TOTAL MAXIMUM DAILY LOAD (TMDL)

For

Total Mercury in Fish Tissue Residue

In the

Middle & Lower Savannah River Watershed

For Segments

Clarks Hill Lake Dam to Stevens Creek Dam

Stevens Creek Dam to US Highway 78/278

US Highway 78/278 to Johnsons Landing

Johnsons Landing to Brier Creek

Brier Creek to the Tide Gate

EPA United States Environmental Protection Agency

Region 4 serving the southeast

TOTAL MAXIMUM DAILY LOAD (TMDL)

Total Mercury in Fish Tissue Residue

In the

Middle & Lower Savannah River Watershed

Under the authority of Section 303(d) of the Clean Water Act, 33 U.S.C. 1251 et seq., as amended by the Water Quality Act of 1987, P.L. 100-4, the U.S. Environmental Protection Agency is hereby establishing a TMDL for total mercury for the protection of public health associated with the consumption of fish taken from the following segments of the Savannah River in Georgia:

Clarks Hill Lake Dam to Stevens Creek Dam

Stevens Creek Dam to US Highway 78/278

US Highway 78/278 to Johnsons Landing

Johnsons Landing to Brier Creek

Brier Creek to the Tide Gate

The calculated allowable load of mercury that may come into the identified segments of the Savannah River without exceeding the applicable water quality standard of 2.8 nanograms per liter is 32.8 kilograms per year. EPA interpreted the State of Georgia's narrative water quality standard for toxic substances for the protection of public health to determine the applicable water quality standard. Based on a current estimated loading of 58.8 kilograms per year, an estimated 44% reduction in mercury loading is needed for the identified sections of the Savannah River to meet the applicable water quality standard of 2.8 nanograms per liter. It is estimated that reductions in air deposition of mercury will result in a 38% to 48% reduction in mercury loading to the Savannah River. Twenty-nine (29) facilities permitted by the State of Georgia under the National Pollutant Discharge Elimination System Program are provided wasteload allocations in this TMDL.

This TMDL shall become effective immediately, and is incorporated into the Continuing Planning Process for the State of Georgia under Sections 303(d)(2) and 303(e) of the Clean Water Act.

Signed this _________ day of___________, 2001.

____

Beverly H. Banister, Director
Water Management Division

Table of Contents

Table of Figures

Table of Tables

1. Executive Summary

The U.S. Environmental Protection Agency (EPA) Region 4 is establishing this Total Maximum Daily Load (TMDL) for total mercury in the middle/lower Savannah River Basin for the 5 contiguous segments of the Savannah River from the Clarks Hill Lake Dam to the Tide Gate. The segments are as follows:

- Clarks Hill Lake Dam to Stevens Creek Dam
- Stevens Creek Dam to US Highway 78/278
- US Highway 78/278 to Johnsons Landing
- Johnsons Landing to Brier Creek
- Brier Creek to the Tide Gate

Four of these segments are listed on the State of Georgia's 2000 Section 303(d) list of impaired waters because mercury in certain species of fish tissue exceeds the the Georgia Department of Natural Resources (GDNR) Fish Consumption Guidelines State's guidelines. The fifth segment, Johnsons Landing to Brier Creek, was inadvertently omitted from the State of Georgia's 2000 Section 303(d) list. This segment is impaired based on GDNR Fish Consumption Guidelines, and the Georgia Environmental Protection Division intends to include this segment on the State's 2002 Section 303(d) List (personal communication, Mork Winn, February 27, 2001). Therefore, this TMDL identifies the allowable annual load of total mercury for the middle/lower Savannah River from Clarks Hill Dam to the Tide Gate that will result in attainment of the applicable water quality standard, and the unrestricted use of these segments for fish consumption.

This TMDL satisfies a consent decree obligation established in Sierra Club, et. al. v. EPA Civil Action, 1: 94-CV-2501-MHS. The State of Georgia requested EPA to develop this TMDL for the impaired segments of the Savannah River, and as such, EPA is establishing this TMDL for Georgia for the 5 segments of the Savannah River. Although the mid-line of the Savannah River serves as the east-west boundary between the states of Georgia and South Carolina, the TMDL does not provide wasteload allocations to South Carolina NPDES facilities. This TMDL reflects assumptions that concentrations of mercury in the South Carolina portion of the Savannah River will meet the applicable Georgia water quality standards at the South Carolina-Georgia border.

EPA originally proposed this TMDL for total mercury for the middle and lower Savannah River between Clarks Hill Dam and the Tide Gate on February 8, 2000. In response to significant comments received during the public comment period, the TMDL was revised and re-proposed on December 8, 2000. This public comment period closed on January 22, 2001. By establishing this TMDL at this time, EPA is satisfying a court-order to finalize this TMDL by February 28, 2001. This TMDL is being established in phases with this TMDL document representing the first phase of the process. EPA expects to develop a revised TMDL for mercury for the middle/lower Savannah River in 2004. EPA believes that a phased approach is appropriate for this TMDL because information on the actual contributions of mercury to the Savannah River from both point and nonpoint sources will be much better characterized in the future.

In order for this TMDL to be developed, the applicable water quality standard must be determined. The State of Georgia does not have a numeric water quality standard for the protection of public health from total mercury. EPA determined that Georgia's numeric water quality standard for protection of aquatic life, 12 nanograms per liter (ng/l), is not protective of human health. Based on site-specific field data from the middle/lower Savannah River, ambient concentrations of total mercury in the water column are well below 12 ng/l yet concentrations of mercury in fish tissue exceed levels protective of public health. Therefore, EPA does not regard the State's aquatic life criterion as the applicable water quality standard for this TMDL. Instead, EPA has derived a numeric interpretation of the State of Georgia's narrative water quality standard for toxic substances (Chapter 391-3-6-.03 Section (5)(e)) using EPA's Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (EPA 2000). Using recommended national values, and site-specific data collected in the middle/lower Savannah River Basin, EPA interpreted Georgia's water quality standard and has determined that the applicable water quality standard for total mercury in the ambient water of the Savannah River Basin is 2.8 ng/l (parts per trillion). At this concentration, or below, fish tissue residue concentrations of mercury will not exceed 0.4 mg/kg, which is protective of the general population from the consumption of freshwater fish. This interpretation of Georgia's water quality standard was based on site-specific data gathered for the Savannah River in 2000 specifically for the purpose of this TMDL. It does not apply to any other water in the State of Georgia. In addition, in any future TMDLs for Savannah River, it is possible that EPA may revise this interpretation based on new site-specific data collected at that time.

During the time that this TMDL was proposed and was in public review between December 8, 2000, and January 22, 2001, EPA issued federal criterion recommendations for methylmercury on December 30, 2000. (See Water Quality Criteria for Protection of Human Health: Methylmercury, EPA-823-F-01-001.) This document recommends 0.3 mg/kg as a fish tissue residue concentration for protection of human health. Since EPA was under court order to finalize this TMDL by February 28, 2001, EPA had insufficient time to consider the new federal criterion recommendations in the establishment of this TMDL. Therefore, EPA may reconsider this TMDL at some future date (prior to 2004) in order to consider the new federal criterion guidance in the context of this waterbody. It should be noted, however, that today's TMDL protects the designated uses and achieves the applicable water quality standard as interpreted by EPA. In order to assure protection, EPA made conservative assumptions in this TMDL in the derivation of the applicable water quality standard, particularly relating to the bioaccumulation factor (BAF). EPA assumed that all 17.5 grams per day of fish consumed are of largemouth bass, which as a trophic level 4 fish, bioaccumulates mercury at comparatively high rates. (This means that consumers of these fish will be exposed to more mercury than would be the case if they consumed lower trophic level fish species.) The resulting water quality standard as interpreted by EPA appears to be as protective as the numeric value EPA would have derived using the recommended assumptions in the Human Health Methodology (a "weighted" BAF rather than a trophic level 4 BAF; a general population consumption rate of 17.5 grams per day; a methylmercury reference dose of 0.0001 mg/k/day; and a relative source contribution dose of 0.00027 mg/kg/day). This conclusion depends on the appropriate "weighted BAF" value, which will be considered in any future revision of this TMDL.

Computerized modeling techniques have been employed in the development of this TMDL. The loading of mercury from the watershed into the Savannah River was simulated using a Watershed Characterization System (WCS) model developed by EPA Region 4 (USEPA, Region 4, 2001). The WCS provides a simplified simulation of precipitation-driven runoff and sediment delivery. Solids load from runoff is used to estimate pollutant delivery to the River from the watershed. The water quality model known as WASP5 (Ambrose, et al., 1993) is used to simulate mercury fate and transport in the Savannah River. WASP5 is a general dynamic mass balance framework for modeling contaminant fate and transport in surface waters.

EPA evaluated the current loading conditions and calculated the water column concentration using the modeling approach described in this document. **The calculated allowable load of mercury that can come into the Savannah River without exceeding the applicable water quality standard as interpreted by EPA of 2.8 ng/l is 32.8 kilograms/year.** Because this assessment indicates that 99% of the loading of mercury is from atmospheric sources, 99% of the allowable load will be assigned to the load allocation, and 1% of the available load will be assigned to the wasteload allocation. Therefore, the Load Allocation and Wasteload Allocation for the middle/lower Savannah River are:

Load Allocation (atmospheric sources) = 0.99 (32.8) = 32.5 kilograms/year

Wasteload Allocation (NPDES sources) = 0.01 (32.8) = 0.3 kilograms/year

The estimated current loading of mercury to the Savannah River from the surrounding watershed is 58.8 kilograms/year. This load was determined by adding the predicted mercury load for each of the subwatersheds taking into account delivery times and volatilization that occurs in the tributaries. The difference between the estimated current mercury load (58.8 kg/year) and the calculated allowable load (32.8 kg/year) is 26 kilograms/year. Since 32.8 kg/year is 56% of the estimated current loading of mercury, it is estimated that a 44% reduction in total mercury loading is needed for the middle/lower Savannah River to achieve a water column concentration of 2.8 ng/l.

An analysis conducted by the EPA Region 4 Air Program concludes that an estimated 38% to 48% reduction in mercury deposition to the Savannah Watershed can be achieved by 2010. EPA expects these reductions to be achieved through full implementation of the current Clean Air Act (CAA) Section 112 Maximum Achievable Control Technology (MACT) requirements, Section 111 New Stationary Source Standards, and Section 129 Solid Waste Combustion requirements at sources within the local airshed. (USEPA, 2000)

This TMDL assigns a cumulative wasteload allocation (WLA) to all NPDES point sources of 0.3 kilograms per year. This TMDL assumes that this cumulative WLA will be accomplished through the imposition of numeric water quality-based permit limits or through the implementation of mercury minimization plans at appropriate NPDES facilities. The wasteload allocation options for NPDES permitted facilities are described in Section 10.

2. Introduction

The U.S. Environmental Protection Agency (EPA) Region 4 is establishing this Total Maximum Daily Load (TMDL) for total mercury for the middle/lower Savannah River from the Clarks Hill Lake Dam to the Tide Gate. The segments are as follows:

- Clarks Hill Lake Dam to Stevens Creek Dam
- Stevens Creek Dam to US Highway 78/278
- US Highway 78/278 to Johnsons Landing

- Johnsons Landing to Brier Creek
- Brier Creek to the Tide Gate

Four of these segments are listed on the State of Georgia's 2000 Section 303(d) list of impaired waters because mercury in certain species of fish tissue exceeds the the Georgia Department of Natural Resources (GDNR) Fish Consumption Guidelines State's guidelines. The fifth segment, Johnsons Landing to Brier Creek, was inadvertently omitted from the State of Georgia's 2000 Section 303(d) list. This segment is impaired based on GDNR Fish Consumption Guidelines, and the Georgia Environmental Protection Division intends to include this segment on the State's 2002 Section 303(d) List (personal communication, Mork Winn, February 27, 2001).

TMDLs are required for waters on a state's Section 303(d) list by Section 303(d) of the Clean Water Act (CWA) and the associated regulations at 40 CFR Part 130. A TMDL establishes the maximum amount of a pollutant a waterbody can assimilate without exceeding the applicable water quality standard. The TMDL allocates the total allowable pollutant load to individual sources or categories of pollution sources through wasteload allocations (WLAs) for point sources regulated by the National Pollutant Discharge Elimination System (NPDES) program and through load allocations (LAs) for all other sources. The WLAs and LAs in the TMDL provide a basis for states to reduce pollution from both point and nonpoint sources that will lead to restoration of the quality of the impaired waterbody. The purpose of this TMDL is to identify the allowable load of mercury that will result in attainment of the applicable water quality standard as interpreted by EPA, and the unrestricted use of the identified segments for fish consumption.

This TMDL satisfies a consent decree obligation established in Sierra Club, et. al. v. EPA, Civil Action: 94-CV-2501-MHS. The Consent Decree requires TMDLs to be developed for all waters on Georgia's current Section 303 (d) list consistent with the schedule established by Georgia for its rotating basin management approach. The State of Georgia requested EPA to develop this TMDL, and as such, EPA is establishing this TMDL for Georgia for the 5 segments of the Savannah River. Although the mid-line of the

Savannah River serves as the east-west boundary between the states of Georgia and South Carolina, the TMDL does not provide wasteload allocations to South Carolina NPDES facilities. This TMDL reflects assumptions that concentrations of mercury in the South Carolina portion of the Savannah River will meet the applicable Georgia water quality standards as interpreted by EPA at the South Carolina-Georgia border.

On February 8, 2000, EPA originally proposed this TMDL for total mercury for the segments of the Savannah River listed on the State of Georgia's 1998 Section 303(d) List. During the public comment period on that proposed TMDL which closed April 10, 2000, EPA received extensive and significant comments on the TMDL. As a result, EPA obtained an extension of the schedule to finalize the TMDL from June 7, 2000 to February 28, 2001. This TMDL satisfies the court-ordered commitment.

3. Phased Approach to the TMDL

EPA recognizes that it may be appropriate to revise this TMDL based on information gathered and analyses performed after February 2001. With such possible revisions in mind, this TMDL is characterized as a phased TMDL. In a phased TMDL, EPA or the state uses the best information available at the time to establish the TMDL at levels necessary to implement applicable water quality standards and to make the allocations to the pollution sources. However, the phased TMDL approach recognizes that additional data and information may be necessary to validate the assumptions of the TMDL and to provide greater certainty that the TMDL will achieve the applicable water quality standard. Thus, the Phase 1 TMDL identifies data and information to be collected after the first phase TMDL is established that would then be assessed and would form the basis for a Phase 2 TMDL. The Phase 2 TMDL may revise the needed load reductions or the allocation of the allowable load or both. EPA intends to gather new information and perform new analyses so as to produce a revised or Phase 2 TMDL for mercury for the identified segments of the Savannah River, if necessary, in 2004. The phased approach is appropriate for this TMDL because information on the actual contributions of mercury to the Savannah River from both point and nonpoint sources will be much better characterized in the future.

3.1. Phased Approach to Atmospheric Sources

The impairment of the Savannah River by mercury is largely due to the deposition of mercury from the atmosphere. This TMDL estimates that approximately 99 percent of the pollutant loads to the River come from the atmosphere (Table 8). An analysis of atmospheric deposition to the Savannah River watershed is included in this TMDL as Appendix A. Mercury is emitted into the atmosphere by a large number of different sources. The mercury that reaches the Savannah River watershed comes from nearby sources (local sources) as well as sources much farther away, both within the United States (national sources) and outside of the United States (international sources). Only a small part, approximately 1 percent, of the mercury loading into the Savannah River is due to discharges from water point sources (e.g., pipes) into the Savannah River or its tributaries.

In Appendix A, EPA has made its best attempt to characterize the air sources of mercury to the watershed, given the time available to the Agency for establishing the TMDL. The analysis of deposition of mercury from the atmosphere to the Savannah watershed depends heavily on modeling conducted for the Mercury Study Report to Congress (EPA, 1997). This Study was based on the Regional Lagrangian Model of Air Pollution (RELMAP) modeling, which has several areas of uncertainty, and assumptions that could affect the level of reductions projected by the analysis. Many of these uncertainties are not unique to the analysis of atmospheric deposition prepared for the Savannah River Mercury TMDL. Some of these uncertainties include the estimates of the amount of the chemical form or species of mercury emitted by each source category; the projected level of reductions from each source category subject to the Clean Air Act (CAA) Section 129 or 111 or MACT; the definition of local sources contributing deposition to the watershed; the contribution from global sources; and other aspects of the modeling. While it is not possible to quantify the net effect of these factors, EPA believes the assumptions made to address these uncertainties are reasonable and consistent with the state-of-the art mercury modeling available at the time this TMDL was prepared and that the agency has reasonable assurance that needed air reductions will be achieved. Nonetheless, it is important to point out that, because of these uncertainties, the anticipated 38% to 48% reductions in atmospheric deposition reported in this TMDL are an estimate only.

EPA expects that emissions of mercury from air sources (and consequently deposition of mercury to the Savannah River) will continue to be reduced during the first phase of this TMDL through implementation of the CAA's MACT and Section 129 and Section 111 regulations. In addition, EPA expects reductions in the air emissions of mercury may be achieved through implementation of voluntary programs. At the same time, EPA is considering additional regulatory actions under the CAA that may result in further reductions of mercury emissions from air sources. EPA is also undertaking new computer modeling that will allow a better characterization of sources contributing to the deposition of mercury and, therefore, more certainty regarding the extent of mercury reductions that can be achieved in a watershed from air sources. By 2004, when EPA expects to revise the TMDL, this additional modeling information and estimates of additional future reductions will be available, allowing EPA to validate the assumptions and verify the anticipated reductions in loadings and revise the TMDL accordingly.

3.2. Phased Approach to Water Point Sources

At this time, there is relatively little data on the actual loading of mercury from NPDES point sources in the basin. Because, until recently, EPA's published method for the analysis of mercury was not sensitive enough to measure mercury at low trace level concentrations, most NPDES facilities have not detected mercury during their required priority pollutant monitoring. EPA assumes, however, that all facilities discharge some mercury into the River with their effluent because mercury is pervasive in the environment and is present in rainwater.

Recently, in 1998, EPA adopted a new analytical procedure that detects mercury at low trace level concentrations (0.5 nanograms/liter) (See EPA Method 1631, Revision B, 40 C.F.R. 136.3(a)). A sampling by EPA of a small subset of the NPDES dischargers in Georgia in the Savannah River Basin using the trace level Method 1631 analytical technique verifies EPA's assumption that all facilities are discharging some mercury. As NPDES permits are reissued, dischargers will be required to use the version of Method 1631 then in effect for analyzing mercury. (Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6-.06). Therefore, in the Phase 2 TMDL, data on the concentration of mercury in point source discharges using the more sensitive analytical technique will be available to characterize the actual loading of mercury into the Savannah River. This will allow EPA, as appropriate, to refine wasteload allocations provided in the TMDL.

