fish from Pond Two are assumed to be representative of all trophic-level four fish potentially caught by anyone within the Millington WMA. Thus, because of these reasons and due to the potential impact to human health indicated by this impairment, MDE considers the fish advisory to apply to all Largemouth Bass (or any trophic-level four fish) caught in the Millington WMA. Additionally, MDE also considers the resultant TMDL to apply to all ponds in the Millington WMA.

Two composite samples of trophic-level four fish (Largemouth Bass) were collected from Pond Two at Millington WMA and analyzed for total mercury tissue concentrations. Water column samples were also taken and analyzed for mercury concentrations. Samples were collected by MDE's Field Office staff. Fish tissue samples were analyzed at the University of Maryland Center for Environmental Science's (UMCES) Appalachian Laboratory, and water column samples were analyzed at UMCES's Chesapeake Biological Laboratory.

In fish tissue, mercury is not usually found in concentrations high enough to cause fish to exhibit signs of toxicity, but the mercury in sport fish (trophic-level four) can present a potential health risk to humans. The health risk to humans represented by the mercury content in consumed fish tissue is due to methylmercury. Typically, almost all of the mercury found in fish tissue (90 to 95%) is in the form of methylmercury. Mercury chemistry in the environment is complex and not totally understood. It exhibits the properties of a metal, specifically persistence in the environment. It is not chemically broken down beyond the elemental mercury form of Hg^0 or the ionic forms of Hg^+ and Hg^{+2}. It also has properties similar to a hydrophobic organic chemical, due to its ability methylate via a bacterial process. Methylation of mercury can occur in water, sediment, and soil matrices under anaerobic conditions and, to a lesser extent, under aerobic conditions. In water, methylation occurs mainly at the water-sediment interface and at the oxic-anoxic boundary within the water column. Methylmercury is readily taken up by organisms and will bioaccumulate as it has a strong affinity for muscle tissue. It is effectively transferred through the food web, with tissue concentrations magnifying at each trophic-level. This process can result in high levels of mercury in organisms high on the food chain, despite nearly immeasurable quantities of mercury/methylmercury in the water column. Appendix B discusses mercury chemistry, including methylation, in greater detail.

For public health purposes, MDE has the responsibility to monitor and evaluate contaminant levels in Maryland's fish, shellfish, and crabs to determine if contaminant levels are within the limits established as being safe for human consumption. In fulfillment of this public health responsibility, MDE issued a statewide fish consumption advisory for mercury in fish in 2001. This advisory provides guidelines (Table 2) on fish consumption (allowable meals per month) for recreational anglers and their families (not including commercially harvested fish) and includes fish species in publicly accessible lakes and impoundments (MDE 2001).

Table 2: MDE Fish Consumption Guidelines

Mercury in Fish Tissue Residue Range (µg/kg)[1]	**Recommended Fish Consumption** (meals per month: based on an 8 ounce meal size)
117 – 235	4 - 7
236 – 322	3
322 – 409	2
410 – 939	1
> 939	< 1

Note: [1]Mercury can either be total mercury or methylmercury.

The fish consumption guidelines were developed in part to be protective for neurobehavioral effects during human fetal development and early childhood. An 8-ounce meal size is assumed for the general population. Assumed meal sizes for women of childbearing age and children (0-6 years) are 6 ounces and 3 ounces, respectively. The guidelines were developed assuming a desired level of protection to the general fish-consuming public corresponding to a consumption level of four fish meals per month. Levels of mercury in fish tissue above 300 µg/kg are an indication of impairment, as recommended by EPA and subsequently adopted by MDE as a state water quality standard, and therefore a TMDL goal of 235 µg/kg mercury in fish tissue ensures safe consumption at a four meal-per-month level. These guidelines were developed based on methylmercury; however, analysis in this document is conducted using total mercury, which therefore represents a conservative assumption. Details of Maryland's fish consumption advisory methodology appear in Appendix C. Appendix D describes MDE's methodology of listing impairments based on contaminants in fish tissue.

2.3.2 Mercury in Fish Tissue Data

Samples of fish were taken from Pond Two at Millington WMA. Trophic-level four fish (Largemouth Bass) were targeted in the collection because they represent the top of the food chain (highest bioaccumulation potential) and provide a conservative estimate of the mercury dose associated with fish consumption from this impoundment. Length and weight of the fish were measured. The individual fish were filleted and combined into two composite samples of five individuals each before being analyzed for total mercury concentrations. Appendix E lists composite sample data for mercury residue in fish tissue from Pond Two at Millington WMA.

As stated previously, levels of mercury (methyl or total) in fish tissue above the EPA criterion of 300 µg/kg are an indication of impairment of the fishable use of the water body. To determine if a water body is impaired, the contaminant concentration from a composite sample of fish fillets of any single common species of recreational fish is compared to the established threshold. Maryland collects composite samples of trophic-level four fish (e.g., Largemouth Bass) of legally harvestable size. If the threshold is exceeded, the water body's designated use (*i.e.,* fishable) is not met and the water body is considered impaired. Table 3 below summarizes the fish tissue data.

Table 3: Summary of Fish Tissue Mercury Concentrations in Millington WMA Pond Two

Trophic-Level	Composite Sample Count	Total mercury mean Concentration (µg/kg)
4	2	335.06

2.3.3 Water Column Mercury Concentrations

Water column samples were taken from the Millington WMA Pond Two and analyzed for total mercury concentrations using EPA Method 1631 (US EPA 2002b). Samples were analyzed for both whole water and as dissolved (filtered). Samples were collected at the dam overflow and the east (opposite) end of Pond Two, and the geometric mean was computed.

The geometric mean value of unfiltered total mercury in the water column for Pond Two is 4.86 nanograms per liter (ng/L). The geometric mean value of filtered (dissolved) total mercury in the water column for Pond Two is 2.76 ng/L. Appendix E also contains the water column data.