Other circumstances may also influence the wasteload allocations that are established in the second phase of this TMDL. As an example, EPA issued criterion guidance for methylmercury on December 30, 2000. (See Water Quality Criteria for Protection of Human Health: Methylmercury, EPA-823-F-01-001.) This new guidance was issued after this TMDL was proposed on December 8, 2000, and is not incorporated into the development of this TMDL. However, the Federal Register notice announcing the availability of the new methylmercury criterion guidance explains that EPA expects the states to use the federal criterion as guidance in updating their water quality standards. EPA expects states to adopt a new or revised water quality criterion for methylmercury at levels necessary to protect human health. The State of Georgia will be undertaking a review of their water quality standards within the next 3 years; therefore, EPA anticipates that by 2004 Georgia will have adopted a numeric human health criterion for methylmercury. The revised 2004 TMDL will be based on the State's numeric human health criterion for mercury, if such criterion exists, rather than on EPA's interpretation of the State's narrative water quality standard for toxic substances as was done in this Phase 1 TMDL (See Section 5).

Because the impairment of the Savannah River by mercury is due predominantly to air deposition, the complete elimination or significant reduction of mercury from water point source discharges would produce little benefit in the quality of the Savannah River. In addition, the elimination or significant reduction of mercury would likely be expensive and possibly technically infeasible for point sources to implement. Since many of the NPDES facilities in the basin affected by this TMDL are municipal wastewater treatment plants that are funded through the taxpayers, EPA chooses to move cautiously before implementing wasteload allocations that may cause significant economic hardship in a situation where, as here, EPA expects most of the needed mercury reductions to be achieved through Clean Air Act reductions in mercury emissions from air sources. In this Phase 1 TMDL, EPA expects point source loadings of mercury will be reduced primarily through mercury minimization programs developed and implemented by some point sources.

In summary, during implementation of the Phase 1 TMDL, EPA expects the following activities to occur:

- 29 NPDES facilities will monitor for mercury and characterize it in their influent and effluent for mercury using the more sensitive analytical technique (the version of Method 1631 then in effect). These facilities consist of 15 municipal facilities, and 14 industrial facilities. (See Section 10.2.)

- Where appropriate, NPDES point sources will develop and implement mercury minimization plans;

- Air point sources will continue to reduce emissions of mercury through implementation of the Clean Air Act Section 112 MACT requirements and Section 129 Solid Waste Combustion requirements;

- EPA and the regulated community will improve the mercury air emissions inventory;

- EPA will refine and revise the mercury air deposition modeling to better characterize sources of mercury; and

- EPA and the states will collect additional ambient data on mercury concentrations in water, sediment and fish.

- EPA expects Georgia to adopt a numeric water quality criterion for methylmercury for the protection of human health that is based on EPA's recent criteria guidance, either as published or as modified to reflect site-specific conditions, or that are based on other scientifically defensible methods. (See 40 C.F.R. 131.11(b))

EPA intends to use the data and information collected and developed during the next four years to revise the Phase 1 TMDL, as necessary, to assure that EPA's interpretation of the State's applicable water quality standard is appropriate, and that the allowable load will be achieved by implementation of the TMDL. EPA's intention to revise the TMDL is consistent with the State of Georgia's Rotating Basin Management Program (RBMP) schedule. Under Georgia's current RBMP schedule, NPDES permits in the Savannah River Basin will be reissued in 2005. Therefore, EPA intends to revise the TMDL one year prior to reissuance of permits in the Savannah River Basin.

4. Problem Definition

The water segments in the Savannah River Basin for which this proposed TMDL is being established are listed on the State of Georgia's 2000 Section 303(d) list except Johnsons Landing to Brier Creek (Johnsons Creek to Brier Creek is impaired and will be listed on the State's 303(d) List, See Section 2). The waters were listed (and Johnsons Landing to Brier Creek will be listed) because mercury in the tissue of several species of fish exceeds the Fish Consumption Guidelines (FCG) established by the State of Georgia. (See Georgia Department of Natural Resources, 2000.) The Fish Consumption Guidelines establish limits on the amount of fish that should be consumed over a given time frame (a week or a month) in order to protect human health.

The Georgia Department of Natural Resources (DNR) uses a risk-based approach to determine how often contaminated fish may be consumed at different levels of fish tissue contamination assuming a consumption rate of approximately 32.5 grams per day. Table 1 provides the frequency of consumption for three different levels of fish tissue contamination with mercury.

Table 1 Georgia Department of Natural Resources Fish Consumption Guideline

Mercury Fish Tissue Threshold (mg/kg)	Frequency of Consumption
0.23	Once a Week

0.70	Once a Month
2.3	Do Not Eat

If fish tissue contains 0.23 mg/kg (parts per million) or more mercury, the State's FCG indicates that the fish should not be consumed more than once a week. If fish tissue contains 0.70 mg/kg (parts per million) or more mercury, the State's FCG indicates the fish should not be consumed more than once a month, and if the fish tissue contains 2.30 mg/kg (parts per million) or greater of mercury, the State issues a "Do Not Eat" guideline.

The following FCG are in place for the segments of the Savannah River covered by this TMDL: 1) Columbia County - 1 meal per week for largemouth bass and spotted sucker, 2) Richmond/Burke Counties - 1 meal per week for largemouth bass, 3) Screven County - 1 meal per week for largemouth bass, 4) Effingham County - 1 meal per month for largemouth bass, 5) Fort Howard - 1 meal per week for white catfish and 1 meal per month for largemouth bass and bowfin, 6) Chatham County - 1 meal per week for largemouth bass, and 7) Tidal Gate - 1 meal per week for white catfish.

4.1. Health Effects of Mercury

The State of Georgia's fish consumption guideline program is designed to protect consumers in Georgia from the health effects of mercury consumed through fish in the diet. Human exposure to inorganic mercury in large amounts can cause a variety of health effects. The two organ systems most likely affected by methylmercury are the central nervous system and the kidney. However, the most significant concerns regarding chronic exposure to low concentrations of methylmercury in fish are for neurological effects in the developing fetus and children.

EPA recently issued national advisory concerning risks to children and to pregnant or nursing women associated with mercury in freshwater fish caught by their friends and family. (See EPA Consumption Advisory: Advice for Women and Children on Non-commercial Fish Caught by Friends and Family, EPA-823-F-01-004, January 2001.) The groups most vulnerable to the effects of mercury pollution include:

women who are pregnant or may become pregnant, nursing mothers, and young children. To protect against the risks of mercury in fish caught in freshwaters, EPA is recommending that these groups limit fish consumption to one meal per week for adults (6 ounces of cooked fish, 8 ounces uncooked fish) and one meal per week for young children (2 ounces cooked fish or 3 ounces uncooked fish). The National Academy of Sciences confirms that methylmercury is a potent toxin and concludes that the babies of women who consume large amounts of fish when pregnant are at greater risk for changes in their nervous system that can affect their ability to learn. (NAS, Toxicological Effects of Methylmercury, July 2000) EPA is issuing this advice for women who are pregnant or may become pregnant, nursing mothers, and young children to raise awareness of the potential harm that high levels of methylmercury in fish can cause to a baby or child's developing brain and nervous system. This advice provides guidance on the amount of fish caught by friends and family that these groups can eat to keep methylmercury from reaching harmful levels.

The purpose of this TMDL is to establish the acceptable loading of mercury from all sources, such that mercury levels in the middle/lower Savannah River will not exceed the applicable water quality standard as interpreted by EPA for protection of public health. If concentrations in the River can be reduced to the applicable water quality standard as interpreted by EPA (expressed in terms of ambient water column concentrations), fish tissue levels of mercury will decrease over time. Eventually, fish tissue levels of mercury should become low enough that consumers may eat unlimited quantities of fish from the River without fear of health effects.

5. Applicable Water Quality Standard

TMDLs are established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards. (See 40 CFR Section 130.7(c)(1).) The State of Georgia's Rules and Regulations for Water Quality Control do not include a numerical water quality standard for human health for total mercury. The only mercury criterion provided in State regulations is 12 ng/l for protection of aquatic life from total mercury. EPA recognizes that the derivation of a human health criterion for mercury is more complex than most metals because of the methylation of mercury that occurs in the aquatic environment. (See Ambient Water Quality Criteria for Mercury Document, EPA, 1986) Like the current criteria guidance, the 1986 criterion document recommends that fish tissue be analyzed to determine whether the concentration of methylmercury exceeds the level necessary to protect human health. The document acknowledges that a 12 ng/l aquatic life criterion, while protecting the health of the fish themselves, may not prevent the unacceptable bioaccumulation of mercury in fish tissue, which would adversely affect the health of humans consuming the fish.

EPA collected site-specific data on ambient mercury in the water column and fish tissue from the Savannah River which indicate the 12 ng/l aquatic life criterion is not protective of human health. In July 2000, EPA collected samples of ambient water at 10 locations in the mainstem and 6 locations in tributaries to the Savannah River from below Clarks Hill Dam to the Tide Gate. Total mercury concentrations in the water ranged from 0.27 ng/l to 9.50 ng/l. These concentrations of mercury are well below the State's 12 ng/l aquatic life criterion. However, the average fish tissue residue concentration from 13 of the 16 sampling locations exceeds 0.23 mg/kg. Thus, at water concentrations below 12 ng/l (significantly below in most instances), fish tissue is accumulating mercury at levels above the State's Fish Consumption Guidelines indicating that a water concentration of 12 ng/l is not protective of human health.

Since the State lacks a numeric water quality criterion for the protection of human health, EPA has interpreted the State's narrative water quality standard for toxic substances (Chapter 391-3-6-.03 Section (5)(e)) to identify a water concentration sufficient to protect the human health designated use. In order to use the best available, sound science in interpreting this narrative, EPA used the Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (EPA 2000) to derive the applicable water quality standard for this TMDL. This standard as interpreted by EPA is the maximum concentration of mercury that can be present in the water column without causing a fish tissue residue concentration that poses adverse health effects.

Using EPA's Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (referred to as EPA's Human Health Methodology), EPA determined that a 0.4 mg/kg fish tissue residue value will protect the general population from the adverse health effects of mercury due to the consumption of freshwater fish. To interpret Georgia's Water Quality Standards, EPA assumed that the general population consumes 17.5 grams per day of large mouth bass, a trophic level 4 fish. EPA is using 0.4 mg/kg in fish tissue as the appropriate "end point" upon which to base the interpretation of the applicable water quality standard.

To calculate the maximum water column concentration that will not allow mercury to bioaccumulate in fish tissue to above 0.4 mg/kg, the EPA Human Health Methodology is again applied. The methodology is expressed below:

$$WQS = \frac{(ReferenceDose * BodyWeight * UnitsConversion)}{(ConsumptionRate * BAF * FractionMeHg)}$$

where:

WQS = EPA's Interpretation of Georgia's Water Quality Standard
Reference Dose = 0.0001 mg/kg/day MeHg
Body Weight = 70 kg
Units Conversion = 1.0E6
Consumption Rate = 0.0175 kg/day Fish•
Bioaccumulation Factor = 4,000,000 as measured in the Savannah Watershed
Fraction of the Total Mercury as Methylmercury = 0.0353 as measured in the Savannah Watershed

In the calculation, the Region used the recommended national values for most of the factors in the Human Health Methodology, including the reference dose of 0.0001-mg/k/day methylmercury; a standard average

• The fish intake value of 17.5 g/day (general adult population) was taken from EPA's 2000 Revisions to the Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (65 FR 66444-66482 (11/3/200)).

adult body weight of 70 kg; and the consumption rate for the general population of 17.5 grams per day. (Note that a recent report by the National Academy of Sciences confirms that methylmercury is a potent toxin, and concludes that EPA's reference dose of 0.0001 mg/kg/day is appropriate (See NAS, Toxicological Effects of Methylmercury, July 2000)). For the other factors in the calculation, bioaccumulation and fraction methylmercury, EPA collected site-specific data from the Savannah River Basin in August and September of 2000. (The site-specific data is presented in Section 6.4.) From this site-specific data, EPA determined a representative BAF value to be 4,000,000 and a median measured percentage methylmercury of 3.53%. Using recommended national values, and factors calculated from site-specific data, EPA interpreted Georgia's water quality standard and has determined that the applicable water quality standard for total mercury in the ambient water of the middle and lower Savannah River Basin is 2.8 ng/l (parts per trillion). This water quality standard, when fully achieved, will prevent the unacceptable bioaccumulation of mercury in fish from all segments of the middle/lower Savannah River. This interpretation of Georgia's water quality standard was based on site-specific data gathered for the Savannah River in 2000 specifically for the purpose of this TMDL. It does not apply to any other water in the State of Georgia. In addition, in any future TMDLs for Savannah River, it is possible that EPA may revise this interpretation based on new site-specific data collected at that time.

In determining the applicable water quality standard as interpreted by EPA, it was necessary to determine a representative bioaccumulation factor (BAF) as discussed above. It is common to have a large range in BAFs calculated from field data collected within the same river system. Figure 1 illustrates the range of BAFs calculated for all the fish sampled by EPA in August and September of 2000. The BAFs range from less than 1 million to over 18 million. An appropriate BAF for interpreting Georgia's Water Quality Standards was selected from the central tendency of the measured data for a fish 315 millimeter (mm) in length. (See Figure 1) EPA is assuming a 305-315 mm fish is representative of the size and age of fish that is most likely to be consumed and also represents the minimum length requirement for the fisherman to keep. A representative BAF for a 315 mm fish in the Savannah River Basin is 4,000,000.

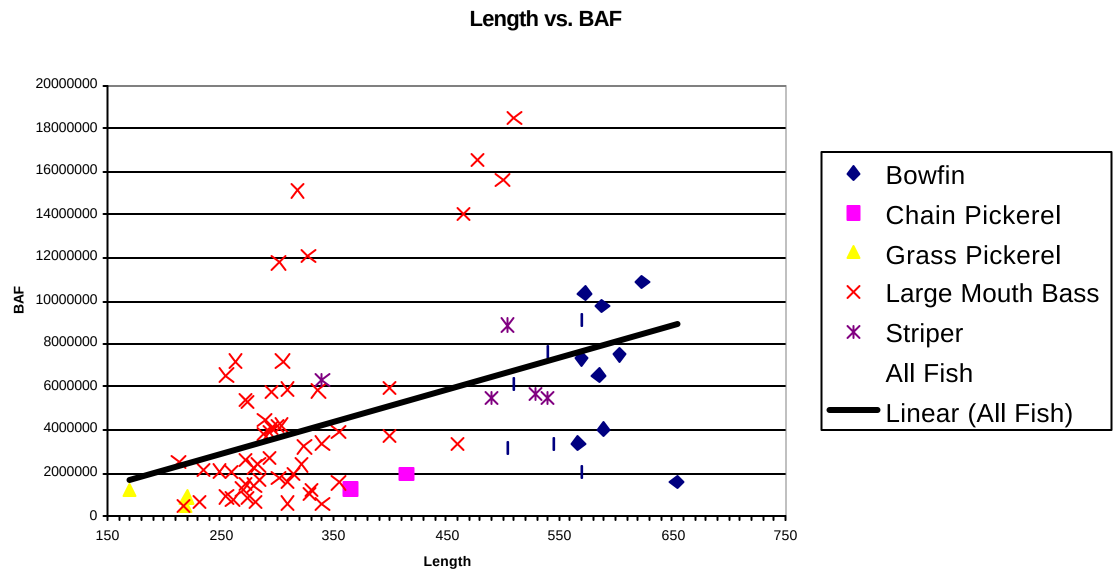

Figure 1 BAF vs. Length Fish Collection from Savannah Basin

Furthermore, to support the selection of the 4,000,000 BAF value, the individual fish for each segment/tributary were analyzed to determine a central tendency BAF that would be protective of the fish species and population that this TMDL is being developed to protect. Data collected for the sections of the river and tributaries were analyzed and compared statistically.

Table 2 provides the average BAFs determined for each tributary and segment of the Savannah River Basin for which data was collected. This analysis shows that an acceptable BAF would be between 3,255,807 and 4,604,485. Using this analysis and regression method shown in Figure 1, the selection of 4,000,000 provides a reasonable estimate of the BAF to be used in the Human Health Methodology calculation.

The site-specific data used to develop the applicable water quality standard was obtained during a one-time sampling event in the summer of 2000. EPA intends to revisit its interpretation of Georgia's water quality standard in Phase 2 when more data is available for total mercury in the water column over a longer time period and environmental conditions.

Table 2 Fish Tissue Analysis

River/Tributary Segment	Average Fish Tissue (ppm)	Water Column Total Hg (ng/L)	Water Column MeHg (ng/L)	Fraction MeHg	Average BAF
Savannah River-Below Clark's Hill Dam	0.251	0.27	0.02	0.078	11,710,280
Savannah River-Below Horse Creek	0.074	0.68	0.10	0.141	768,229
Savannah River-Below Butler Creek	0.316	1.19	0.16	0.131	2,026,871
Savannah River-Below Upper Three Run	0.181	3.27	0.07	0.020	2,744,723
Savannah River-Below Lower Three Run	0.180	9.50	0.06	0.006	3,142,770
Savannah River-Below Brier Creek	0.415	2.80	0.09	0.032	4,703,913
Savannah River-Clyo, USGS Gage	0.633	3.28	0.09	0.027	7,271,958
Savannah River-Below Ebenezer Creek	0.665	3.44	0.08	0.022	8,698,953
Savannah River-Tide Gate (Freshwater)	0.407	4.44	0.09	0.021	4,319,872
Savannah River-Tide Gate (Estuary)	0.389	4.09	0.06	0.015	6,321,951
Horse Creek	0.264	6.16	0.24	0.039	1,096,266
Butler Creek	0.305	2.14	0.39	0.182	780,769
Upper Three Runs Creek	0.783	5.82	0.16	0.027	4,896,829
Lower Three Runs Creek	1.085	2.43	0.13	0.051	8,676,761
Brier Creek	0.493	2.15	0.11	0.050	4,562,963
Ebenezer Creek	1.269	3.34	0.65	0.195	1,948,651
Average	0.482	3.44	0.15	0.065	4,604,485
Median	0.398	3.28	0.10	0.035	4,441,418
Average (Mean) River	0.351	3.30	0.08	0.049	5,170,952
Median River	0.352	3.28	0.08	0.024	4,511,893
Average (Mean) Tributary	0.700	3.67	0.28	0.091	3,660,373
Median Tributary	0.638	2.89	0.20	0.051	3,255,807

6. Background

The middle & lower Savannah River watershed is located in eastern Georgia. The entire drainage area of the Savannah watershed (USGS Hydrologic Unit Code (HUC) 3060106, 3060108, 3060109) is approximately 9318 square kilometers. The Savannah watershed is presented in Figure 2.