Table 4: Summary of Water Column Data Analysis in Millington WMA Pond Two

Geometric Mean of Total Hg (ng/L)	4.86
Geometric Mean of Dissolved Total Hg (ng/L)	2.76

2.4 Water Quality Impairment

The Maryland water quality standards Surface Water Use Designation of the MD 8-digit Upper Chester River and its tributaries is Use II (Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting), and the designated use of the nontidal portion of the MD 8-digit Upper Chester River and its tributaries, including the Millington WMA Ponds and their tributaries, is Use I (Water Contact Recreation and Protection of Aquatic Life) (COMAR 2010a,b,c,d). The water quality impairment of the Millington WMA Ponds addressed by this TMDL is due to elevated levels mercury in fish tissue. Maryland's water quality standards, under the federal CWA, require that water quality support public health and welfare for a waterbody's designated uses. In the Millington WMA Ponds, concentrations in the water are well below the threshold for concern with regard to drinking water. However, an existing public health fish consumption advisory for the Millington WMA Ponds recommends significant limits on the consumption of fish caught from the impoundments. This is a violation of the State's narrative water quality standards, because the "fishable" designated use is not being fully supported (COMAR 2010e). This nonattainment of the ponds' designated use results in the listing of the Millington WMA Ponds on Maryland's 2008 Integrated Report as impaired for mercury residue in fish tissue.

3.0 TARGETED WATER QUALITY GOAL

The objective of the TMDL established herein is to reduce mercury loads to the Millington WMA Ponds to levels that support the Use I designation (Water Contact Recreation and Protection of Aquatic Life) (COMAR 2010b,c). Specifically, a reduction in mercury loads is expected to result in mercury concentrations in fish tissue that are protective of human health.

- MDE considers the term “suitable for…fishing” or “fishable” (COMAR 2010e) as the ability for the general population to eat at least four meals per month of any single common recreational fish species from a given water body. This threshold concentration for fish tissue reflective of the consumption of 4 meals per month is 235 μg/kg for mercury.

The fish tissue threshold is designed to ensure that the general population can safely consume at least four meals per month. This is consistent with water quality standards, which must protect the overall population and do not have to be protective of more sensitive subpopulations. The risk assessment used by MDE to determine this concentration threshold incorporates the same risk level, reference dose (RfD) and body weight, and is consistent with the guidance adopted by the U.S. EPA for the protection of human health from methylmercury, as described in *Water Quality Criteria for the Protection of Human Health: Methylmercury* (US EPA 2001).

4.0 TOTAL MAXIMUM DAILY LOADS AND ALLOCATIONS

4.1 Overview

This section describes how the mercury TMDL and loading allocations were developed for the Millington WMA Ponds. The second subsection describes the analysis framework for developing the TMDL calculation. The third subsection describes the steps in the TMDL calculation, and the fourth subsection describes the TMDL allocations. The fifth subsection addresses seasonal variations and critical conditions, and the sixth subsection explains the rationale for the MOS. Finally, in the seventh subsection, the pieces of the equation are combined in a summary accounting of the TMDL.

4.2 Analysis Framework

In the calculation of previously established mercury TMDLs (i.e., Mercury TMDLs submitted to the EPA by MDE in 2002), Maryland used a computational framework based on a refinement of the methodology described in the *Total Maximum Daily Load for Total Mercury in Fish Tissue Residue in Big Haynes Reservoir,* which was developed and proposed by the EPA, Region 4 for the State of Georgia (US EPA 2002a). Maryland refined that methodology by using a fish tissue threshold for mercury that is consistent with its fish consumption advisory methodology, which was more stringent than the EPA guidelines applied in Georgia. In 2002, Maryland estimated atmospheric deposition of mercury using the National Atmospheric Deposition Program – Mercury Deposition Network (NADP-MDN). Five sites in this network were used: Wye (MD), Lewes (DE), and Valley Forge, Arendtsville, and Holbrook (Pennsylvania). Loads were estimated using extrapolations of measurements at these sites, along with mass balance calculations. Details of the 2002 methodology are described in full in any mercury TMDL developed by Maryland and approved by EPA up through 2004; these are available at www.mde.state.md.us/tmdl.

The previous approach, while suitable and representative of the best tools available at the time, can be improved and simplified by using refined air deposition modeling and an updated data inventory. Additionally, the 1996 data inventory that was previously used in modeling air deposition contained an error in one emission source in Maryland (this issue has since been corrected). In addition to incorporating an updated methodology and data, the new approach will allow potential future impairments to be addressed more expeditiously.

Maryland has recently adopted a TMDL approach based on the principle of proportionality, as was first done in the Minnesota Statewide Mercury TMDL (MPCA 2007) and subsequently in the Northeastern Regional Mercury TMDL (NEIWPCC 2007). The background and rationale are described fully in either TMDL and summarized in MDE (2010c). In addition to incorporating updated tools and data, the approach will also make it easier for Maryland to address any future mercury listings. The principle of proportionality can be outlined as follows:

- It is assumed that a specified reduction in mercury emissions will result in a proportionate reduction in deposition;
- This reduction in deposition will in turn result in a proportionate reduction in mercury load to the watershed and water body in question;
- The reduced load will ultimately result in a proportionate decrease in concentrations of mercury in fish tissue.

The TMDL analysis sets a maximum allowable depositional load, which ensures that the mercury concentration in fish tissue will remain below the fish consumption threshold protective of human health described in Section 3.0. The TMDL is expressed in terms of an average annual load to the watershed and assumes steady-state conditions both initially and under the TMDL scenario. For the purposes of this TMDL, the term "watershed" should be interpreted as comprising the drainage area and the surface of the pond itself; however, baseline and allowable loads are still provided for informational purposes for both the drainage area and the water surface of the impoundment for consistency with prior mercury TMDLs. Maximum Daily Loads (MDLs) are also provided for informational purposes, though long-term loads are more meaningful, since deposition is driven by emissions and meteorological conditions, fish tissue bioaccumulation occurs over long periods of time, and the overriding methodology, the principle of proportionality, assumes steady-state conditions.

The TMDL analysis framework can be summarized in the following steps:

(1) Determine baseline conditions by assessing trophic-level four fish tissue concentrations of mercury and modeled atmospheric deposition of mercury;
(2) Compute the reduction in fish tissue mercury concentration needed to reach the TMDL endpoint of 235 μg/kg;
(3) On the basis of the principle of proportionality as described above, using the reduction factor computed in step (2), calculate a required reduction in deposition needed to reach the targeted water quality goal of a mean fish tissue concentration of 235 μg/kg;
(4) Compute the allowable depositional load to the watershed.