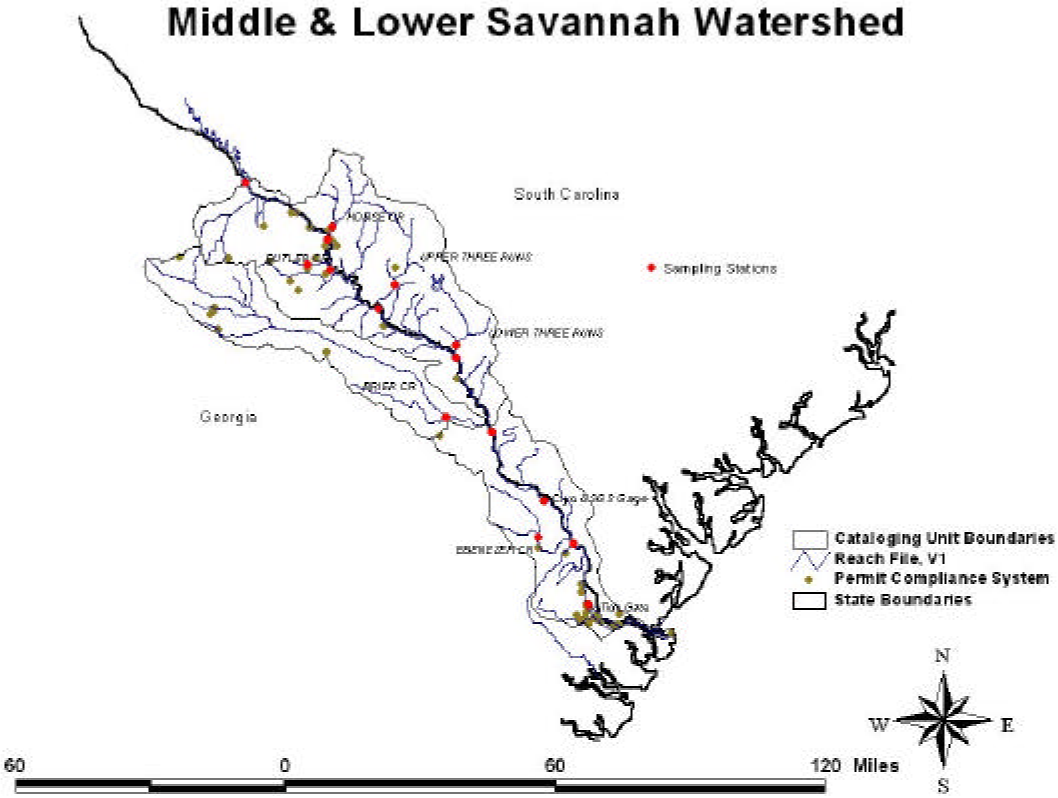

Figure 2 Savannah Watersheds

To develop the TMDL, EPA divided the Savannah watershed into 31 subwatersheds (Figure 3) that represent all of the major tributaries to the Savannah River. This TMDL presents a total mercury load for each of these subwatersheds in order to determine the impact of atmospheric deposition on the Savannah River.

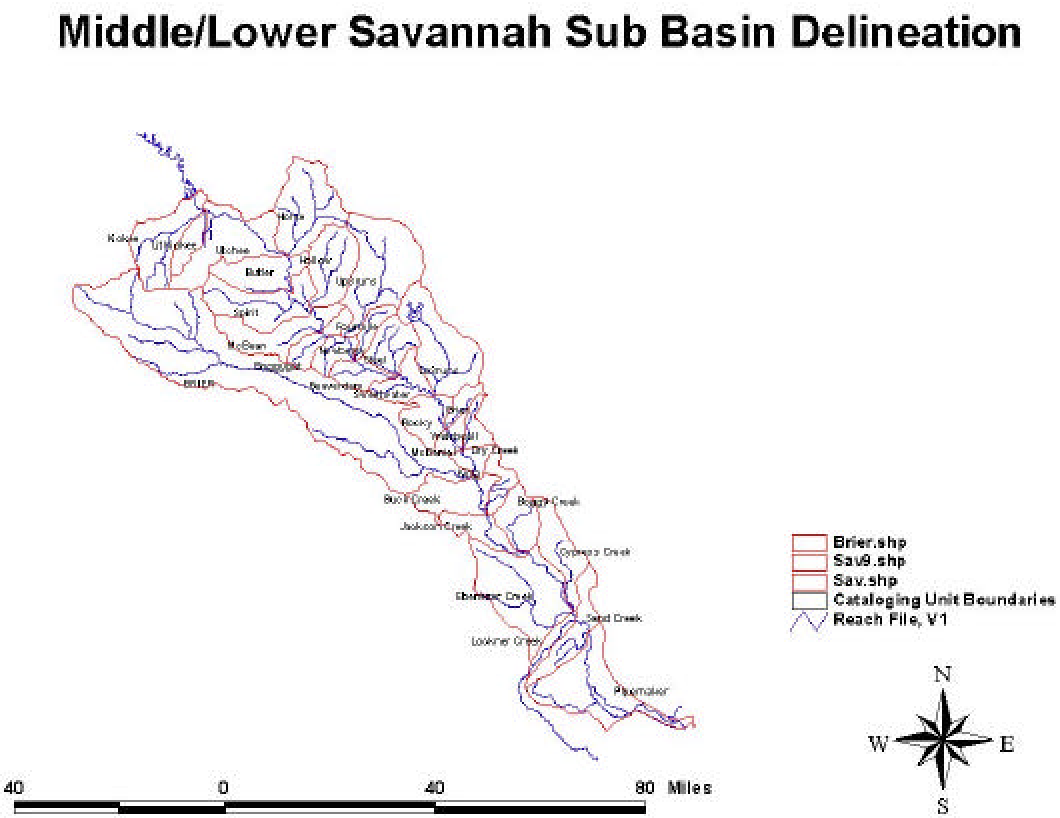

Figure 3 Savannah Watershed Delineation

The watershed contains several different types of land uses. The landuses for the Savannah River watershed are given in Figure 4. Different landuses collect and distribute mercury at different rates as a function of runoff and erosion.

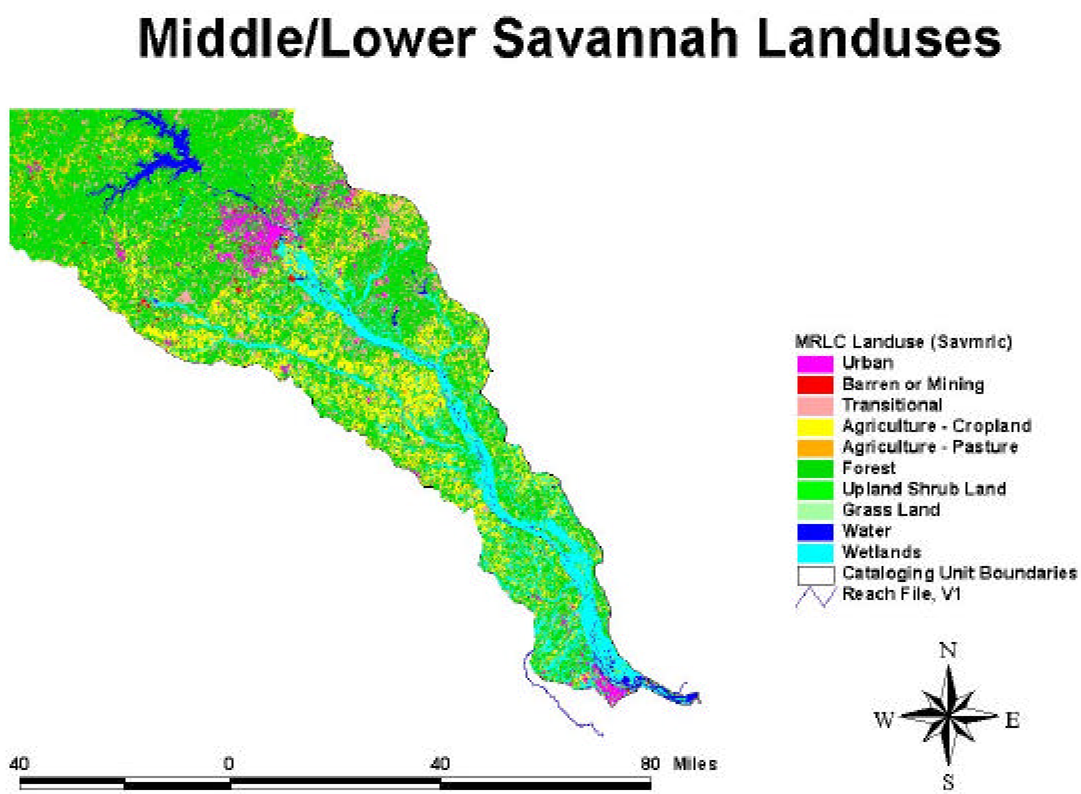

Figure 4 Savannah Watershed Landuses

6.1. Mercury Cycling

Mercury chemistry in the environment is quite complex and is not totally understood. Mercury has the properties of a metal (including persistence due to its inability to be broken down), but also has some properties of a hydrophobic organic chemical due to its ability to be methylated through a bacterial process. Methylmercury is easily taken up by organisms, and will bioaccumulate. It is effectively transferred through the food web, magnifying at each trophic level. This can result in high levels of mercury in organisms high on the food chain, despite nearly immeasurable quantities of mercury in the water column. In fish, mercury is not usually found in levels high enough to cause the fish to exhibit signs of toxicity, but the mercury in sport fish can present a potential health risk to humans.

Figure 5 provides a schematic of mercury cycling in the aquatic environment. The boxes represent stores of mercury, while the arrows illustrate the various fluxes that control mercury cycling in the environment. The top of the diagram summarizes the various forms of mercury that may be loaded into a waterbody. It is important to recognize that mercury exists in a variety of forms, including elemental mercury (Hg (0)), ionic mercury (Hg (I) & Hg (II)), and compounds in which mercury is joined to an organic molecule. In the schematic, Hg (I) is ignored, as Hg (II) generally predominates in aquatic systems. Mercuric sulfide (HgS or cinnabar) is a compound formed from Hg (II), but is shown separately, as it is the predominant natural ore. Organic forms of mercury include methylmercury (CH3Hg or "MeHg"), and also other organic forms, including natural forms such as dimethylmercury and man-made compounds such as organic mercury pesticides.

In the aquatic mercury cycle it is critical to consider the distribution of mercury load between the various forms. The major forms reaching the water from the watershed can have different behavior:

- Mercuric sulfide (HgS), can be washed into the water as a result of weathering of natural cinnabar outcroppings. HgS has low solubility under typical environmental conditions and would be expected to settle out to the bottom sediments. However, under aerobic conditions Hg (II) may be liberated by a bacteria-mediated oxidation of the sulfide ion. This Hg (II) would then be more bioavailable and would be available for methylation. Alternatively, under anaerobic conditions, HgS may be formed from Hg (II).

- Methylmercury (MeHg) is found in rainfall and may be found in small amounts in mine tailings or sediments. It is more soluble than HgS and has a strong affinity for lipids in biotic tissues.

- Elemental mercury (Hg (0)), may remain in mine tailings, as has been noted in tailings piles from recent gold mining in Brazil. Elemental mercury tends to volatilize into the atmosphere, though some can be oxidized to Hg (II).

- Other mercury compounds contain and may easily release ionic Hg (II). Such compounds are found in the fine residue left at abandoned mine sites where mercury was used to extract gold or silver from pulverized rock.

Dimethylmercury is ignored in the schematic because this species seems to occur in measurable quantities only in marine waters. Organic mercury pesticides also have been ignored in this TMDL study since such pesticides are not currently used in this country and past use is probably insignificant.

Mercury and methylmercury form strong complexes with organic substances (including humic acids) and strongly sorb onto soils and sediments. Once sorbed to organic matter, invertebrates can ingest mercury. Some of the sorbed mercury will settle to the bottom, and if buried deep enough, mercury in the bottom sediments will become unavailable to cycle. Burial in bottom sediments can be an important route of removal of mercury from the aquatic environment.

Methylation and demethylation play an important role in determing how mercury will accumulate through the food web. A biological process that appears to involve sulfate-reducing bacteria may result in methylated Hg (II). Rates of biological methylation of mercury can be affected by a number of factors. Methylation can occur in water, sediment and soil solution under anaerobic conditions and to a lesser extent under aerobic conditions. In water, methylation occurs mainly at the sediment-water interface and at the oxic-anoxic boundary within the water column. The rate of methylation is affected by the concentration of available Hg (II) (which can be affected by the concentration of certain ions and ligands), the microbial concentration, pH, temperature, redox potential, and the presence of other chemical processes. Methylation rates appear to increase at lower pH. Bacteria also cause demethylation of mercury.

Note in Figure 5 that both Hg (II) and methylmercury (MeHg) sorb to algae and detritus, but only the methylmercury is assumed to be passed up to the next trophic level. Invertebrates eat algae and detritus, thereby accumulating any MeHg that has sorbed to these constituents. Fish eating the invertebrates and either growing into larger fish (which have been shown to have higher body burdens of mercury) or eaten by larger fish will then bioaccumulate mercury. At each trophic level, a bioaccumulation factor must be assumed to represent the magnification of mercury that occurs as one moves up the food chain.

Typically, almost all of the mercury found in fish (greater than 95%) is in the methylmercury form. Studies have shown that fish body burdens of mercury increase with increasing size or age of the fish, with no signs of leveling off.

Although it is important to identify sources of mercury to the waterbody, there may be fluxes of mercury within the waterbody that would continue nearly unabated for some time even if all the sources in the watershed and waterbody were eliminated. In other words, compartments within the watershed and waterbody store significant amounts of mercury, and this mercury can continue to cycle through the system even without an ongoing source of mercury. The most important store of mercury is likely the river sediments and the surrounding swamps and marshes. The mercury in these pools may cause exposure to biota by being:

- Resuspended into the water column, where it is ingested or adsorbs to organisms that are later ingested.

- Methylated by bacteria. The methylmercury tends to attach to organic matter, which may be ingested by invertebrates and thereby introduced to the food web. It is methylmercury that poses the real threat to biota due to its strong tendency to accumulate in biota and magnify up the food chain.

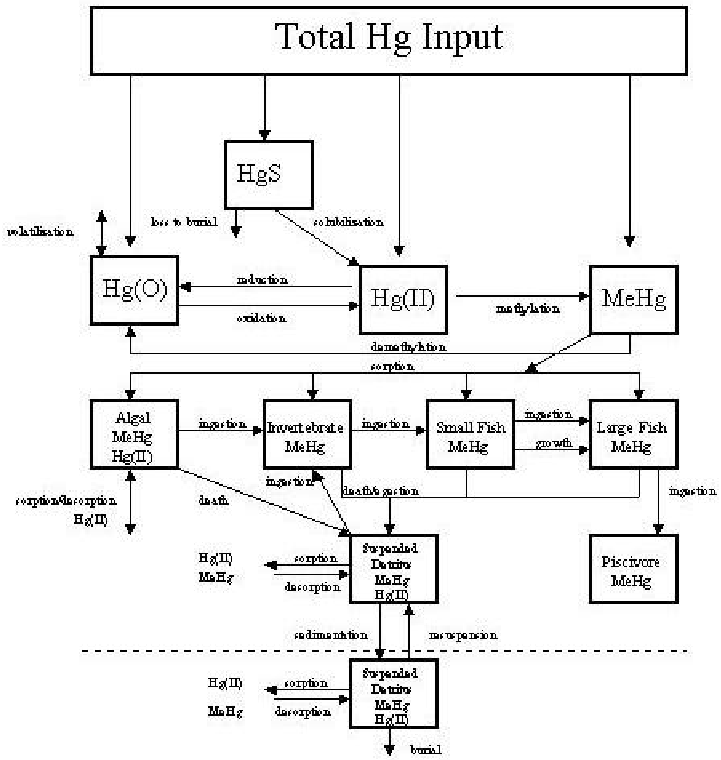

Figure 5 Mercury Cycling in the Aquatic Environment

6.2. Source Assessment

A TMDL evaluation examines the known potential sources of the pollutant in the watershed, including point sources, nonpoint sources, and background levels. For the purpose of this TMDL, facilities permitted under the National Pollutant Discharge Elimination System (NPDES) Program are considered point sources. Similarly, for the purpose of this TMDL air sources of mercury identified in the Mercury Report to Congress (EPA, 1997) which are located in the watershed and within a 100-kilometer boundary around the watershed, referred to as the local airshed are treated as nonpoint sources. All other air sources, outside the local airshed, are considered background sources of mercury. The source assessment serves as the basis for development of a model, and as the basis for the allocation of the total allowable load.

6.2.1. Sources of Mercury

It is estimated that approximately 99% of the mercury loading to the watershed is from atmospheric deposition (See Table 8 Annual Average Total Mercury Load). Mercury is deposited to the watershed as wet deposition (dissolved in rain) and as dry deposition of gaseous and particulate forms of mercury. For a more inclusive discussion of the air analysis performed as part of this TMDL, see Appendix A. Mercury deposited in the watershed comes from sources within the local airshed, from national sources located beyond the local airshed, and from international sources far away. Reactive gaseous mercury (RGM) is the dominant form of mercury in both rainfall and most dry deposition processes, and most of the RGM emitted from man made sources is deposited relatively quickly. Therefore, the analysis of air point sources focuses on sources located in the local airshed, and on their emissions of RGM to the air. For the purposes of this TMDL, the sources within the local airshed are treated as the nonpoint sources of mercury. Those sources outside the local airshed are considered to be part of the background load of mercury since identification of the distant sources that contribute mercury to the watershed was not accomplished for this Phase 1 TMDL.

The emissions inventory files prepared for the Mercury Report to Congress (EPA, 1997) identify stationary point sources of mercury in Georgia and South Carolina within the local airshed. Table 3 identifies these stationary sources of mercury deposition and their estimated contribution in 1995 of RGM, the form of mercury that is most likely to deposit within the local airshed, including the Savannah River watershed.