4.3 Scenario Descriptions and Results

This section expands upon the steps outlined above in Section 4.2. The analyses allow a comparison of baseline conditions (under which water quality problems exist) with future conditions, which project the water quality response to simulated reductions in mercury loadings. The analyses are grouped according to baseline conditions and future conditions of maximum allowable loads associated with the TMDL.

The key findings in these analyses are the depositional loads estimated using the CALPUFF model, and the proportionate relationship between fish tissue concentrations (baseline and maximum allowable) and these loads.

4.3.1 Baseline Conditions

Two composite samples of Largemouth Bass were analyzed for total mercury. The mean of the two composite samples was computed to be 335.06 μg/kg. For a more detailed description of the process and rationale, see Section 2.3, and the actual individual composite fish tissue data are presented in Appendix E.

Using the CALPUFF model (simulating 2007 conditions), about 21.70 grams per year (g/yr) is estimated to be the baseline load to Millington WMA Pond Two (Sherwell et al. 2006). The baseline load is comprised of loadings from atmospheric deposition to the surface of the pond and to the pond's watershed, and it comprises both wet and dry deposition. This value of 21.70 g/yr works out to a unit area load of approximately 18.90 grams per square kilometer per year ($g/km^2/yr$). Steady-state conditions are assumed. The calculation of the baseline mercury load using the CALPUFF model is described in Appendix A.

The baseline loads are summarized as follows:

Atmospheric Deposition to Pond Two	=	0.84 g/yr (3.87 %)
Atmospheric Deposition to Pond Two Watershed	=	20.86 g/yr (96.13 %)
Point Sources	=	0.00 g/yr (0.00 %)
Total Baseline Load	=	21.70 g/yr (100.00 %)

4.3.2 Maximum Allowable Watershed Load

The maximum allowable load to the watershed ensures that fish tissue concentrations of mercury will not exceed 235 μg/kg for any trophic-level fish. This loading is computed as follows:

- A reduction in the fish tissue mercury concentration from 335.06 μg/kg to 235 μg/kg constitutes a reduction of 29.86%.
- Using the principle of proportionality, the same reduction in atmospherically-deposited mercury is required to meet water quality standards. Thus, this 29.86% reduction in fish tissue mercury concentrations is applied to the modeled baseline load. The 29.86% reduction equates to a maximum allowable depositional load to the watershed that is 70.14% of the baseline load. This works out to about 15.22 g/yr for the entire area, including both the watershed and pond surface. For informational purposes, the maximum allowable depositional load to the surface of Pond Two is approximately 0.59 g/yr.

The maximum allowable loads are summarized as follows:

Atmospheric Deposition to Pond Two	=	0.59 g/yr (3.87 %)
Atmospheric Deposition to Pond Two Watershed	=	14.63 g/yr (96.13 %)
Point Sources	=	0.00 g/yr (0.00 %)
Total Maximum Allowable Load	=	15.22 g/yr (100 %)

Since there are no point sources in the area and the analysis area is used for wildlife management, this allocation scheme is not expected to change. Thus, there is no allocation to point sources, nor is an allocation to account for future growth necessary.

4.4 Total Maximum Daily Load Allocations

Per EPA regulation, all TMDLs need to be presented as a sum of waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint source loads generated within the assessment unit, accounting for natural background, tributary, and upstream segment loads (CFR 2010a). Also, per EPA requirements, "stormwater discharges that are regulated under Phase I or Phase II of the NPDES stormwater program are point sources that must be included in the WLA portion of a TMDL" (US EPA 2002c). However, no point sources, including individual municipal WWTPs, individual industrial, or NPDES regulated stormwater discharges, have been identified in the Millington WMA. Therefore, the TMDL allocation consists only of an LA (i.e., the nonpoint source loads within the watershed), which is furthermore entirely from atmospheric deposition. The State, however, reserves the right to allocate the TMDL among different sources, should different sources arise in the future, in any manner that protects the "fishing" designated use of the impoundments (COMAR 2010e).

An LA has been assigned to the sole nonpoint source: atmospheric deposition to the surface of the impoundment and the surrounding watershed area. The required reductions in mercury loadings from atmospheric deposition are expected to take place over time as mercury emissions decline as a result of controls that are to be installed due to the recently established Clean Air Interstate Rule (CAIR), which will be replaced by the Clean Air Transport Rule (once the latter is finalized), and Maryland's Healthy Air Act (HAA) (COMAR 2010h,i). The allocation presented herein demonstrates how the TMDL can be implemented to achieve water quality standards in the Millington WMA Ponds.

4.5 Seasonal Variations and Critical Conditions

Seasonal Variations: This TMDL represents an allowable depositional load that is designed to reduce mercury concentrations in fish tissue, thus protecting human health by minimizing exposure to mercury via fish consumption. Although many factors may vary over a given year, the effect is averaged out over several years during which fish bioaccumulate mercury. An analysis of the length and weight of individual fish sampled (see Table E-1 of Appendix E) indicates they were of legal (keepable) size. The averaging effect of long-term bioaccumulation is reflected in the analysis and supports the use of an average annual load. Specifically, the fish tissue concentration at the time of sampling is the result of long-term accumulation in fish that are several years old.

Critical Conditions: Critical conditions are implicitly included in the threshold mercury concentration used to calculate the maximum allowable mercury loading, as it is based on human fish consumption over a long time period, which averages out critical events. Also, the TMDL is at all times protective of human health via fish consumption, thereby indicating that any "critical conditions" within that time frame are considered. Finally, the TMDL established to be protective of human health is more conservative than the mercury levels to protect environmental resources (i.e., EPA recommended and the State of Maryland adopted mercury criteria in fish tissue of 300 μg/kg), implying that critical conditions for environmental resources are also addressed by the reasoning that is applied to human health.

The average annual load is the appropriate maximum allowable loading characterization for this TMDL since mercury bioaccumulation and the resulting risk to human health that results from fish consumption is a long-term phenomenon. Therefore, shorter seasonal inputs are less meaningful than total annual loads over many years. The use of annual loads allows for integration of short-term or seasonal variability. MDLs are provided for informational purposes only.

Modeled and observed mercury deposition and resultant fish tissue concentrations assume and reflect 'steady state' conditions over long periods of time, thus taking into account any temporal hydrological or seasonal differences.