Table 3 Summaries of Mercury Emissions in the RGM Airshed during the Baseline Period (1994-1996)

Source Category	No. of Sources	Total Hg Emissions Baseline Period (kg/yr)	% of Total Hg	% of Total Hg that is RGM	Total RGM Emissions Baseline	% of Total RGM
MedWIs	36	963	25.65	73	703	39.93
Power Plants	17	866	23.08	30	260	14.76
Chlor-alkali	1	597	15.92	30	179	10.18
MuniWCs	3	589	15.69	60	353	20.08
Res/Ind Boilers	80	477	12.70	30	143	8.12
Pulp and Paper	12	121	3.23	30	36	2.06
Portland Cement	3	113	3.01	10	70	3.95
Sew Sludge Incin	6	26	0.69	60	16	0.88
HazWIs	2	1	0.03	8-95	<1	0.02
Total	160	3753	100.00		1760	100.00

6.2.2. Water Point Sources

Facilities covered by the National Pollutant Discharge Elimination System (NPDES) program are considered in this TMDL to be point sources of mercury within the Savannah watershed. There are approximately 80 NPDES facilities in Georgia discharging effluent to the Savannah River and its tributaries. (See Appendix B for a list of these facilities.) Because of the pervasive nature of mercury, and its presence in rainwater, it is assumed that all NPDES facilities discharge some mercury to the River. Because, until recently, EPA's published method for the analysis of mercury was not sensitive enough to measure mercury at low trace level concentrations, most NPDES facilities have not detected mercury during priority pollutant monitoring. Therefore, most facilities do not have permit limits for mercury in their NPDES permits since they have not demonstrated "reasonable potential" for mercury in their effluent. This TMDL will address only those facilities that have the potential to discharge mercury above 2.8 ng/l (the applicable water quality standard as interpreted by EPA) and that may be adding mercury to their effluent above that in their present source water (See Section 10.2).

In 1999, EPA published a new analytical detection method for mercury that can reliably measure the chemical down to 0.5 ng/l (64 CFR 30417). Using this more sensitive analytical procedure and related field sampling protocols, EPA sampled a small cross section of the NPDES facilities in Georgia in the watershed (22 out of approximately 80 facilities). This limited sampling study confirmed EPA's suspicion that all NPDES facilities are discharging some concentration of mercury. Half of the facilities sampled (11 out of 22) are discharging mercury at a concentration below the water quality standard as interpreted by EPA of 2.8 ng/l, and the other half are discharging above this concentration. Based on the limited data from this one-time sampling event, EPA is estimating that NPDES point sources contribute approximately 1% of the current total load of mercury to the River.

6.3. RELMAP Mercury Deposition Rates

As part of the Mercury Report to Congress, a national airshed model (RELMAP) was applied to the continental United States. This model provides a distribution of both wet and dry deposition of mercury as function of air emissions and global sources. Figure 6 and Figure 7 illustrate the dry and wet deposition rates for the Savannah River watershed as derived by RELMAP. The RELMAP model was based upon the existing emissions inventory (1995 and 1996) and did not include some foreign airsheds (e.g., Mexico).

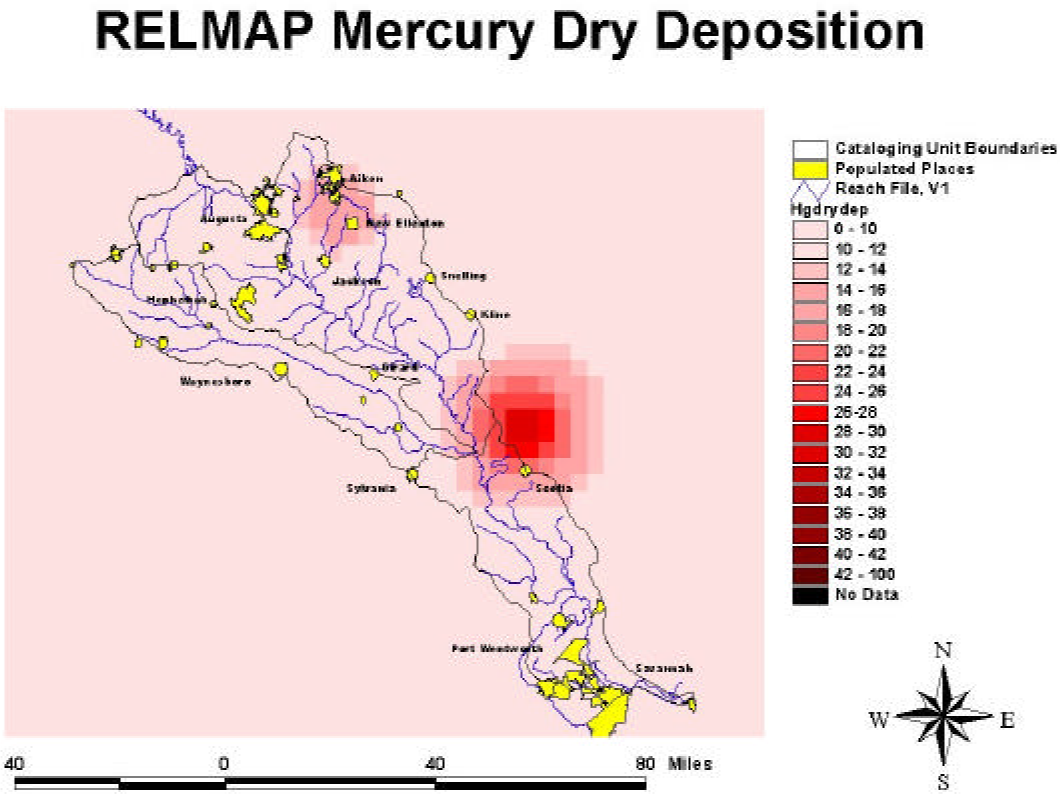

Figure 6 Mercury Dry Deposition Rates as Reported in the Mercury Report to Congress

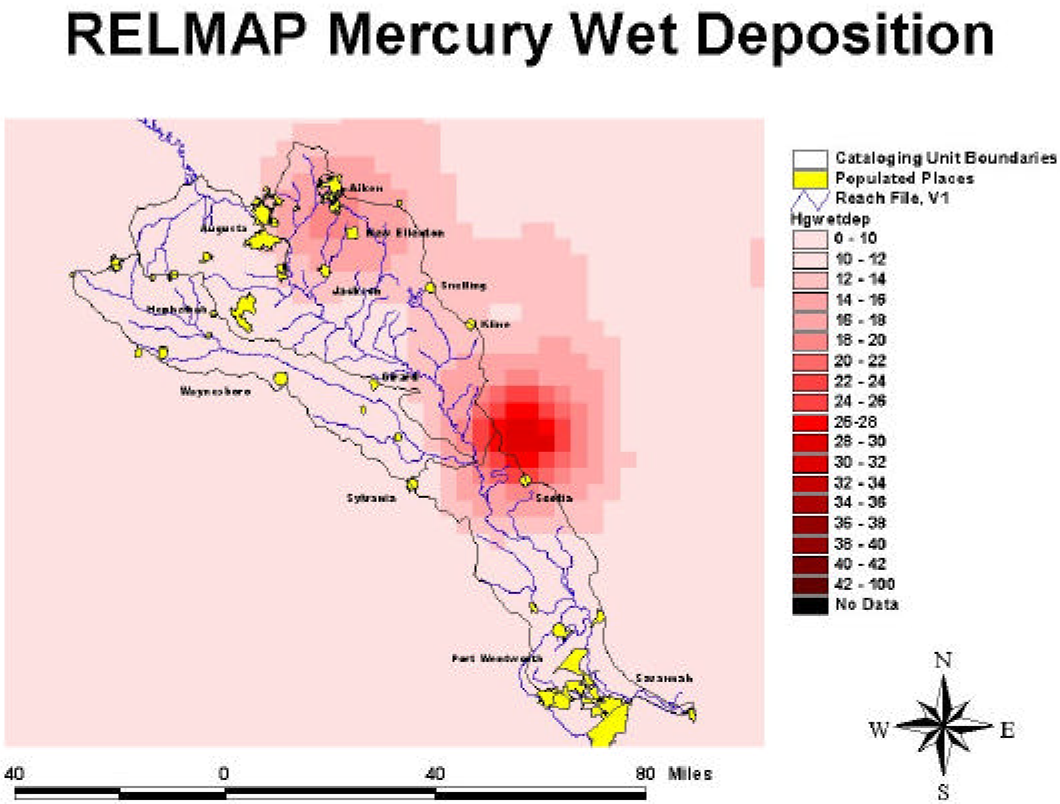

Figure 7 Mercury Wet Deposition Rates as Reported in the Mercury Report to Congress

6.4. Available Monitoring Data

The States of Georgia and South Carolina have routinely collected fish from the Savannah River for fish tissue analysis. Because mercury may bioaccumulate in fish tissue to mg/kg levels (parts per million), analytical procedures have been capable of detecting mercury at these levels. Therefore, data is available from the states for 1988 to 1998 on fish tissue from the Savannah River. These data indicate fish tissue, on average; exceed the State's Fish Consumption Guidelines in the water segments covered by this TMDL. In addition, EPA conducted a field sampling study in August and September of 2000 that included fish-tissue sampling and analysis. These data are available below in Section 6.4.4.

The states have also collected and analyzed ambient water concentration samples for total mercury. As explained above in Section 6.2.2, the analytical method for mercury used in the recent past has a detection limit of 200 ng/l, which is not sensitive enough to detect mercury at the low concentrations typically found in ambient surface water (rivers, creeks, and estuaries.) Therefore, laboratory results from samples of surface water collected by the states during their routine surface water monitoring programs typically have indicated a non-detect for mercury. Therefore, there is little ambient surface water mercury data available from the states. EPA's sampling study of the listed segments of the Savannah River in August and September of 2000 (EPA, November 2000) included water samples from 16 locations within the watershed. Samples were analyzed using EPA Method 1631, which has a detection limit of 0.5 ng/l. The results are presented below at Section 6.4.2.

6.4.1. EPA Region 4 Data

EPA Region 4 sampled the Savannah River watershed in August and September of 2000. Since even low concentrations of mercury in water can lead to significant accumulation of mercury in fish tissue, EPA sampled the Savannah River using the most sensitive sampling and analytical techniques. The samples were collected using the "clean hands" method (EPA, November 2000), and analyzed using the ultra-trace level analytical technique, EPA Method 1631 (USEPA, 1999). EPA adopted this method in June of 1999 for mercury in water for data gathering and compliance monitoring under the Clean Water Act and Safe Drinking Water Act. This method can reliably measure mercury to 0.5 ng/l (parts per trillion).

The purpose of this data collection effort was to collect data needed for the development of this mercury TMDL. The sample locations for the water column are illustrated in Figure 8. Water column, sediment and soil samples (taken adjacent to the water column samples outside the flood plain) were taken from 10 locations in the mainstem and 6 locations in tributaries throughout the middle and lower Savannah River watershed.

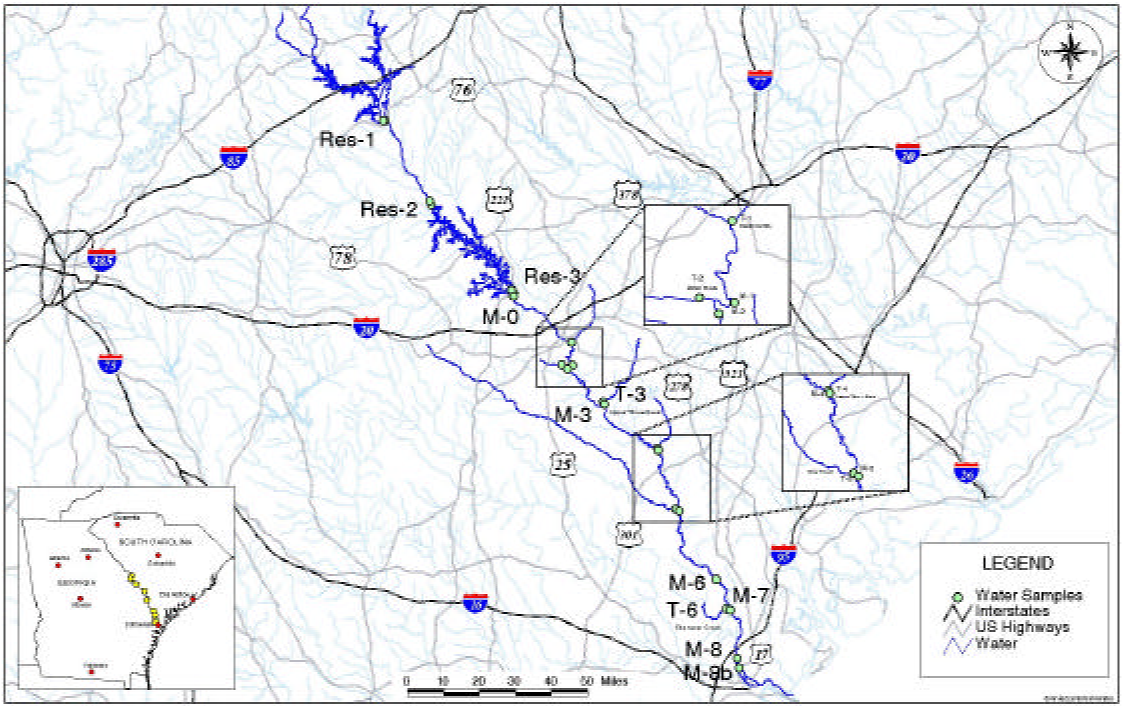

Figure 8 Savannah Watershed Water Column Sample Locations

Sample locations for the fish collection are illustrated in Figure 9. The 16 collection sites are located throughout the mainstem and tributaries in the middle and lower Savannah Basins. The fish collection consisted of 5 fish per sampling location, with the species of interest being largemouth bass. Largemouth bass were targeted because the State of Georgia's Fish Consumption Guideline is established to protect consumers from the consumption of largemouth bass. When 5 largemouth bass were not obtainable, other fish (Bowfin, Chain Pickerel, Grass Pickerel) were substituted.

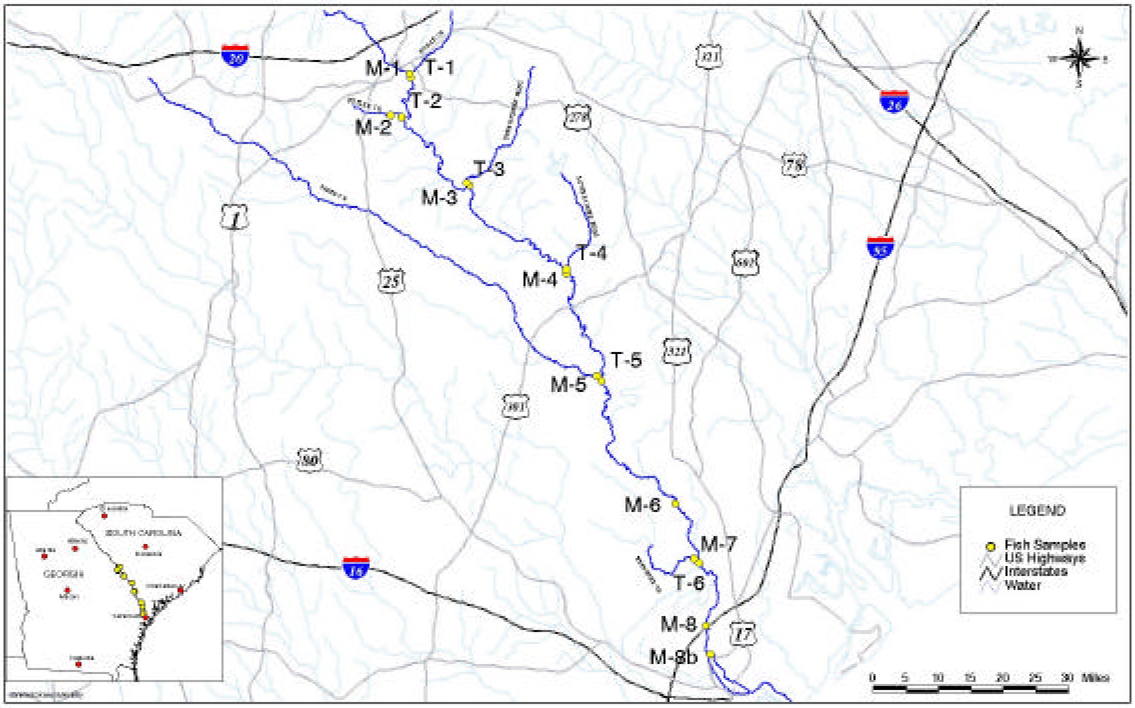

Figure 9 Savannah Watershed Fish Collection Locations

The following sections provide the results of the field sampling for mercury.

6.4.2. Water Column Data

Water column samples were taken to determine the ambient concentration of mercury in the water column using Method 1631, an ultra-trace level clean sampling and analytical technique with a quantification level of 0.5 ng/l. The water column samples were analyzed for both total mercury and methylmercury. Because methylmercury is the primary form of mercury taken up in the food chain, it was important to quantify the fraction of the total mercury in the methyl form. Table 4 provides the measured mercury concentrations in the water column in mainstem and tributaries in the Middle/Lower Savannah watershed.

Table 4 Water Column Mercury Concentrations

ID	Station	Total Hg (ng/l)	MeHg (ng/l)	Percent MeHg
M-0	Savannah River-Below Clark's Hill Dam	0.27	0.02	7.8
M-1	Savannah River-Below Horse Creek	0.68	0.10	14.1
M-2	Savannah River-Below Butler Creek	1.19	0.16	13.1
M-3	Savannah River-Below Upper Three Runs Creek	3.27	0.07	2.0
M-4	Savannah River-Below Lower Three Runs Creek	9.50	0.06	0.6
M-4	Savannah River-Below Lower Three Runs Creek(Filtered)	1.47	0.07	4.4
M-5	Savannah River-Below Brier Creek	2.80	0.09	3.2
M-6	Savannah River-Clyo, USGS Gage	3.28	0.09	2.7
M-7	Savannah River-Below Ebenezer Creek	3.44	0.08	2.2
M-8a	Savannah River-Tide Gate (Freshwater)	4.44	0.09	2.1
M-8a	Savannah River-Tide Gate (Freshwater) (Filtered)	1.00	0.03	3.2
M-8b	Savannah River-Tide Gate (Estuary)	4.09	0.06	1.5
T-1	Horse Creek	6.16	0.24	3.9
T-2	Butler Creek	2.14	0.39	18.2
T-3	Upper Three Runs Creek	5.82	0.16	2.7
T-4	Lower Three Runs Creek	2.43	0.13	5.1
T-5	Brier Creek	2.15	0.11	5.0
T-6	Ebenezer Creek	3.34	0.65	19.5

6.4.3. Sediment Data

Samples of river and tributary sediments were gathered at the same locations as the water samples to determine the amount of mercury associated with the sediments and porewater. This data provides important information that can be used to parameterize the water quality model by providing evidence of the effects of mercury in the sediments on the total mercury water column concentration.

Table 5 Sediment Mercury Concentrations

ID	Station	Total Hg (ng/g)	MeHg (ng/g)	Percent MeHg
M-0	Savannah River-Below Clark's Hill Dam	2.69	0.02	0.6
M-1	Savannah River-Below Horse Creek	10.16	0.00	0.0
M-2	Savannah River-Below Butler Creek	3.09	0.00	0.1
M-3	Savannah River-Below Upper Three Runs Creek	3.18	0.01	0.3
M-4	Savannah River-Below Lower Three Runs Creek	2.98	0.00	0.1
M-5	Savannah River-Below Brier Creek	10.08	0.01	0.1
M-6	Savannah River-Clyo, USGS Gage	2.53	0.12	4.7
M-7	Savannah River-Below Ebenezer Creek	83.36	0.56	0.7
T-1	Horse Creek	19.56	0.03	0.2
T-2	Butler Creek	14.02	0.02	0.1
T-3	Upper Three Runs Creek	3.08	0.00	0.1
T-4	Lower Three Runs Creek	3.13	0.00	0.1
T-5	Brier Creek	3.43	0.00	0.1
T-6	Ebenezer Creek	143.23	0.34	0.2

6.4.4. Watershed Soil Data

Soil samples were collected from the surrounding watershed where the other samples were taken. EPA collected the soil samples to be used in the calibration of the watershed model. Table 6 provides the mercury concentrations associated with soils collected during the summer of 2000.

Table 6 Mercury Concentrations in Soils from Surround Watershed

Station	Percent Dry Wt.	Total Hg (ng/g) Dry Weight	MeHg (ng/g) Dry Weight
Savannah River-Below Clark's Hill Dam	75.7	78.6	0.04
Savannah River-Below Butler Creek	79.1	33.1	0.03
Savannah River-Below Upper Three Runs Creek	82.5	22.7	0.05
Savannah River-Below Lower Three Runs Creek	82.9	56.8	0.00
Savannah River-Below Brier Creek	90.8	43.6	0.26
Savannah River-Clyo, USGS Gage	78.1	71.8	0.95
Savannah River-Below Ebenezer Creek	94.5	33.9	0.01
Butler Creek	97	43.8	0.06

Horse Creek	82.6	43.6	0.01
Upper Three Runs Creek	82.5	56.4	0.01
Lower Three Runs Creek	66.1	137.7	0.54
Brier Creek	84	26.3	0.32
Ebenezer Creek	91.7	28.1	0.11

6.4.5. Fish Tissue Data

Samples of fish were taken from the Savannah River and tributaries within the same area as the water column and sediment samples. Trophic level four fish (largemouth bass) were targeted in the collection because they represent a major portion of the fish size that is caught and kept by anglers and consumed as a source of food, and because Georgia's Fish Consumption Guideline is based on the protection of public health from the consumption of largemouth bass. Trophic level four fish also represent the upper end of the food chain where the biomagnification of mercury would be the highest. The fish fillets obtained during EPA's sampling effort were analyzed for total mercury. Table 7 provides the individual fish data. The fish tissue mercury concentration was used to determine the appropriate interpretation of Georgia's water quality standard for use in the TMDL.

Table 7 Fish Tissue Mercury Data

Location	Type	Total Length (mm)	Wt. lbs.	Total Hg (Wet Weight) (mg/kg)
Below Clark's Hill Dam	LMB	510	3.79	0.40
Below Clark's Hill Dam	LMB	337	1.13	0.12
Below Clark's Hill Dam	LMB	328	1.16	0.26
Below Clark's Hill Dam	LMB	305	0.77	0.15
Below Clark's Hill Dam	LMB	319	0.94	0.32
Horse Creek	LMB	340	1.22	0.12
Horse Creek	LMB	331	1.20	0.29
Horse Creek	LMB	310	0.86	0.14
Horse Creek	LMB	270	0.56	0.30
Horse Creek	LMB	316	0.94	0.48
Below Horse Creek	LMB	329	1.12	0.10
Below Horse Creek	LMB	261	0.57	0.07

Location	Type	Total Length (mm)	Wt. lbs.	Total Hg (Wet Weight) (mg/kg)
Below Horse Creek	LMB	255	0.47	0.08
Below Horse Creek	LMB	218	0.33	0.05
Butler Creek	GP	219	0.17	0.19
Butler Creek	GP	170	0.08	0.45
Butler Creek	GP	220	0.18	0.33
Butler Creek	LMB	232	0.38	0.25
Below Butler Creek	LMB	460	3.13	0.52
Below Butler Creek	LMB	310	0.87	0.24
Below Butler Creek	LMB	288	0.61	0.59
Below Butler Creek	LMB	282	0.79	0.10
Below Butler Creek	LMB	275	0.59	0.13
Upper Three Runs Creek	Bowfin	585	4.21	1.04
Upper Three Runs Creek	Bowfin	589	3.92	0.64
Upper Three Runs Creek	Bowfin	567	3.72	0.54
Upper Three Runs Creek	Bowfin	603	3.91	1.19
Upper Three Runs Creek	Bowfin	505	2.67	0.50
Below Upper Three Runs Creek	LMB	322	0.91	0.16
Below Upper Three Runs Creek	LMB	340	1.03	0.22
Below Upper Three Runs Creek	LMB	280	0.58	0.09
Below Upper Three Runs Creek	LMB	304	0.78	0.28
Below Upper Three Runs Creek	LMB	284	0.61	0.16
Lower Three Runs Creek	Bowfin	624	5.12	1.36
Lower Three Runs Creek	Bowfin	570	3.61	1.14
Lower Three Runs Creek	Bowfin	509	2.45	0.76
Lower Three Runs Creek	Bowfin	588	3.38	1.22
Lower Three Runs Creek	Bowfin	540	3.01	0.95
Below Lower Three Runs Creek	LMB	302	0.76	0.10
Below Lower Three Runs Creek	LMB	401	1.90	0.34
Below Lower Three Runs Creek	LMB	294	0.70	0.15
Below Lower Three Runs Creek	LMB	355	1.41	0.22
Below Lower Three Runs Creek	LMB	273	0.57	0.08
Brier Creek	LMB	290	0.59	0.48
Brier Creek	LMB	263	0.47	0.78

Location	Type	Total Length (mm)	Wt. lbs.	Total Hg (Wet Weight) (mg/kg)
Brier Creek	LMB	255	0.47	0.71
Brier Creek	LMB	235	0.37	0.23
Brier Creek	LMB	214	0.25	0.27
Below Brier Creek	LMB	302	0.76	1.04
Below Brier Creek	LMB	401	1.90	0.33
Below Brier Creek	LMB	294	0.70	0.34
Below Brier Creek	LMB	355	1.41	0.14
Below Brier Creek	LMB	273	0.57	0.23
Clyo, USGS Gage	LMB	477	3.98	1.44
Clyo, USGS Gage	LMB	301	0.83	0.36
Clyo, USGS Gage	LMB	310	0.71	0.51
Clyo, USGS Gage	LMB	295	0.65	0.50
Clyo, USGS Gage	LMB	295	0.69	0.36
Ebenezer Creek	Bowfin	654	2.32	1.02
Ebenezer Creek	Bowfin	545	2.30	2.17
Ebenezer Creek	Chain Pickerel	415	0.98	1.25
Ebenezer Creek	Chain Pickerel	365	0.59	0.82
Ebenezer Creek	LMB	285	0.64	1.08
Below Ebenezer Creek	LMB	325	0.91	0.25
Below Ebenezer Creek	LMB	272	0.56	0.41
Below Ebenezer Creek	LMB	275	0.51	0.40
Below Ebenezer Creek	LMB	465	3.00	1.07
Below Ebenezer Creek	LMB	500	3.94	1.19
Tide Gate (Freshwater)	Bowfin	570	3.96	0.19
Tide Gate (Freshwater)	Bowfin	570	3.94	0.68
Tide Gate (Freshwater)	Bowfin	572	3.94	0.97
Tide Gate (Freshwater)	LMB	260	0.45	0.19
Tide Gate (Freshwater)	LMB	280	0.61	0.21
Tide Gate (Freshwater)	LMB	250	0.42	0.20
Tide Gate (Estuary)	Striper	490	2.98	0.34
Tide Gate (Estuary)	Striper	530	3.71	0.35
Tide Gate (Estuary)	Striper	540	3.94	0.34
Tide Gate (Estuary)	Striper	340	3.29	0.39

Location	Type	Total Length (mm)	Wt. lbs.	Total Hg (Wet Weight) (mg/kg)
Tide Gate (Estuary)	Striper	505	3.10	0.54

7. Model Development

The link between the fish tissue residue concentration and the identified sources of mercury is the basis for the development of the TMDL. The linkage is defined as the cause and effect relationship between the selected indicators, the fish tissue residue concentration and identified sources. This provides the basis for estimating the total assimilative capacity of the river and any needed load reductions. In developing this TMDL, EPA combined models of watershed loading of mercury with a model of mercury cycling and bioaccumulation in the water. This enables a translation between the end-point for the TMDL (expressed as a fish tissue residue concentration of mercury) and the mercury loads to the water. The loading capacity of the River for mercury is then determined by the linkage analysis as a mercury-loading rate that is consistent with meeting the end-point fish tissue residue concentration.

7.1. Watershed Hydrologic and Sediment Loading Model

An analysis of watershed loading could be conducted at various levels of complexity, ranging from a simplistic gross estimate to a dynamic model that captures the detailed runoff from the watershed to the receiving waterbody. The limited amount of data available for the Savannah River watershed prevented EPA from using a detailed dynamic watershed runoff model, which needs a great deal of data for calibration. Instead, EPA determined the mercury contributions to the Savannah River from the surrounding watershed and atmospheric components based on an annual mass balance of mercury in water and sediment loading from the watershed.

Watershed-scale loading of mercury in water and sediment was simulated using the Watershed

Characterization System (WCS) (USEPA, 2001). The complexity of this loading function model falls between that of a detailed simulation model, which attempts a mechanistic, time-dependent representation of pollutant load generation and transport, and simple export coefficient models, which do not represent temporal variability. The WCS provides a mechanistic, simplified simulation of precipitation-driven runoff and sediment delivery, yet is intended to be applicable without calibration. Solids load from runoff can then be used to estimate pollutant delivery to the receiving waterbody from the watershed. This estimate is based on mercury concentrations in wet and dry deposition, which is processed by soils in the watershed and ultimately delivered to the receiving waterbody by runoff, erosion and direct deposition (EPA, November 2000)

7.2. Water Quality Fate and Transport Model

Water Quality Analysis Simulation Program (WASP5) (Ambrose, et al., 1993) was chosen to simulate mercury fate in the Savannah River. WASP5 is a general dynamic mass balance framework for modeling contaminant fate and transport in surface waters. Based on the flexible compartment modeling approach, WASP can be applied in one, two, or three dimensions with advective and dispersive transport between discrete physical compartments, or segments. A body of water is represented in WASP as a series of discrete computational elements or segments. Environmental properties and chemical concentrations are modeled as spatially constant within segments. Each variable is advected and dispersed among water segments, and exchanged with surficial benthic segments by diffusive mixing. Sorbed or particulate fractions may settle through water column segments and deposit to or erode from surficial benthic segments. Within the bed, dissolved variables may migrate downward or upward through percolation and pore water diffusion. Sorbed variables may migrate downward or upward through net sedimentation or erosion.

Two WASP models are provided with WASP5. The toxics WASP model, TOXI5, combines a kinetic structure adapted from EXAMS2 with the WASP5 transport structure and simple sediment balance algorithms to predict dissolved and sorbed chemical concentrations in the bed and overlying waters.

TOXI5 simulates the transport and transformation of one to three chemicals and one to three types of particulate material. The three chemicals may be independent, such as isomers of PCB, or they may be linked with reaction yields, such as a parent compound-daughter product sequence. Each chemical exists as a neutral compound and up to four ionic species. The neutral and ionic species can exist in five phases: dissolved, sorbed to dissolved organic carbon (DOC), and sorbed to each of the three types of solids. Local equilibrium is assumed so that the distribution of the chemical between each of the species and phases is defined by distribution or partition coefficients. The model, then, is composed of up to six systems, three chemical and three solids, for which the general WASP5 mass balance equation is solved.

The WASP model was parameterized to simulate the fate and transport of mercury for the development of this TMDL. Site specific and literature values were used to predict water column concentrations as a function of flow.

8. Total Maximum Daily Load (TMDL)

The TMDL is the total amount of a pollutant that can be assimilated by the receiving waterbody without exceeding the applicable water quality standard, in this case, a numeric interpretation of the State of Georgia's narrative water quality standard for toxic substances of 2.8 nanograms per liter (ng/l). This TMDL determines the maximum load of total mercury that can enter the Savannah River watershed within a year without exceeding 2.8-ng/l total mercury in the water column. (See Section 5 for a discussion of EPA's interpretation of Georgia's water quality standard for this TMDL.)

8.1. Critical Condition Determination

The average annual flow and average annual loading represents the critical conditions for this TMDL. Average annual flow and average annual loading are appropriate for several reasons. First, EPA's human health methodology, which has been used to derive an appropriate numeric interpretation of Georgia's narrative water quality standard for toxic substances for this TMDL, assumes that health effects due to mercury occur as a result of long-term exposure to mercury in fish tissue through consumption of contaminated fish. The bioaccumulation of methylmercury in fish tissue is a long-term, multi-year, process. In fact, the applicable water quality standard as interpreted by EPA in this TMDL is based upon a largemouth bass of 315 millimeters in length, which represents a 3 to 5 year old bass. Therefore, the annual average load is more appropriate than a daily load for representing the long-term processes of bioaccumulation in fish tissue that are associated with the potential for health effects. Second, the State applies their human health criteria at a flow equivalent to the annual average flow (Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6-.03(5)(e)(iv) which requires the application of average annual load in the TMDL.

8.2. Seasonal Variation

Mercury is expected to fluctuate based on the amount and distribution of rainfall, and variable emissions from local and distant atmospheric sources. Since wet deposition is greatest in the spring and winter seasons, loadings of mercury are highest during these seasons. However, these seasonal impacts or other short-term variability in loadings are damped out by the biotic response of bioaccumulation, which as discussed above, is a long-term process. Therefore, seasonal variations are not important in this TMDL, which is expressed as an average annual load.

Methylation of mercury is expected to be highest during the summer because high temperatures and static hydrologic conditions result in hypoxic and/or conditions that promote methylation, and since predator feeding activity is also high during the summer, mercury bioaccumulation is expected to be greatest during the summer. However, based on the refractory nature of mercury, seasonal changes in body burden would be expected to be slight. Inherent variability of mercury concentrations between individual fish of the same and/or different size categories is expected to be greater than seasonal variability.

8.3. Margin of Safety

A Margin of Safety (MOS) is a required component of a TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving waterbody. The MOS is typically incorporated into the conservative assumptions used to develop the TMDL. A MOS is incorporated into this TMDL in a variety of ways. These include:

- Selecting the highest predicted water column concentration of mercury in the entire stretch of river to determine the load reduction needed to achieve Georgia's water quality standard. This approach conservatively assumes that fish are exposed to the highest water column concentration and accounts for uncertainties associated with identifying the precise locations where the fish take in mercury.

- Calculating BAFs from only trophic level four fish. This approach conservatively assumes that the public consumes only largemouth bass. This may be an over-estimate of amount of mercury to which the public is exposed through fish consumption because the typical diet of fish from other trophic levels that do not bioaccumulate mercury to the same degree as trophic level four fish. However, this assumption contributes to the TMDL's margin of safety because it accounts for uncertainties associated with precise fish diet. It also protects members of the public that consume fish from different trophic levels, but at a rate higher than the 17.5 g/day fish consumption rate employed for this TMDL.

- Assigning a 1% load reduction to point sources. While EPA believes that such reductions, considered together with reductions from air sources, are necessary to achieve water quality standards, EPA also recognizes that future studies of mercury emissions from air sources may indicate that water quality standard can be achieved solely by controlling air sources. By assigning a 1% load reduction to point sources, EPA accounts for the possibility that air source reductions are insufficient. Thus, in addition to reflecting what EPA believes today are necessary load reductions from point sources, the 1% reduction helps account for EPA's lack of precise knowledge concerning the relationship between the effects of Clean Air Act controls and water quality.

- Incorporating a number of conservative assumptions in deriving the estimate of anticipated reductions in emissions to the air. These are described in the Analysis of Atmospheric Deposition of Mercury to the Savannah River Watershed (2000). In addition, the resulting estimate does not take into account reductions resulting from voluntary control measures or new regulations. Therefore, reductions from air sources may possible be greater than presently estimated.

9. TMDL Development

In order to establish the maximum annual average load of mercury that be assimilated by the Savannah River and achieve the appropriate water quality standard, interpreted by EPA to be 2.8 ng/l, the watershed loadings of mercury to the River must be integrated with the fate and transport of mercury in the River. As discussed above (Section 8.1.), annual average loads and average annual flows are used as the basis for assessing the current loadings of mercury to the River and to assess the future load reductions of mercury needed to achieve the applicable water quality standard.

9.1. Model Results

Both the Watershed Characterization System (WCS) nonpoint source runoff model and the receiving waterbody model (WASP5) are used to determine the maximum load of mercury that can occur and not exceed the applicable water quality standard of 2.8 ng/l as interpreted by EPA. This section provides detailed information on how the models are applied, how the watershed and waterbody are broken down into segments (computational boxes) and how the mercury is transported throughout the watershed.

9.1.1. Nonpoint Source

The main driving force for the WCS mercury model is the input of the appropriate wet and dry deposition rates for mercury. The wet and dry deposition rates that were used in the WCS model were derived from the RELMAP air deposition model results reported in the Mercury Report to Congress. The RELMAP predictions for both wet and dry deposition were converted to a GIS coverage (Figure 6 and Figure 7) to provide a spatially variable deposition rate for the watershed. The WCS model was used to calculate the total load of mercury entering the mainstem portion of the Savannah River from the sub basins delineated in Figure 3. The predicted annual loads are given in Table 8. For each of the sub basins, the total load is presented in mg/yr, and the percentage of the contribution of mercury from soil/erosion, runoff, direct deposition and impervious soil are presented. The watershed model was calibrated to match the soil concentrations that were measured in the field.