4.6 Margin of Safety

All TMDLs must include a MOS to account for any lack of knowledge and uncertainty concerning the relationship between loads and water quality (CFR 2010b). Specifically, knowledge is incomplete regarding the exact nature and magnitude of pollutant loads from sources and the specific impacts of those pollutants on the chemical and biological quality of complex, natural water bodies. The MOS is intended to account for such uncertainties in a manner that is conservative from the standpoint of environmental and human health protection.

Based on EPA guidance, the MOS can be achieved through one of two approaches (US EPA 1991). One approach is to reserve a portion of the loading capacity as a separate term in the TMDL (i.e., TMDL = WLA + LA + MOS). The second approach is to incorporate the MOS as conservative assumptions in the design of the TMDL analysis. For purposes of this mercury TMDL, Maryland has adopted a MOS that makes use of conservative assumptions within the methodology (i.e., a built-in MOS). The following are several components of the implicit MOS:

(1) The analyses presented in this TMDL assume that anglers consume only trophic-level four fish. Trophic-level four fish are near the top of the food chain and thus consistently have the highest observed fish tissue mercury concentrations due to bioaccumulation and biomagnification. Adopting the assumption that people eat only trophic-level four fish represents a conservative assumption of mercury exposure to humans.

(2) EPA's recommended threshold for mercury in fish tissue is 300 μg/kg, and MDE uses this value as a threshold for determining impairment. However, MDE is using a value of 235 μg/kg as the TMDL goal. This lower threshold is based on a risk analysis used for Maryland's fish consumption procedures. The analysis assumes that some people consume more meals of fish over a

given period of time than is assumed by EPA. This constitutes an implicit MOS of about 21.67%.

(3) Methylated mercury, not total mercury, is the actual impairing substance as per the 2008 Integrated Report. For the purposes of issuing fish consumption advisories, however, Maryland now analyzes fish tissue for total mercury rather than methylmercury. This adds the equivalent of a 5% - 10% additional MOS to the TMDL, since best estimates are that about 90% – 95% of the total mercury content in fish tissue is in its methylated form.

(4) The calculations involve deposition to the watershed as a whole, not making a distinction between the actual waterbody and the land surrounding it. This effectively assumes that land deposition has the same impact as deposition to the surface water itself. While it can be assumed that under steady-state conditions, a large portion of the mercury deposited to the watershed reaches the waterbody, it is also true that a portion of the mercury is bound to sediments, and therefore not all of it will reach the actual impoundment due to sediment deposition within the watershed. This adds another conservative assumption, although it cannot be quantified.

4.7 Summary of Total Maximum Daily Loads

The average annual TMDL for mercury is calculated from the equation:

TMDL = WLA + LA + MOS

Where: WLA = Waste Load Allocation
LA = Load Allocation
MOS = Margin of Safety

The TMDL for mercury is presented in g/yr in Table 5 below.

Table 5: Summary of Mercury TMDL for the Millington WMA Pond Two Watershed

TMDL (g/yr)	=	**WLA** (g/yr)	+	**LA** (g/yr)	+	**MOS**
15.220		0.0		15.220		Implicit[1]

On average, the TMDL will result in an MDL of approximately 0.04698 grams per day (g/day).

5.0 ASSURANCE OF IMPLEMENTATION

The Millington WMA Ponds are located in a watershed in which the mercury impairment is driven exclusively by nonpoint source mercury contributions in the form of atmospheric deposition. The EPA considers coal-fired electric power generating plants to be the largest anthropogenic source of mercury emissions in the nation. As such, the TMDL implementation provisions may differ from the implementation of TMDLs from other pollutant types. The EPA expects to see reduced emissions of mercury from this industry sector as regulations (e.g., provisions under the CAIR/Clean Air Transport Rule) are implemented to control oxides of sulfur and nitrogen (COMAR 2010i). This is due both to the fact that some control technologies used to limit these pollutants provide ancillary mercury emissions reductions to some degree, and because reductions in sulfur deposition to an aquatic environment make it less favorable for the methylation of mercury. While not quantifiable at this point, the benefit is expected to be significant. The controls for atmospheric emissions are expected to be implemented in phases.

At the State level, Maryland passed the HAA in 2007. The HAA impacts Maryland's largest coal-burning power plants, which account for over 95% of the state's power plant emissions. Facilities covered include: Constellation Energy Group's Brandon Shores, Crane, and Wagner plants; Mirant Corporation's Chalk Point, Morgantown, and Dickerson plants; and the R. Paul Smith Plant located in Washington County, Maryland. Under full implementation of the HAA in 2013, mercury emissions will have been reduced by 90% at these plants from 2002 levels (COMAR 2010h). The HAA is projected to result in a reduction of 3.771 g/yr in mercury deposited to the Millington WMA watershed when fully implemented. This equals approximately a 17% reduction in total deposition and a 91% reduction in deposition originating from EGUs in Maryland. It also accounts for about 42% of the reduction required to meet this TMDL.

In addition to controls on mercury air emissions, proper management of mercury-containing products and source reduction are critical components to reducing mercury in the waste stream and to the environment. To this end, MDE has published extensive information for consumers and businesses concerning the reduction of mercury levels in Maryland's environment at http://www.mde.state.md.us/programs/landprograms/hazardous_waste/mercury/mercuryinfo.asp. Information includes descriptions of mercury in the home and the environment, alternative products to mercury-containing products, mercury spill cleanup safety, and mercury recycling resources (MDE 2010a).

As additional data and information are collected for the Millington WMA Ponds and as new legal requirements are imposed under the Clean Air Act (CAA) and other environmental statutes, MDE will continue to evaluate the effectiveness of the regulatory and non-regulatory programs in achieving the water quality targets used to establish this TMDL.

For public health purposes, MDE has the responsibility to monitor and evaluate Maryland's fish, shellfish, and crabs to determine if contaminant levels are within the limits established as being safe for human consumption. The currently issued fish consumption advisories are the result of the execution of this responsibility.

REFERENCES

CFR (Code of Federal Regulations). 2010a. *40 CFR* 130.2(i). http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=43ac087684bf922499af8ffed066cb09;rgn=div5;view=text;node=40%3A21.0.1.1.17;idno=40;cc=ecfr#40:21.0.1.1.17.0.16.3 (Accessed July, 2010).