Table 8 Annual Average Total Mercury Load

Sub Watershed	Area (ha)	Total Load mg/yr	Load/ha	% Impr Soil	% Sediment	% Runoff	% Direct Dep	% NPDES
Kiokee	32836.2	1669435.968	17.84	11.77	65.95	13.57	8.71	0
Little Kiokee	10088.81	331540.4058	11.05	31.17	23.49	34.63	10.7	0
Horse	42746.97	5147562.706	41.76	48.53	7.95	35.83	7.68	0
Butler	25390.8	3334875.266	49.68	66.84	7.04	14.13	11.98	0.01
Hollow	29416.43	2526441.021	29.43	37.81	33.08	22.42	6.69	0
Upper Three Runs	56241.64	3329200.071	22.57	58.61	11.55	27.76	2.09	0
Fourmile	8710.13	3595104.186	14.92	60.68	1.25	32.14	5.93	0
Lower Three Runs	46814.15	363748.1273	19.34	34.16	23.6	34.85	19.89	0
Brier Creek, SC	6666.03	2997886.561	22.05	30.02	36.68	29.28	4.02	0
Watchcall	8565.4	440622.7377	19.56	22.18	38.29	34.33	5.19	0
Boggygut	12453.06	513979.5685	15	17.29	47.96	25.32	9.42	0
Newberry	10942.14	566475.2132	18.24	30.34	35.14	20.52	14	0
Steel	18310.91	793120.762	12.03	42.15	1.43	45.59	37.34	0
Beaverdam	12445.57	630715.4352	17.83	41.31	18.39	23.24	16.96	0.1
Sweetwater	15726.24	1025257.81	21.55	18.38	34.82	29.49	17.3	0
Rocky	17327.97	1190980.475	22.3	10.02	51.67	21.94	16.37	0
King	7684.87	483180.7	22.22	12.57	20.19	23.28	43.96	0
McDaniel	7389.59	369119.15	17.92	15.7	15.71	22.93	45.66	0
Dry	10533.89	835142.4918	25.97	19.63	40.85	30.46	9.06	0
Buck	24444.06	1448923.275	20.02	16.76	35.24	26.26	21.73	0
Utchee	42722.19	3836027.353	33.56	57.18	9.71	12.67	20.42	0.02
Spirit	36322.28	1933472.456	19.07	43.43	18.67	21.09	16.39	0.68
McBean	28999.99	2996561.842	15.72	24.1	38.67	25.45	11.78	0
Boggy	18934.66	993640.7169	17.21	21.83	30.71	40.29	7.17	0
Jackson	15552.96	945151.025	20.75	17.3	35.21	21.92	25.57	0
Cypress	23982.3	942136.3707	13.05	22.65	32.07	33.37	11.91	0
Ebenezer	60100.2	1995424.682	11	21.56	24.35	38.82	15.26	0.01
Pipemaker	52092.53	3482463.854	25.96	32.44	2.04	8.72	56.39	1
Lockner	7001.55	209844.6119	10.33	42.03	11.97	38.36	6.88	0.75
Sand	22305.24	618689.0742	9.54	33.85	17.55	34.7	13.9	1.53
Brier Creek, GA	219195.9	9230475.848	10.92	31.01	25.68	36.62	6.68	0

9.1.2. Water Quality Model

The WASP5 toxic chemical program TOXI5 was set up to simulate mercury in the mainstem of the Savannah River. The segments identified in Section 1 comprise the mainstem of the Savannah River for the purposes of this analysis. The mainstem of the river was divided into 31 reaches. Each reach was further divided into 2 vertical compartments representing surface water and surficial sediment. The 2 centimeters (cm) deep surficial sediment layer actively exchanges silt and clay-sized solids as well as chemicals within the water column. In addition, this layer is the site for active microbial transformation reactions. Sediment-water column diffusion coefficients were set at 10^{-5} cm^2/sec. Two classes of solids, sand and silt, were simulated. Sand makes up most of the benthic sediment compartments, which have a dry bulk density of 0.5 g/ml. Given a particle density of 2.7 g/ml, the sediment porosity is about 0.8 and the bulk density is 1.3 g/ml. Silt is found both suspended in the water column and in the sediment. These simulations assumed that 10 mg/L of silt enters the mainstem from the subwatersheds, settling out at an assumed velocity of 0.3 m/day. Silt in the surficial sediment compartments is assumed to resuspend at a velocity of 0.006 m/day, giving a concentration of about 0.005 g/ml, or about 1% of the surficial sediment. The exchanging silt carries sorbed mercury between the water column and surficial sediment. Mercury was simulated as 3 components B elemental mercury, Hg^0; inorganic divalent mercury, Hg(II); and monomethyl mercury, MeHg. Hg(II) and MeHg partition to solids and dissolved organic carbon (DOC). These are represented as equilibrium reactions governed by specified partition coefficients. The three mercury components are also subject to several transformation reactions, including oxidation of Hg^0 in the water column, reduction and methylation of Hg(II) in the water column and sediment layer, and demethylation of MeHg in the water column and sediment layer. These are represented as first-order reactions governed by specified rate constants. Reduction and demethylation are driven by sunlight, and the specified surface rate constants are averaged through the water column assuming a light extinction coefficient (here, 0.5 m^{-1}). In addition to these transformations, Hg^0 is subject to volatile loss from the water column. This reaction is governed by a transfer rate calculated from velocity and depth, and by Henry's Law constant, which was set to 7.1 H 10^{-3}

L-atm/mole-K. Under average flow conditions, velocity ranges from 0.2 to 0.3 m/sec, while depth ranges from 0.37 to 0.69 m. The specified and calculated reaction coefficients used here are summarized in Table 9.

Table 9 Specified and Calculated Reaction Rates and Coefficients

Component	Reaction	Compartment	Coefficient Value
Hg0	Volatilization	Water	1.0 - 3.9 day^{-1} (calc)
	Oxidation	Water	0.0001 day^{-1}
Hg(II)	Reduction	Water	0.010 day^{-1} (surface) 0.074 - 0.090 (calc)
	Methylation	Water	0.0001 day^{-1}
	Methylation	Sediment	0.00002 day^{-1}
	Partitioning to silt	Water, Sediment	4×10^5 L/kg
	Partitioning to sand	Water, Sediment	1×10^4 L/kg
	Partitioning to DOC	Water, Sediment	2×10^4 L/kg
MeHg	Demethylation to Hg(II)	Water Sediment	0.0001 day^{-1} 0.00002 day^{-1}
	Demethylation to Hg0	Water (Photolysis)	0.1 day^{-1} (surface) 0.074 - 0.090 (calc)
	Partitioning to silt	Water, Sediment	4×10^5 L/kg
	Partitioning to sand	Water, Sediment	1×10^3 L/kg
	Partitioning to DOC	Water, Sediment	2×10^5 L/kg

Two separate simulations of mercury in the Savannah River were run representing average flow and drought flow conditions. The average flow simulation was run for 30 years, so that steady-state conditions are achieved in the water and surficial sediment. Drought flow conditions were run for 180 days using the average-flow concentrations as initial conditions. Volumes, depths, and velocities were obtained from the EPDRIV1 hydrodynamic model currently being applied to Savannah River in support of work being conducted by Georgia EPD.

The flows, depths, velocities, and volumes used for average and drought conditions are summarized in Table 10.

Table 10 Flows, Depths, Velocities and Volumes used in WASP Model

River Mile	Segment	Volume (m)	Depth (m)	Velocity (m/sec)	Tributary	Flow (cms)
213	1	2916469	2.33	0.43	Headwater	273.49
203	2	2427977.4	2.52	0.53		
197	3	3737187.3	3.50	0.68		
193	4	5808927.7	6.96	0.27		
190	5	6741527	7.53	0.28	Horse Creek	4.50
186	6	4740424.8	7.44	0.38		
182	7	3374938.1	7.20	0.37		
179	8	2684006.2	5.87	0.61	Butler Creek	0.85
175	9	4041461.1	6.20	0.69	Spirit Creek/Bear Island	2.15
169	10	3085140.2	5.74	0.75	Hollow Creek	2.41
164	11	3806153.5	6.98	0.65		0.00
159	12	3738075.5	5.84	0.65	McBean, Boggy Gut, Newberry	2.83
154	13	2841953.7	6.71	0.66	Upper Three Runs	3.77
150	14	5921744	5.79	0.66	Fourmile Creek	1.10
142	15	7914561.9	5.70	0.65	Beaverdam, Steel Creek	3.34
133	16	9761070	5.57	0.81	Sweetwater, Lower Three Runs	3.99
116	17	6340925.8	5.63	0.70	Brier Creek, SC	1.81
107	18	7804913.5	5.96	0.65	Savannah Watch Call	2.04
96	19	5184161.4	6.95	0.72	Brier Creek, GA	25.57
89	20	3849710.4	7.51	0.67		0.00
84	21	3905226.2	7.21	0.70	Savannah Dry Branch	4.90
79	22	3989054.6	7.20	0.67		0.00
74	23	4086191.3	7.03	0.66		0.00
69	24	3918680.3	7.15	0.73	Boggy Branch	4.39
64	25	4858331.9	7.56	0.61		0.00
59	26	4767405.5	7.70	0.61		0.00
54	27	5109182.5	7.85	0.56		0.00
49	28	4910985.4	7.94	0.55		0.00
44	29	3656800.3	7.84	0.76	Ebenzer, Lockners, Abercorn	12.46
39	30	8558710.5	6.36	0.94		0.00
29	31	10107590	5.73	1.45		0.00

The WCS model calculates mercury loadings to each reach. These values are specified as constant Hg(II) and MeHg loadings for each surface water compartment. Loadings for average flow conditions reflect both wet and dry deposition throughout the watershed, followed by runoff and erosion to the tributary stream network. Loadings for drought flow conditions include only dry deposition (11 ì g/m^2-yr) directly to water surfaces. These loadings to the tributary network are subject to reduction and volatilization losses in transport to the mainstem. Under drought flow conditions, these losses could be very significant due to the long travel times. Average reduction factors were calculated for each tributary inflow using a reduction rate constant of 0.1 day^{-1} along with that subwatershed's flow, water surface area, and assumed depth:

$$reduction\ \ factor = (1 - e^{-k_r \bullet T_{\max}})\ /\ k_r \bullet T_{\max}$$

where k_r is the reduction rate constant in day^{-1} and T_{max} is the travel time for the tributary in days. The travel time is calculated as the total tributary surface area times its average depth divided by its average flow.

Figure 10 compares the model predictions versus what was measured in the field summer of 2000. Because of the severe drought condition in Georgia prior to and during the sample collection, the only loading source of mercury to the watershed was direct deposition on the water. This modeling exercise was done to aid in the parameterization and calibration of the water quality model.

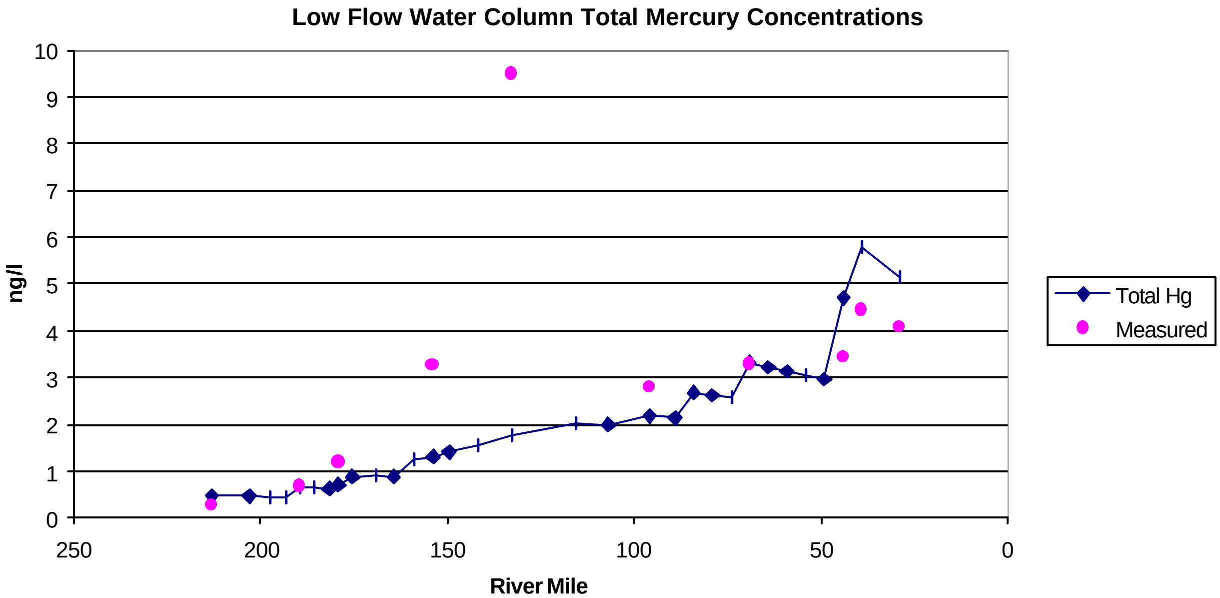

Figure 10 Model Predictions versus Observed Data for the Savannah River for Drought Conditions

Figure 11 provides a comparison of model predicted mercury sediment concentrations versus what was measured in the field.

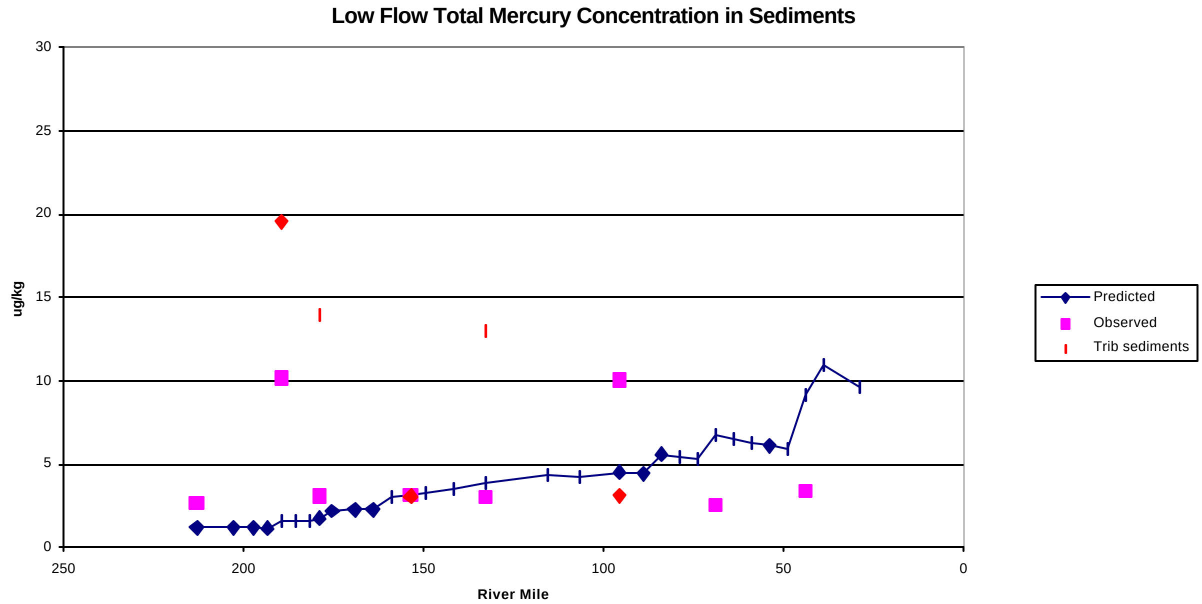

Figure 11 Model Predictions versus Observed Data for Total Mercury in the Sediments during Low Flow

Figure 12 provides the predicted water column concentrations under annual average load and flow for the Savannah River. The highest predicted water column concentration is used in the TMDL calculation to determine the maximum annual average load that could occur and still achieve the applicable water quality standard as interpreted by EPA.

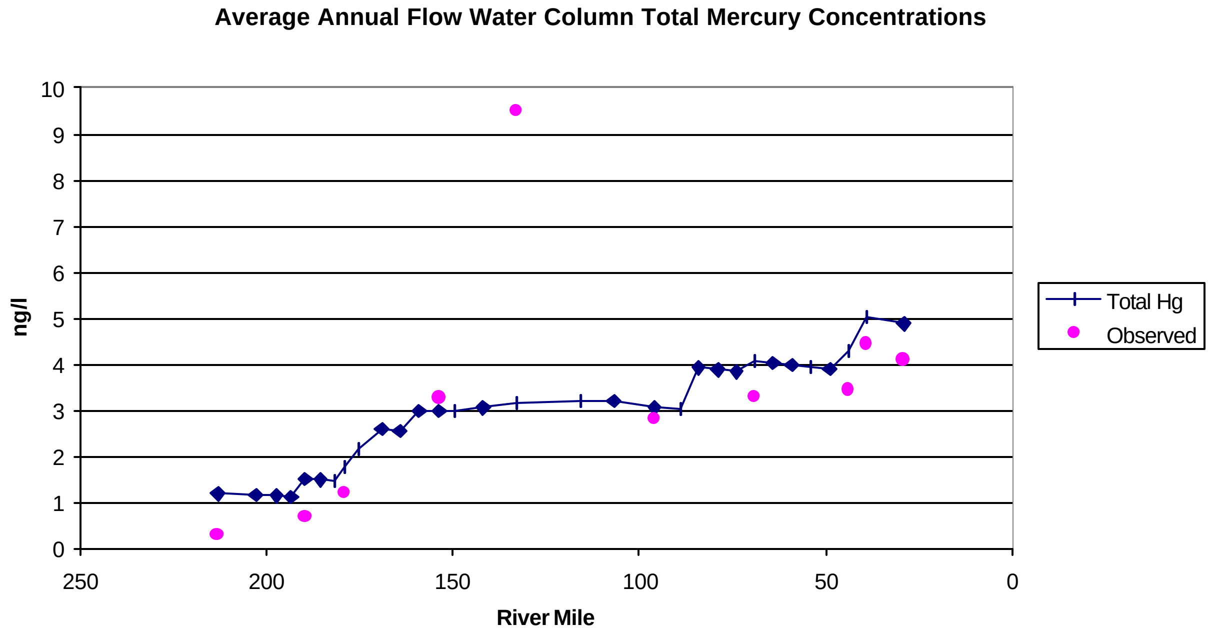

Figure 12 Model Predictions versus Observed Data for the Savannah River for Annual Average Flow

Figure 13 provides a comparison of model predicted mercury sediment concentrations versus what was measured in the field under annual average flow conditions.