__________. 2010b. *40 CFR 130.7*. http://a257.g.akamaitech.net/7/257/2422/22jul20061500/edocket.access.gpo.gov/cfr_2006/julqtr/40cfr130.7.htm (Accessed July, 2010).

COMAR (Code of Maryland Regulations). 2010a. *26.08.02.08* G*(2)*. http://www.dsd.state.md.us/comar/ (Accessed July, 2010).

___________. 2010b. *26.08.02.07 A*. http://www.dsd.state.md.us/comar/ (Accessed July, 2010).

___________. 2010c. *26.08.02.02 B(1)*. http://www.dsd.state.md.us/comar/ (Accessed July, 2010).

___________. 2010d. *26.08.02.02 B(3)*. http://www.dsd.state.md.us/comar/ (Accessed July, 2010).

___________. 2010e. *26.08.02.02 B(1)(c)*. http://www.dsd.state.md.us/comar/ (Accessed July, 2010).

___________. 2010f. *26.08.02.03-2 G(1)*. http://www.dsd.state.md.us/comar/ (Accessed July, 2010).

___________. 2010g. *26.08.02.04*. http://www.dsd.state.md.us/comar/ (Accessed July, 2010).

___________. 2010h. *26.11.27*. http://www.dsd.state.md.us/comar/ (Accessed July, 2010).

___________. 2010i. *26.11.28*. http://www.dsd.state.md.us/comar/ (Accessed July, 2010).

Dean, J. A. 1992. *Lange's Handbook of Chemistry and Physics* 14th Ed. New York: McGraw Hill.

DNR (Department of Natural Resources). 2010a. *Millington WMA*. http://www.dnr.state.md.us/publiclands/eastern/millington.asp (Accessed July, 2010).

___________. 2010b. *Physiography of Maryland*. http://www.dnr.state.md.us/forests/healthreport/mdmap.html (Accessed July, 2010).

DOLP (Delaware Office of Land Planning). 2007. *Delaware 2007 Land Use/Land Cover*. Dover, DE.

Gavis, J., and J. F. Ferguson. 1972. The Cycling of Mercury Throughout the Environment. *Water Research* 6: 986 – 1008.

Gilmour, C. C., and E. A. Henry. 1991. Mercury Methylation in Aquatic Systems Affected by Acid Deposition. *Environmental Pollution* 71: 131–169.

MDE (Maryland Department of the Environment). 2000. *An Overview of Wetlands and Water Resources of Maryland*. Baltimore, MD: Maryland Department of the Environment.

___________. 2001. *MDE Issues New Fish Consumption Advisories*. Baltimore, MD: Maryland Department of the Environment.

___________. 2002. *Memo to Mercury Thermometer Manufacturers and Retailers*. Baltimore, MD: Maryland Department of the Environment. Also Available at http://www.mde.state.md.us/assets/document/retailers_manu_web_version.pdf.

___________. 2008. *The 2008 Integrated Report of Surface Water Quality in Maryland*. Baltimore, MD: Maryland Department of the Environment. Also Available at http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/Maryland%20303%20dlist/2008_Final_303d_list.asp.

___________. 2010a. *General Mercury Information*. http://www.mde.state.md.us/programs/landprograms/hazardous_waste/mercury/mercuryinfo.asp (Accessed July 2010).

___________. 2010b. *Maryland Tier II Dataset.* Baltimore, MD: Maryland Department of the Environment.

___________. 2010c. In Preparation. *Revised Approach For Addressing Maryland's Lakes Impaired By Methylmercury In Fish Tissue*. Baltimore, MD: Maryland Department of the Environment.

MDP (Maryland Department of Planning). 2002. *2002 Land Use/Land Cover*. Baltimore, MD: Maryland Department of Planning.

MGS (Maryland Geological Survey). 2010. *A Brief Description of the Geology of Maryland*. http://www.mgs.md.gov/esic/brochures/mdgeology.html (Accessed July, 2010).

MPCA (Minnesota Pollution Control Agency). 2007. *Minnesota Statewide Mercury Total Maximum Daily Load*. St. Paul, MN: Minnesota Pollution Control Agency.

NEI (National Emissions Inventory). 2010. *National Emissions Inventory Air Pollutant Trends Data*. http://www.epa.gov/ttnchie1/trends/ (Accessed July, 2010).

NEIWPCC (New England Interstate Water Pollution Control Commission). 2007. *Northeast Regional Mercury Total Maximum Daily Load*. Lowell, MA: New England Interstate Water Pollution Control Commission.

PPRP (Maryland's Power Plant Research Program). 1994. *Power Plant Contributions To Environmental Mercury In Maryland*. Annapolis MD: Maryland's Power Plant Research Program.

Sherwell, J., M. Garrison, A. Yegnan, A. Baines. 2006. Application of the CALPUFF Modeling System for Mercury Assessments in Maryland. In *Proceedings 99th Annual Meeting of the Air and Waste Management Association* 429. Pittsburgh, PA: Air and Waste Management Association.

Shimomura, S. 1989. Analytical Behavior and Some Physical Properties of Mercury: A Review. *Analytical. Sciences* 5: 633 – 639.

US Census Bureau. 2000. *2000 Census*. Washington, DC: US Census Bureau.

USDA (United States Department of Agriculture). 1982. *Soil Survey of Kent County*. Washington, DC: United States Department of Agriculture.

____________. 2006. *State Soil Geographic (STATSGO) Database for Maryland*. Washington, DC: United States Department of Agriculture, Natural Resources Conservation Service. Also Available at http://www.soils.usda.gov/survey/geography/statsgo/.

US EPA (U.S. Environmental Protection Agency). 1991. *Guidance for Water Quality-Based Decisions: The TMDL Process*. Washington, DC: U.S. Environmental Protection Agency.

____________. 1997. *Mercury Study Report to Congress* (*The Mercury Study*). Washington, DC: U.S. Environmental Protection Agency.

____________. 2000a. *Office of Wetlands, Oceans and Waterways Memorandum # WQSP-00-03*. Washington, DC: U.S. Environmental Protection Agency.

____________. 2000b. *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories; Third Edition*. Washington, DC: U.S. Environmental Protection Agency.

____________. 2001. *Water Quality Criterion for the Protection of Human Health: Methylmercury*. Washington, DC: U.S. Environmental Protection Agency.

____________. 2002a. *Total Maximum Daily Load For Total Mercury in Fish Tissue Residue In Big Haynes Reservoir*. Atlanta, Georgia: U.S. Environmental Protection Agency Region IV.

____________. 2002b. *Method 1631, Revision E. Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry*. Washington, DC: U.S. Environmental Protection Agency.

____________. 2002c. *Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs*. Washington, DC: U.S. Environmental Protection Agency.

____________. 2005. *Clean Air Mercury Rule*. Washington, DC: U.S. Environmental Protection Agency. Also Available at http://www.epa.gov/mercuryrule/.

Appendix A: Mercury Air Deposition

Summary

Mercury air deposition loads to the Millington WMA Pond Two watershed were estimated under a number of scenarios using the CALPUFF model, which is an advanced, non-steady-state Gaussian meteorological and air quality modeling system, approved by EPA for many atmospheric pollutant modeling purposes. The CALPUFF scenario runs and output were made available to MDE from Maryland DNR's PPRP. The scenarios were conducted and analyzed in the following manner (Sherwell et al. 2006):

- Baseline loads were calculated based on the 2007 stack test for Maryland sources and 2002 National Emissions Inventory (NEI) for other sources (NEI 2010). This calculation was representative of typical conditions over the last decade, assuming no reductions from Maryland's HAA;
- Loads reflecting reduced emissions resulting from full implementation of the HAA in 2013 as specified in COMAR (2010h) were calculated;
- Analyses to separate loads originating from the following sources were performed:
  - Within the state of Maryland:
    - EGUs vs. non-EGUs;
  - Outside of Maryland, but within the model domain (roughly the eastern third of the United States):
    - EGUs vs. non-EGUs;
  - Global background loads, including natural loads (Sherwell et al. 2006).

Tables A-1 and A-2 below show the loads and proportions thereof from these source sectors under baseline and full-HAA implementation scenarios, respectively.

Table A-1: Modeled Total Baseline Mercury Loads to Millington WMA Pond Two

BASELINE CONDITIONS		
SOURCE CATEGORY	**LOAD (g/yr)**	**PERCENT**
Maryland Non-EGU Total	0.345	1.59%
Maryland EGU Total	4.145	19.08%
Non-Maryland Non-EGU	4.359	20.07%
Non-Maryland EGU	5.924	27.27%
Global Background	6.949	31.99%
TOTAL	21.7	100.0%

Table A-2: Modeled Total Mercury Loads to Millington WMA Pond Two Under Full Implementation of Maryland's HAA

FULL HAA IMPLEMENTATION CONDITIONS		
SOURCE CATEGORY	LOAD (g/yr)	PERCENT
Maryland Non-EGU Total	0.345	1.92%
Maryland EGU Total	0.374	2.08%
Non-Maryland Non-EGU	4.359	24.28%
Non-Maryland EGU	5.924	33.00%
Global Background	6.949	38.71%
TOTAL	**17.9**	**100.0%**

The model output also 'tags' certain individual emitters. This is not presented in the course of the development of this TMDL, but is available and remains a viable option for use during the course of TMDL implementation.

Appendix B: Mercury Chemistry

Mercury is a Group IIB (Periodic Table) element, as are zinc and cadmium. Elemental metallic mercury exists as a high luster silver-colored liquid at room temperature. Key physical properties are listed in Table B-1. Some of the varied industrial and consumer uses of mercury include electrical apparatus, such as fluorescent light tubes, and control instruments - including thermometers and barometers. It is also used in the manufacture of pharmaceuticals, antifouling paints, mercury fulminate, electrolytic cells, and dental amalgams. Mercury is a constituent of a number of antiseptics such as *mercurochrome, merthiolate, and mercressin*. Mercury and all its compounds are toxic. Mercury fulminate, $Hg(CNO)_2$, is used as a detonator for initiating the explosion of smokeless powder and various high explosives (i.e., TNT, dynamite, etc.). Mercury fulminate is very unstable and can be exploded by shock; its explosion causes the main explosive to be detonated. Mercury electrolytic cells are used in a manufacturing process for chlorine/ alkali production. Liquid mercury dissolves many metals, especially the softer ones such as copper, silver, gold, and the alkali elements. The resulting alloys, which may be solids or liquids, are called amalgams. Dental amalgam is an alloy of mercury and silver.

Table B-1: Physical Properties of Metallic Mercury[1]

Atomic Number	80
Atomic Weight	200.59
Density[2,3]	13.5 g/cm^3 @ 25^0C
Melting Point	-39^0C
Boiling Point	357^0C
Water Solubility (molarity)[4]	3.0×10^{-7} mol/L @25^0C
Water Solubility (mass basis)[5]	60 µg/L @ 25^0C

Notes: [1] Source: (Dean 1992).
[2] g/cm^3 = grams per centimeters cubed
[3] C = Celcius
[4] Mol/L = mols per Liter
[5] µg/L = micrograms per Liter

Mercury exists in three oxidation states: the metallic, uncharged state (Hg^0); the mercurous state (Hg^{+1}); and the mercuric state (Hg^{+2}). These states are separated by only a small oxidation potential (Eh), and the metal readily participates in redox chemical reactions. In particular, Hg^{+1} salts disproportionate under many conditions to yield the Hg^{+2} salt and metallic mercury. Reduction of both the mercurous and the mercuric salts normally yields the metal state (PPRP 1994).

Mercury in natural waters may assume any of the three oxidation states. The predominate state is determined by the hydrogen ion concentration (described as pH) and the Eh of the water. Since chloride and sulfide complex Hg^{+1} and Hg^{+2} ions, concentrations of these compounds also affect the relative species distribution (Gilmour and Henry 1991; Shimomora 1989). Ammonium, carbonate, bicarbonate, and phosphate concentrations do not affect speciation (PPRP 1994).

In natural systems, pH is generally in the range of 5 to 8 and the Eh is typically less than 0.5 Volts. For these systems, HgS and metallic mercury are the most likely solids to be found in equilibrium with saturated solutions of mercury salts at moderate Cl^{-1} and S^{-2} concentrations. The predominant species in the corresponding solutions will be $Hg(OH)_2$ and $HgCl_2$ in well oxygenated waters and Hg metal in poorly oxygenated waters (Gavis and Ferguson 1972). In reducing sediments, HgS will predominate the solid phase (PPRP 1994).