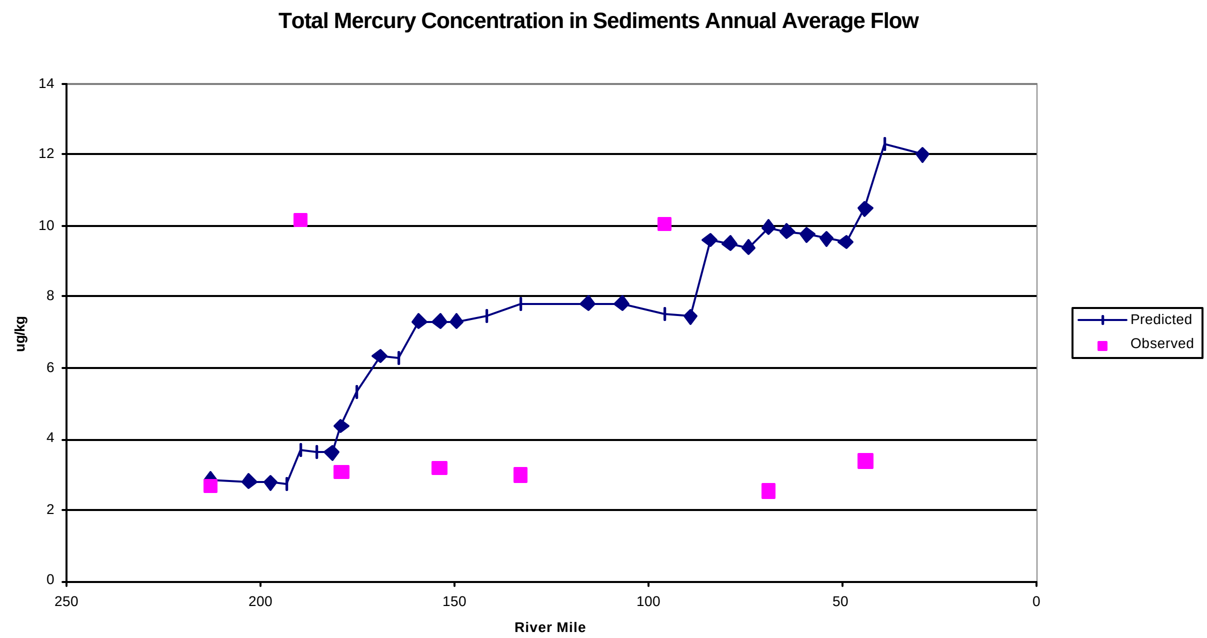

Figure 13 Model Predictions versus Observed Data for Total Mercury in the Sediments Annual Average Flow

9.2. TMDL Determination

To determine the total maximum load that can come into the Savannah River without exceeding the applicable water quality standard of 2.8 ng/l as interpreted by EPA, the current loading conditions are evaluated and the water column concentration in the River is determined using the modeling approach described above. This allows the development of a relationship between mercury loading and water column mercury concentrations in the River. Using this developed relationship, the total maximum load can be determined. Because the water column mercury concentration response is linear with respect to changes in load, a proportion can be developed to calculate the total maximum mercury load from the watershed that would achieve the derived water quality standard of 2.8 ng/l as interpreted by EPA. The TMDL is calculated as given below:

$$\frac{Highest\ Segment\ Concentration}{Current\ Annual\ Average\ Load} \cdot \frac{WQS}{TMDL\ Load}$$

where:

Highest Segment Concentration = 5.0 ng/l
Current Annual Average Load to the Savannah River = 58.8 kilograms/year
Water Quality Standard = 2.8 ng/l as interpreted by EPA

The TMDL Load is calculated as 32.8 kilograms/year total mercury.

10. Allocation of Loads

In a TMDL assessment, the total allowable load is divided and allocated to the various pollutant sources. This allocation is provided as a Load Allocation (LA) to the nonpoint sources, defined in this TMDL as the air sources within the 100-kilometer boundary of the watershed, and as a Wasteload Allocation (WLA) to the point-source facilities in Georgia with a NPDES permit. The difference between the current load and the allowable load is the amount of pollutant reduction the sources need to achieve in order for the waterbody to ultimately achieve the applicable water quality standard of 2.8 ng/l as interpreted by EPA.

The calculated allowable load of mercury that can come into the Savannah River without exceeding the applicable water quality standard of 2.8 ng/l as interpreted by EPA is 32.8 kilograms/year. Because this assessment indicates that 99% of the loading of mercury is from atmospheric sources, 99% of the allowable load will be assigned to the load allocation, and 1% of the available load will be assigned to the wasteload allocation. Therefore, the Load Allocation and Wasteload Allocation for the middle/lower Savannah River are:

Load Allocation (atmospheric sources) = 0.99 (32.8) = 32.5 kilograms/year

Wasteload Allocation (NPDES sources) = 0.01 (32.8) = 0.3 kilograms/year

The estimated current loading of mercury to the Savannah River from the surrounding watershed is 58.8 kilograms/year. This load was determined by adding the predicted mercury load for each of the subwatersheds taking into account delivery times and volatilization that occurs in the tributaries. The difference between the estimated current mercury load (58.8 kg/year) and the calculated allowable load (32.8 kg/year) is 26 kilograms/year. Since 32.8 kg/year is 56% of the estimated current loading of mercury, it is estimated that a 44% reduction in total mercury loading is needed for the middle/lower Savannah River to achieve a water column concentration of 2.8 ng/l.

10.1. Atmospheric Reductions

EPA estimates that approximately 99% of current mercury loadings to the River are from atmospheric deposition; therefore, significant reductions in atmospheric deposition will be necessary if the applicable water quality standard as interpreted by EPA of 2.8 ng/l is to be attained. Based on the total allowable load of 32.8 kilograms per year, a 44% reduction of mercury loading is needed to achieve the applicable water quality standard as interpreted by EPA. An analysis conducted by the EPA Region 4 Air Program (Appendix A) concludes that an estimated 38% to 48% reduction in mercury deposition to the Savannah River watershed can be achieved by 2010. This conclusion was derived using the following methodology:

- The analysis used the results of national atmospheric mercury deposition modeling done for EPA's 1997 *Mercury Study Report to Congress* (referred to as *The Mercury Study*) to estimate the level of mercury deposited to the Savannah River watershed during the baseline period (1994-1996) from local sources (those in the watershed or within 100 km of the watershed), plus national and global sources. The analysis presumes that local sources primarily contribute to the loading by deposition of reactive gaseous mercury (RGM, divalent mercury gas), while national sources (i.e., at a distance >100 km) contribute particle bound mercury, and global sources contribute gaseous elemental mercury.

- The total RGM emitted from local sources was estimated for the baseline period from the emissions data files used to conduct *The Mercury Study* modeling. Local sources include categories such as hospital and medical waste incinerators, municipal waste incinerators, electric utility plants, a chlor-alkali chlorine production facility, and industrial and residential boilers.

- Future RGM emissions for 2010 from local sources were estimated using projected population growth as an indicator of growth in emissions over time, along with calculated reductions in mercury emissions due to MACT and Waste Combustion controls. Then an estimate of RGM deposition to the watershed was calculated for 2010 as proportional to local emissions.

- Combining the RGM value with an estimate of proportional national and global source contributions in 2010 developed the sum total deposition of mercury to the watershed in 2010. Comparison of the total value emitted in 1995/1996 with the total value calculated for emissions in 2010 indicates that a 38% to 48% reduction of mercury deposition is probable over the approximately 15 years from the baseline to 2010, based on currently promulgated standards in the Clean Air Act (MACT and Section 129.)

EPA expects these reductions to be achieved through full implementation of currently promulgated Clean Air Act (CAA) requirements under Section 112(d) Maximum Achievable Control Technology (MACT) and Section 129 Solid Waste Combustion, and Section 111 New Stationary Sources, at sources within the local airshed and nationally. The local airshed is defined in this TMDL to be the area within the watershed and a 100-kilometer boundary around the watershed. Additional reductions may be realized after further implementation of these requirements and other Clean Air Act sections.

The analysis conducted by the EPA Region 4 Air Program in Appendix A provides reasonable assurance that reductions needed in mercury loading can be achieved by reductions in mercury emissions from air sources within the local airshed and nationwide. There are, however, uncertainties in the air deposition analysis that should be recognized and are explained in Appendix A. Some of these uncertainties include the estimates of the amount of the chemical form or species of mercury emitted by each source category; the projected level of reductions from each source category subject to Section 129 or MACT regulations; the definition of local sources contributing deposition to the watershed, the contribution from global sources, and other aspects of the modeling. While it is not possible to quantify the net effect of these factors, EPA believes the assumptions made to address these uncertainties are reasonable and consistent with the state-of-the art mercury modeling available at the time this TMDL was prepared, and that the Agency has reasonable assurance that needed air reductions will be achieved notwithstanding these uncertainties. It is anticipated, however, that additional data and information collected during implementation of this Phase 1 TMDL will allow a more certain analysis of attainable air reductions to be accomplished in the Phase 2 TMDL. EPA will determine at that time whether it is appropriate to revise the load allocation, or the wasteload allocation, to assure that the applicable water quality standard as interpreted by EPA will be achieved.

Future additional reductions in air deposition of mercury, beyond that presented in Appendix A, may occur through the implementation of voluntary programs as well as new CAA regulatory actions being considered by EPA. This TMDL does not currently depend on any additional future reductions beyond those identified in Appendix A. While it is not possible at this time to quantify these anticipated mercury reductions, an estimate of such quantification will be more likely during the Phase 2 TMDL. In December 2000, EPA announced that it intends to begin developing a regulation under CAA Section 112 to limit mercury emissions from coal-fired power plants. A proposal is expected in late 2003 and a final regulation at the end of 2004. As a group, these plants are the largest remaining source of mercury emissions in the United States. It is too early to estimate the reductions in mercury emissions that may result from regulation of electric utilities. In the meantime, we expect to see reduced emissions of mercury from this sector as a number of regulations are implemented to control SO_2 and NO_x, since some control technologies used to limit these pollutants collaterally reduce mercury emissions as well. A review of regulatory and related initiatives to reduce mercury emissions is provided in Appendix A. At this time, the overall, or relative percent, reduction in mercury emissions that may be realized in the future from the variety of activities underway or proposed is uncertain, and estimating such reductions is not appropriate for this TMDL. However, EPA is committed to continuing to track emissions of mercury and evaluate additional ways to reduce releases of mercury to the environment.

10.2. Allocation to NPDES Point Sources

This TMDL estimates that approximately 1% of the current loadings of mercury to the River are from NPDES point sources. For a discussion of EPA's basis for this estimate, see Section 8.2.2. At this time, one NPDES point source in Georgia has a permit to discharge mercury to the Savannah River. This facility is the Olin Corporation located in Augusta (NPDES Permit Number GA0003719). The TMDL also identifies 28 other NPDES point sources in Georgia for a wasteload allocation in this TMDL that Georgia and EPA believe have the potential to discharge significant amounts of mercury in their effluent. Twenty-four of these facilities have been identified because of their volume of flow (greater than 1 million gallons per day) or based on limited effluent data or the fact that they were rated as "major industrial" facilities by the State of Georgia. In making such "major industrial" facility determinations, Georgia takes into account factors such as toxic pollutant potential, public health impacts, and impacts on water quality. Another 4 facilities, considered to be "minor municipal" or "minor industrial" facilities, are also identified in the TMDL for a wasteload allocation. Data collected by EPA at these facilities in August 2000, indicate mercury concentrations in the facility's effluent above the applicable water quality standard as interpreted by EPA of 2.8 ng/l. EPA believes it is reasonable to assume that mercury is present in the discharge of these 29 NPDES permittees because of the persistent nature of mercury, and its pervasive presence in the environment, including rainwater. Table 11 (below) provides the list of NPDES facilities in Georgia that are provided a wasteload allocation in this TMDL.

There are approximately 50 other NPDES permitted facilities in Georgia located within the watershed. (See Appendix B for a list of all NPDES facilities in the watershed of the middle and lower Savannah River Basin provided to EPA by the Georgia Environmental Protection Division.) The TMDL does not provide a specific wasteload allocation to these facilities since they discharge less than 1 million gallons per day, or are considered "minor industrial" facilities. EPA assumes that these facilities are discharging mercury in concentrations below the 2.8-ng/l applicable water quality standard as interpreted by EPA, or are not adding concentrations of mercury above that in their source water. These facilities have a smaller flow rate (compared to the facilities identified above), and they are considered by the State of Georgia to be "minor municipal" or "minor industrial" facilities based on the factors set forth above (a "minor municipal" facility has flow less than 1 million gallons pre day). As the new more sensitive EPA Method 1631 mercury analytical procedure is implemented in the NPDES program these "minor" facilities must verify through monitoring whether or not they are significant contributors of mercury (State of Georgia Rules and Regulations for Water Quality Control, April 2000, Chapter 391-3-6-.06, and January 1995 Reasonable Potential Procedures). EPA can consider this information in the revision of the TMDL in 2004, and will establish a wasteload allocation for any facilities for which data demonstrates mercury is present in their effluent at levels above the amount present in their source water.

In order to achieve the water quality standard as interpreted by EPA for mercury in the Savannah River, EPA has assigned to all NPDES point sources in the basin a cumulative wasteload allocation of 0.3 kg/year. For each of the 29 facilities identified as potential significant contributors of mercury, EPA is providing a specific wasteload allocation (WLA). This WLA is expressed in two different forms. The first is described as Option A below, and the second is described as Option B. The NPDES permitting authority is authorized by this TMDL to apply either option to the NPDES point sources affected by this TMDL. In the context of this TMDL, EPA believes it is reasonable to offer this choice to the permitting authority for the following reasons. First, based on EPA's analysis, either wasteload allocation option, in the aggregate, is expected to result in point source mercury loadings less than the cumulative wasteload allocation. Second, EPA believes this flexibility is the best way of ensuring that the necessary load reductions are achieved without causing significant social and economic disruption. EPA recognizes that NPDES point sources contribute only a small share of the total mercury contributions to the Savannah River. However, EPA also recognizes that mercury is a highly dangerous pollutant that can bioaccumulate in fish tissue at levels harmful to human health. Therefore, EPA has determined, as a matter of policy, that NDPES point sources known to discharge mercury at levels above the amount present in their source water should reduce their loadings of mercury using appropriate, cost-effective mercury minimization measure in order to ensure that the total point source discharges are at a level equal to or less than the cumulative wasteload allocation specified in this TMDL. The point sources' WLA will be applied to the increment of mercury in their discharge that is above the amount of mercury in their source water. For further discussion of the legal and policy rationale underlying these wasteload allocations, see the Response to Comments. EPA recommends that the permitting authority make this choice between Option A and Option B in consultation with the affected discharger because EPA is not able to make the case-by-case judgments in this TMDL that EPA believes are appropriate.

<u>Option A: Criteria end-of-pipe</u>

Under Option A, the wasteload allocation is equivalent to applying Georgia's water quality standard as interpreted by EPA to the discharger's effluent at the outfall point. For this TMDL, EPA has interpreted Georgia's water quality standard to be 2.8 ng/l. Therefore, under this option, the wasteload allocation for each NPDES point source identified in this TMDL would be the product of multiplying 2.8 ng/l by the permitted or design flow rate of each identified NPDES point source. The result would be the maximum mass loading of mercury from that point source. The sum of these individual wasteload allocations is 0.001 kg/year, which is significantly less than the 0.3 kg/year cumulative wasteload allocation provided to all NPDES facilities. Under Option A, the individual wasteload allocations for each NPDES point source affected by this TMDL are provided in Table 11.

Table 11 NPDES Permitted Facilities and Assigned Wasteload Allocation at 2.8 ng/l

Major Municipal	NPDES ID	MGD	Kg/Yr
Augusta – Butler Creek	GA0037621	46.1	1.78E-04
Columbia County – Crawford Creek	GA0031984	1.5	5.81E-06
Columbia County – Reed Creek	GA0031992	4.6	1.78E-05

Columbia County – Little River	GA0047775	1.5	5.81E-06
Garden City WPCP	GA0031038	2	7.74E-06
Richmond County – Spirit Creek	GA0047147	2.24	8.67E-06
Savannah Crossroads (proposed facility)	GA0038326	1.2	4.64E-06
Savannah - President Street	GA0025348	27	1.04E-04
Savannah -Wilshire/Windsor	GA0020443	4.5	1.74E-05
Savannah Travis Field	GA0020427	1	3.87E-06
Sylvania WPCP	GA0021385	1	3.87E-06
Tybee Island	GA0020061	1	3.87E-06
Waynesboro	GA0020231	2	7.74E-06
Major Industrial/Federal			
DSM Chemicals Augusta Inc	GA0002160	3.765	1.46E-05
Fort James	GA0046973	18	6.97E-05
Georgia Power Vogtle	GA0026786	7.2	2.79E-05
International Paper Company	GA0002801	58.6	2.27E-04
Kemira	GA0003646	23	8.90E-05
PCS Nitrogen Fertilizer L.P.	GA0002071	1.152	4.46E-06
PCS Nitrogen Fertilizer LP	GA0002356	0.362	1.40E-06
Savannah Electric Effingham	GA0003883	108	4.18E-04
Stone Container	GA0002798	4.86	1.88E-05
Union Camp Corporation	GA0001988	28.09	1.09E-04
USA Fort Gordon	GA0003484	1.921	7.43E-06
USA Hunter AFB STP	GA0027588	0.544	2.11E-06
Significant Municipal Minors			
DHR Gracewood School Rec WPCP	GA0047279	0.5	1.94E-06
DHR Gracewood Hospital	GA0022161	0.003	1.16E-08
Significant Industrial Minors			
Olin Corporation Augusta	GA0003719	1.246	4.82E-06
Citgo Asphault	GA0004332	0.054	2.09E-07

Option B: Mercury characterization or minimization

Under Option B, the individual wasteload allocations are equivalent to the level of mercury in a point source's effluent after implementation, when appropriate, of cost-effective and appropriate mercury minimization measures. EPA assumes that feasible/achievable mercury load reductions resulting from the mercury minimization efforts will, as a cumulative amount of all 29 facilities, result in a total loading of less than 0.3 kg/year. This assumption is based on information indicating wastewater treatment plants, which account for about 50% of the affected facilities, can attain significant mercury reductions through source reduction efforts. The effectiveness of mercury minimization efforts at industrial facilities is highly facility-specific; however, significant reductions may be attained through product substitution and other measures

(See Mercury Report to Congress, 1997, Section 4, and Overview of Pollution Prevention Approaches at POTW's, EPA 1999). If the cumulative effects of mercury minimization planning efforts are shown during the Phase 2 TMDL evaluation in 2004 not to be less than the cumulative 0.3 kg/yr wasteload allocation, EPA will provide a specific wasteload allocation to each facility to assure that the cumulative wasteload allocation will be attained.