Methylated forms of mercury, CH_3HgCl and $(CH_3)_2Hg$, are formed in both aerobic and anaerobic sediments through the action of bacteria. Methylated mercury is thought to be thermodynamically unstable in water; quantities of organic mercury found in surface waters are probably preserved through reaction barriers that prevent degradation. Methylation does not occur in the presence of moderate to high sulfide concentrations which immobilize the Hg^{+2} ion (PPRP 1994).

In fish tissue, mercury is not usually found in concentrations high enough to cause fish to exhibit signs of toxicity, but the mercury in sport fish (trophic-level four) can present a potential health risk to humans. The health risk to humans represented by the mercury content in consumed fish tissue is due to methylmercury. Typically, almost all of the mercury found in fish tissue (90 to 95%) is in the methylmercury form. Mercury chemistry in the environment is complex and not totally understood. It has the properties of a metal, specifically, persistence in the environment because it is not chemically broken down beyond the elemental mercury form (Hg^0) or its ionic forms (Hg^+ and Hg^{+2}). It also has properties similar to a hydrophobic organic chemical due to its ability to be methlyated through a bacterial process. Methylation of mercury can occur in water, sediment, and soil matrices under anaerobic conditions, and to a lesser extent, under aerobic conditions. In water, methylation occurs mainly at the water-sediment interface and at the oxic-anoxic boundary within the water column. Methylmercury is readily taken up by organisms and will bioaccumulate as it has a strong affinity for fish muscle tissue. It is effectively transferred through the food web, with tissue concentrations magnifying at each trophic-level. This process can result in high levels of methylmercury in organisms high on the food chain, despite nearly immeasurable quantities of mercury/methylmercury concentrations in the water column.

Appendix C: Risk Assessment

Fish consumption advisory thresholds were determined by utilizing human health risk assessment procedures as presented in US EPA (1997) and modifications as described in MDE (2002). These advisories recommend that a certain number of meals per month of a particular fish species not be exceeded in order to avoid long-term health effects from exposure to methylmercury.

Variables considered in the advisory risk assessment included: 1) meal frequency (zero, one, two, four, eight, or unlimited meals per month); 2) meal size (eight ounces for people 18-75 of the general population and women 18-45 years of age, and three ounces for children zero to six years of age); and 3) population weights of 70.0 kilograms (kg) for the general population, 64.0 kg for women, and 14.5 kg for children. A methylmercury RfD of 0.1µg/kg-day, based on neurological and developmental studies of infants chronically exposed to methylmercury through fish consumption, was also used in the risk analysis. These factors are shown in Table E1.

Table C-1: Human Health Risk Assessment Parameters for MDE's Fish Consumption Advisories[1]

RfD (ug/kg-day)	Body Weight (kg)	Meal Size (ounces/meal)	Fish Consumption Rate (kg/day)	Recommended Meal Frequency (meals/month)	Mercury Concentration in Fish Tissue (ppm)		
Men and Women 18 - 75 Years Old							
0.1	70	8	3.7	No Consumption		>	0.939
0.1	70	8	7.5	1	0.470	-	0.939
0.1	70	8	14.9	2	0.236	-	0.469
0.1	70	8	29.8	4	0.118	-	0.235
Women 18 - 45 Years Old							
0.1	64	8	3.7	No Consumption		>	0.858
0.1	64	8	7.5	1	0.430	-	0.858
0.1	64	8	14.9	2	0.216	-	0.429
0.1	64	8	29.8	4	0.108	-	0.215
Children 0 - 6 Years Old							
0.1	14.5	3	1.4	No Consumption		>	0.519
0.1	14.5	3	2.8	1	0.260	-	0.519
0.1	14.5	3	5.6	2	0.131	-	0.259
0.1	14.5	3	11.2	4	0.066	-	0.130

Note: [1] Source: (US EPA 2000b).

Appendix D: Addendum For Toxics Methodology in Maryland's 2002 Integrated Report: Designated Use Impairments Based on Fish Tissue.

Background

Section 101(a)(2) of the CWA establishes as a national goal "water quality which provides for the protection and propagation of fish, shellfish, wildlife, and recreation in and on the water, wherever attainable" .These are commonly referred to as the "fishable/swimmable" goals of the Act. Section 303(c)(2)(A) requires water quality standards to protect the public health and welfare, enhance the quality of water, and serve the purposes of the CWA. EPA, along with MDE, has interpreted these regulations to mean that not only should waters of the State support thriving and diverse fish and shellfish populations, but when caught, may also be safely consumed (COMAR 2010e). Some water bodies may have elevated levels of contaminants, especially in the sediment. Some of these contaminants (especially mercury and PCBs) tend to bioaccumulate to elevated levels in the tissues of game fish and "bottom-feeders" (largemouth bass and catfish, respectively). When tissue levels of a contaminant are sufficiently elevated to increase the risk of chronic health effects if the fish is consumed regularly, the State has the responsibility to issue a fish consumption advisory to protect public health. Fish consumption advisories are designed to protect the general population as well as sensitive populations (i.e., young children and women who are or may become pregnant). If a consumption advisory is issued for a water body, its designated use may not be supported and that water body may be listed as impaired for the contaminant(s) responsible for the fish consumption advisory.

MDE has defined "fishable" as the ability to eat AT LEAST four meals/month (general population) for common recreational fish species from a given water body. The tissue level corresponding to this will be the upper threshold at the four meal/month level for a given contaminant. In addition to this, if the tissue concentration is within 5% of the threshold, the water body's designated use will be considered impaired. The 5% "safety factor" accounts for the uncertainty and spatial/temporal variability in monitoring data and sampling regimes. This safety factor is designed to protect and maintain the "fishable" designated use status of a water body. To determine if a water body is impaired, the appropriate measure of central tendency (i.e. geometric mean) for a contaminant from the fillet samples of common recreational fish species will be compared to the established threshold. If the threshold is exceeded, the water body's designated use is not met, and the water body is considered impaired.

Data Requirements

The data required to list a water body as impaired are similar to the data requirements for the development of a fish consumption advisory. The same decision rules are used to test data adequacy as well as spatial and temporal representation. Consumption advisories based on the minimum required samples that resulted in an impairment decision will be re-sampled prior to TMDL development to insure that the advisory was not due to a localized condition, and that the impairment is still temporally relevant. The data requirements for listing a water body are:

a. The advisory is based on fish and shellfish tissue data. All available data will be used.
b. The data are collected from the specific water body in question.
c. A minimum of five fish from a given species (individual or composite analysis) for a given water body.
d. The species used to determine impairment should be representative of the water body; migratory and transient species may be used if they are the dominant recreational species, but should only be used in conjunction with resident species, especially in the case of tidal rivers of the Chesapeake Bay.
e. Contaminant thresholds used will reflect concentrations used to set consumption recommendations for the general population. The general population is defined as women beyond the years of childbirth (~45) and adult males.

In some instances, it may be inappropriate to consider certain fish and shellfish consumption advisories in making an impairment determination. For example, a State may have issued a statewide or regional warning, based on data from a subset of water bodies and species or a higher consumption value may have been used in determining the need for an advisory to protect a specific sensitive population compared to the value used in establishing water quality criteria for the protection of human health. In such instances, these types of advisories were not considered for making an impairment determination. This approach is consistent with EPA's current recommendations regarding impairment determinations using contaminant data from fish advisories.

Appendix E: Composite Sample Data and Analysis

This appendix presents all of the data for fish tissue samples and water column samples. The data reduction steps are also described.

Table E-1: Millington WMA Ponds Composite Fish Sample Data for Mercury Residue in Fish Tissue (Pond Two)

Sample ID	**Trophic-Level**	**Species** (gender)	**Collection Date**	**Composite Samples**	**Total Mercury Wet weight** (ppb)[1]	**Length** (mm)[2]	**Weight** (g)[3]
04/2010MILL-01A	4	LMB (F)	April 5, 2010	Composite #1	N/A[4]	395	882
04/2010MILL-02A	4	LMB (M)	April 5, 2010	Composite #1	N/A	390	751
04/2010MILL-03A	4	LMB (F)	April 5, 2010	Composite #1	N/A	330	514
04/2010MILL-04A	4	LMB (F)	April 5, 2010	Composite #1	N/A	312	402
04/2010MILL-05A	4	LMB (M)	April 5, 2010	Composite #1	N/A	310	454
COMPOSITE 1[5]					410.92	347.4	600.6
04/2010MILL-06A	4	LMB (M)	April 5, 2010	Composite #2	N/A	310	391
04/2010MILL-07A	4	LMB (M)	April 5, 2010	Composite #2	N/A	305	403
04/2010MILL-08A	4	LMB (M)	April 5, 2010	Composite #2	N/A	300	383
04/2010MILL-09A	4	LMB (F)	April 5, 2010	Composite #2	N/A	295	344
04/2010MILL-10A	4	LMB (F)	April 5, 2010	Composite #2	N/A	290	313
COMPOSITE 2[5]					259.91	300.0	366.8
Total[6]					**335.06**	**323.70**	**483.70**

Notes:
1 ppb = parts per billion.
2 mm = millimeters.
3 g = grams.
4 N/A = Not Applicable.
5 Composite mercury concentrations are average calculations from filets of the individual samples.
6 The total is an average of the two composites.

An analysis of the length and weight of these fish indicates that they were of legal (keepable) size.

Two water column samples were collected from Millington WMA Pond Two. Samples were collected at the dam overflow and at the east (opposite) end of the pond. Water column data are shown in Table E-2 for informational purposes only (they were not necessary in the calculation of the TMDL).

The analytical method used for these analyses (U. S. EPA Method 1631) has a minimum detection level of 0.5 ng/L. One ng/L represents a detection level of one part per trillion. Method 1631 has an inherent variability of about +/- 15% (US EPA 2002b). All the data were subject to laboratory quality assurance/quality control procedures, prior to being released to MDE (such as blanks, spiked samples, etc.). However, due to the sensitive nature of this test, there are cases in which the results from the same sample show a larger concentration of dissolved mercury than the total concentration. When this occurs, and the difference is within the inherent range of variability, the two values must be interpreted as being the same. To check this, a data reduction process was developed and employed as described below.

Water Column Data Reduction Process

The TMDL analysis requires that we aggregate a number of samples into a single value that represents an estimate of the central tendency of the data. This data reduction process also must account for any data that we suspect is not valid.

Performing a laboratory analysis for trace elements is a very sensitive undertaking. The potential error in the measurements for total mercury in the water column is about 15 % in either direction (over or under estimation). This implies that two samples that are within 30% of each other cannot be considered different.

The measurement of whole concentrations (dissolved plus particulate) is less subject to error than measurements of dissolved concentrations. This is because measuring whole concentrations does not require a filtration step, which can introduce error. In cases where the dissolved values are significantly greater than the whole sample (20% or more), it has been advised by the UMCES laboratory that the dissolved sample not be used due to the potential contamination during the filtration process.

The data reduction process described below addresses pairs of water column samples of total mercury representing whole samples and dissolved samples. It is outlined in the form of decision rules to address all of the different cases that can be confronted.

For each pair of results from a given sample, whole and dissolved:

i. If the whole sample is more than 20% greater than the dissolved sample, keep both numbers as good, and interpret the difference as being the particulate fraction.

ii. If the whole sample and dissolved are within 20% of each other, compute the arithmetic mean of the two numbers. Use this average value to represent both whole and dissolved values in future calculations.

iii. If the dissolved number is more than 20% greater than the whole, discard the dissolved as being contaminated. Interpret the whole value as dissolved, and use this value to represent both whole and dissolved values in future calculations.

Table E-2: Water Column Total Mercury Concentration Data from Millington WMA Ponds (Pond Two)

Date Sampled	**Sample Site**	**Total Mercury Concentration (Whole)** (ng/L)	**Total Mercury Concentration (Dissolved)** (ng/L)	**Difference** (%)
04/05/2010	Downstream of Inflow of Pond Two	4.92	2.71	77.14
04/05/2010	Near outfall of Pond Two	4.80	2.82	74.46
Geometric Mean		**4.86**	**2.76**	**N/A**

In each case, the percentage difference is greater than 20 %, and case (i) applies. The value of 4.86 ng/L represents the expected whole water column concentration for total mercury. The value of 2.76 ng/L represents the expected water column concentration of dissolved mercury. The difference represents the expected particulate fraction.