Option B has a variety of different components that apply depending on whether the point source currently has a water quality-based effluent limitation for mercury in its NPDES permit. Affected NPDES permits would need to incorporate permit conditions or limitations as follows in order to be consistent with the assumptions of this TMDL. See 40 C.F.R. § 122.44(d)(1)(vii)(B).

For the NPDES facility in Georgia with a current permit limit for mercury (Olin Corporation, NPDES Permit Number GA0003719), this TMDL assumes that the permit will include:

- a numeric water quality-based effluent limitation for mercury that is identical to its current water quality-based limit for mercury;
- a requirement to monitor for mercury using the version of EPA Method 1631 then in effect;
- a requirement to expeditiously develop a mercury minimization plan;
- a requirement to implement appropriate cost-effective mercury minimization measures identified through mercury minimization planning; and
- following completion of the mercury minimization plan, a numeric effluent limitation for mercury will be established in the permit that reflects the achievable level of mercury in the discharger's effluent upon implementation of appropriate, cost-effective minimization measures.

For NPDES facilities in Georgia identified in Table 11 (except for Olin Corporation, NPDES Permit Number GA0003719) this TMDL assumes that the permits will includes:

- a requirement to characterize the effluent using the version of EPA Method 1631 then in effect in order to quantify the amount of mercury present in the influent and effluent, if any;

- a requirement to develop a mercury minimization plan if the monitoring data shows mercury is present in their effluent at levels greater than in their influent or source water, and the effluent concentration exceeds 2.8 ng/l).

- a requirement to implement appropriate cost-effective mercury minimization measures identified through mercury minimization planning if the monitoring data shows that an increased amount of mercury is present in the final effluent (as described above).

While this TMDL assumes that the State of Georgia, as the permitting authority, will determine the necessary elements of a mercury characterization/ minimization study plan, EPA would expect the plan(s) to have elements similar to the following: (1) influent/effluent monitoring with sufficient frequency to determine variability and to identify if an increased amount of mercury is present. If the facility's discharge is shown to result in an increased amount of mercury, the plan should also include the following additional elements: (2) the identification and evaluation of current and potential mercury sources; (3) monitoring to confirm current/potential sources of mercury; (3) the identification of potential methods for reducing/eliminating mercury, including housekeeping practices, material substitution, process modifications, materials recovery, spill control & collection, waste recycling, pretreatment, public education, laboratory practices, and disposal practices, and the evaluation of the feasibility of implementation; (4) implementation of cost-effective and appropriate minimization measures identified in the plan; and (5) monitoring to verify the results of waste minimization efforts. In addition, EPA expects the permit to establish a reasonable schedule for the implementation of each element and to require appropriate progress reports.

This TMDL accords the permitting authority a certain amount of discretion in incorporating these wasteload allocations into NPDES permits. The permitting authority is free to determine the appropriate frequency, duration and location of monitoring associated with the mercury characterization component of the wasteload allocation. The permitting authority also has the discretion to determine the level of oversight in connection with the development of mercury minimization plans and the discharger's choice of appropriate, cost-effective measures to implement. EPA believes that each of these decisions is heavily fact-dependant and that the permitting authority is in a better position than EPA to make them.

As discussed below, this TMDL assumes that point sources will not be authorized to discharge mercury above current effluent levels. Option B is predicated on the judgment that the 0.3 mg/year cumulative wasteload allocation will be achieved by applying waste minimization measures to current point source effluent conditions. Allowing an increase in current effluent loadings of mercury could undercut the assumptions upon which this TMDL is based unless the permitting authority can demonstrate that any such increase is offset by decreases of mercury from other point source(s) so that the cumulative wasteload allocation of 0.3 kg/year is not exceeded.

EPA recognizes that the State of Georgia's regulations authorize compliance schedules for water quality-based effluent limitations and conditions once those requirements are imposed in NPDES permits. See Rules and Regulations for Water Quality Control, Chapter 391-3-6-.06(10). Under these regulations, the Director of EPD is authorized to establish as a compliance deadline the date that he or she determines to be "the shortest reasonable period of time necessary to achieve such compliance, but in no case later that an applicable statutory deadline." Because there is no applicable statutory deadline relating to the achievement of these WLA-based limitations, point sources affected by this TMDL may be eligible for compliance schedules under this provision of Georgia's regulations. This TMDL assumes that the permitting authority will establish the shortest reasonable period of time for compliance with permit limitations and conditions based on this TMDL. This TMDL also recognizes, however, that the permitting authority is in the best position to determine the timing of mercury characterization and the compliance schedules for developing and implementing mercury minimization plans.

Regarding the compliance schedules in permits to meet permit limitations and conditions based on Option B, EPA makes the following observations. First, EPA believes that a point source with a flow of under 5 million gallons per day can develop a detailed mercury minimization plan within three to six months after the mercury characterization phase is completed and it has been determined that a minimization plan is requires. Point sources with a larger flow could develop a plan within about six to 12 months. Second, prompt characterization of the point sources' mercury discharges will assist EPA in determining whether it is necessary to revise the TMDL in the near future. Any unnecessary delay in obtaining this information could interfere with that effort. Third, with respect to implementation of appropriate, cost-effective mercury minimization measures, EPA believes that the permitting authority is in the best position to determine what constitutes "the shortest reasonable period of time for compliance." EPA recognizes that the implementation of mercury minimization measures can take several years, especially when they involve small, diffuse sources discharging mercury to Publicly Owned Treatment Works (POTWs).

Other Assumptions Incorporated into this TMDL.

The wasteload allocation component of this TMDL reflects the following additional assumptions:

- The permitting authority may write permit conditions that allow the discharge of mercury at levels equal to the amount of mercury in the facility's intake water (from the Savannah River or its tributaries), stormwater, and/or water drawn from the public water supply. If the permitting authority determines that mercury is present in the final effluent at levels above that level present in the influent, the permitting authority will establish permit limits consistent either Option A or Option B of this WLA. The permitting authority also should consider whether any increased mercury concentration in such discharges present potential for violation of an applicable acute standard for mercury, and include appropriate limits to protect against such violations.

- No NPDES point source will be authorized to increase its mass loadings of mercury above levels reflected in current water quality-based effluent limitations or current effluent quality, whichever is lower (in the case of facilities with such limitations) or current effluent quality (in the case of facilities subject to mercury characterization requirements).

- The permitting authority will establish the shortest reasonable period of time for compliance with permit limitations and conditions based on this TMDL.

- The State of Georgia will require those facilities rated as “minor municipal” and “minor industrial” facilities to monitor for mercury using the version of EPA Method 1631 then in effect to verify whether or not they have a added mercury. (State of Georgia Rules and Regulations for Water Quality Control, April 2000, Chapter 391-3-6-.06, and January 1995 Reasonable Potential Procedures).

This TMDL incorporates wasteload load allocations in the form of Option B only because each of the following factors is present:

- this TMDL addresses mercury, which EPA believes is best handled at these levels through waste minimization rather than through end-of-pipe treatment;

- the NPDES point sources, in the aggregate contribute only 1% of the total current mercury loadings to the Savannah River;

- EPA has reasonable assurance that implementation of pollution controls required under current law will result in reductions sufficient to achieve the load allocation of 32.5 kg/year assigned to air sources, thus authorizing a cumulative wasteload allocation of 0.3 kg/year.

- if the Savannah River were currently attaining water quality standards, mercury discharges from the identified NPDES point sources at levels equivalent to the cumulative wasteload allocation of 0.3 kg/year would not cause or contribute to an exceedance of applicable water quality standards for mercury as interpreted by EPA in the River; and

- the recent adoption of EPA Method 1631 Revision B makes it difficult for EPA to state with certainty how many of the point sources identified in this TMDL actually discharge a net addition of mercury at levels exceeding 2.8 ng/l. Under these circumstances, waste characterization is a reasonable first step.

10.3. State and Federal Responsibility

EPA intends to undertake the following responsibilities under this TMDL:

1. Review "major" NPDES permits and other identified "minor" NPDES permits for facilities located in the watershed of the segments of the Savannah River that are covered by this Phase 1 TMDL;

2. Take the lead on further characterization of air sources; and

3. Take the lead on revising the TMDL.

EPA expects Georgia to undertake the following responsibilities:

1. Identify the "major" NPDES facilities affected by this TMDL;

2. Identify other NPDES "minor" facilities affected by this TMDL which have the potential for a significant concentration of mercury in their effluent;

3. Modify the NPDES permits for the facilities identified in 1 and 2 above to reflect the conditions as identified in Section 10.2.;

4. Determine the frequency and duration of the mercury characterization to be undertaken by the facilities identified in 1 and 2 above;

5. Determine the due date and objectives for the mercury minimization plan to be developed by the facilities in 1 and 2 above that are shown to be discharging mercury in excess of 2.8 nanograms/liter through the mercury characterization effort in 4 above;

6. Review the mercury minimization plans and determine the plan's acceptability as identified in 5 above;

7. Assure that mercury minimization plans are implemented as expeditiously as practicable; and

8. Adopt numeric water quality criteria for mercury for protection of public health in accordance with 40 C.F.R. §131.11(b).

11. Assumptions with Respect to Loadings from South Carolina

This TMDL reflects EPA's assumption that concentrations of mercury in the South Carolina portion of the Savannah River will meet the applicable Georgia water quality standards at the South Carolina-Georgia border. The water quality standard that applies to this TMDL is Georgia's narrative water quality criterion for toxics, which provides that Georgia waters shall be free from toxic substances in amounts harmful to humans. EPA has interpreted that standard as 2.8 ng/l. As a technical matter, meeting Georgia's standard at the border is important because there is no hydrological difference between the South Carolina and Georgia portions of the Savannah River. Moreover, the fish travel freely across the border; they may be exposed to mercury in South Carolina, but be consumed by individuals in Georgia. Therefore, an important assumption of this TMDL is that concentrations of mercury at the Georgia/South Carolina border will not exceed 2.8 ng/l.

EPA believes that this assumption is reasonable because the TMDL already takes into account substantial reductions from South Carolina air sources located within the Savannah River watershed and within a 100 km radius of the watershed. The TMDL's gross load allocation to air sources also already accounts for emissions that EPA expects to remain from South Carolina air sources after application of air pollution controls. In addition, with respect to NPDES point sources in South Carolina, EPA believes that loadings from South Carolina can meet Georgia's water quality standard as interpreted by EPA for mercury at the border if South Carolina employs either of the two-wasteload allocation approaches discussed above for Georgia NPDES point sources. This TMDL expressly assumes that limitations on South Carolina point sources that reflect either approach will meet the requirements of 40 C.F.R. § 122.4(d), which states that South Carolina may not issue an NPDES permit unless it includes conditions that ensure compliance with Georgia's water quality standards. For a discussion of the bases for EPA's assumption, see the Response to Comments.

12. Appendix A

Appendix-A Savannah River Hg TMDL.PDF

Appendix B – List of NPDES Facilities in Middle/Lower Savannah Basin

Facility	NPDES Permit #	County
A&M Products Inc.	GA0036811	Jefferson
Air Liquid America	GA0046230	Chatham
Albion Kaolin Company	GA0002470	Richmond
Atlantic Wood Ind.	GA0047783	Chatham
Augusta Butler Creek	GA0037621	Richmond
Budget Inn Savannah	GA0034096	Chatham
Central of Georgia R/R	GA0002381	Chatham
Citgo Asphalt Refining Co.	GA0004332	Chatham
Coastal Water & Sewer Co.	GA02-234	Effingham
Columbia Co. Crawford	GA0031984	Columbia
Columbia Co. Detention Center	GA02-002	Columbia
Columbia Co. Health Dept.	GA0049735	Columbia
Columbia Co. Little River	GA0047775	Columbia
Columbia Co. Reed	GA0031992	Columbia
Crawford Eastside WPCP	GA0033693	Oglethorpe
CSR Aggregates Richmond	GA0037231	Richmond
Dearing LAS	GA02-007	McDuffie
DHR Gracewood Hospital	GA0022161	Richmond
DHR Gracewood Sch. WPCP	GA0047279	Columbia
DIT SRA#112/I-75 Visitor	GA0033278	Chatham
DIT Sylvania Welcome Stat	GA0030287	Screven
DOT Rest Areas #62 & #63	GA0047325	Columbia
DSM Chemicals Augusta, Inc.	GA0002160	Richmond
E.M. Industries Inc.	GA0034355	Chatham
ECC International Wrens	GA0048101	Jefferson
Effingham Elem School	GA0046990	Effingham
Engelhard Corp Chatham	GA0048330	Chatham
Fort James Company	GA0046973	Effingham
GAF Corporation Savannah Plant	GA0003841	Chatham
Garden City WPCP	GA0031038	Chatham
Georgia Pacific Corp.	GA0047007	Chatham
Georgia Pacific Gypsum	GA0001961	Chatham
Georgia Power Vogtle	GA0026786	Burke
Grovetown LAS	GA02-222	Columbia
Gulfstream Aerospace Corp	GA0003255	Chatham
Harlem WPCP	GA0020389	Columbia
Hephzibah WPCP	GA0049433	Richmond
Hercules	GA0026867	Chatham
Herty Foundation Savannah	GA0002402	Chatham
Hiltonia LAS	GA02-033	Screven
Intermarine USA	GA0003671	Chatham
International Paper Co.	GA0037711	Burke
International Paper Co.	GA0002801	Richmond
Kemira	GA0003646	Chatham
King Division of Spartan Mills	GA0004049	Richmond
Martin Marietta Aggr.	GA0002909	Richmond
Martin Marietta Matl Inc	GA0037346	Columbia

Olin Corporation Augusta	GA0003719	Richmond
PCS Nitrogen Fertilizer LP	GA0002071	Richmond
PCS Nitrogen Fertilizer LP	GA0002356	Chatham
Peridot Chemicals	GA0002925	Richmond
Pooler/Bloomingdale Req	GA0047066	Chatham
Richmond Co Spirit Cr.	GA0047147	Richmond
Rincon	GA0046442	Effingham
Sardis WPCP	GA0020893	Burke
Savannah Elec Effingham	GA0003883	Effingham
Savannah Elec Riverside	GA0003751	Chatham
Savannah Elec Wentworth	GA0003816	Chatham
Savannah Electric & Power Co	GA0047708	Chatham
Savannah President St	GA0025348	Chatham
Savannah Sugar Refinery	GA0003611	Chatham
Savannah Travis Field	GA0020427	Chatham
Savannah Wilshire/Windsor	GA0020443	Chatham
Savannah Yacht Club	GA0033189	Chatham
Solutia Inc	GA0002178	Richmond
South Carolina Electric	GA0003786	Richmon
Southern Aggregates Columbia	GA0036790	Columbia
Southern States Phosphorous & Fert	GA0002437	Chatham
Springfield	GA0020770	Effingham
Stone Container Corp	GA0002798	Chatham
Sylvania Yarns Systems Inc	WQ-IP-047	Screven
Thermal Ceramics Inc	GA0002488	Richmond
Thiel Kaolin Hobbs	GA0032981	Warrant
Tybee Island	GA0020061	Chatham
Union Camp Corporation	GA0001988	Chatham
USA Ft. Gordon	GA0003484	Richmond
USA Hunter AFB STP	GA0027588	Chatham
Waynesboro WPCP	GA0020231	Burke
Wrens WPCP	GA0021857	Jefferson

13. References

Ambrose Jr R.B., Wool, T.A., and Martin J.L. (1993) *WASP%, A Hydrodynamic and Water Quality Model – Model Theory, User's Manual, and Programmer's Guide*. U.S. Environmental Protection Agency. Environmental Research Laboratory, Athens, Georgia. EPA/600/3-87/039.

Balogh, S. and L. Liang. 1995. Mercury pathways in municipal wastewater treatment plants. Water Air and Soil Pollution 80: 1181-1190.

Bodaly, R.A., J.W.M. Rudd, and R.J. Flett. 1998. Effect of urban sewage treatment on total and methyl mercury concentrations in effluents. Biogeochemistry 40: 279-291.

Dvonch, J.T., J.R. Graney, G.J. Keeler, and R.K. Stevens. 1999. Use of Elemental Tracers to Source Apportion Mercury in South Florida Precipitation. *Environ. Sci.Technol.* 1999, *33*, 4522-4527.

Georgia Department of Natural Resources. 2000. Guidelines for Eating Fish from Georgia Waters.

Mugan, T. J.. 1996. Quantification of total mercury discharges from publicly owned treatment works to Wisconsin surface waters. Water Environment Research 68(2): 229-234.

Tsiros, I.X. and Ambrose, R.B., 1998. Environmental Screening Modeling of Mercury in the Upper Everglades of South Florida. Journal of Environmental Science and Health, A33(4), 497-525.

USEPA. 1997. Capsule Report. Aqueous Mercury Treatment. EPA/625/R-97/004

USEPA. 2000. EPA's 2000 Revisions to the Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (65 FR 66444-66482) (11/3/200)

USEPA. Office of Research and Development. Technology Transfer. Washington, DC.

USEPA. 1997. Mercury Study Report to Congress. EPA-452/R-97-003. Office of Air Quality, Planning and Standards. Office of Research and Development. Washington, DC.

USEPA. 1998. Better Assessment Science Integrating Point and Nonpoint Sources, BASINS, *Version 2.0 User' s Manua*l. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

USEPA. 1986. *Quality Criteria for Water 1986.* U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

USEPA. Region 4. 2000. Savannah River Mercury TMDL Data Report. U.S. Environmental Protection Agency, Region 4, Atlanta, Georgia.

USEPA. Region 4. 2001. Watershed Characterization System – User's Manual. U.S. Environmental Protection Agency, Region 4, Atlanta, Georgia.

USEPA, 2000. Water Quality Criteria for Protection of Human Health: Methylmercury,

USEPA. 1999. Method 1631. Mercury in water by oxidation, purge and trap, and cold vapor atomic fluorescence spectrometry. USEPA, Office of Water, Office of Science and Technology, Washington, D.C.

USEPA, 2001. Consumption Advisory: Advice for Women & children on Non-commercial Fish Caught by Family and Friends.

USEPA. 1996. Method 1669. Sampling ambient water for trace metals at EPA water quality criteria levels. USEPA, Office of Water, Washington, D.C.

USEPA. 1998. Method 1630. Methyl mercury in water by distillation, aqueous methylation, purge and trap, and cold vapor atomic fluorescence spectrometry. USEPA, Office of Water, Office of Science and Technology, Washington, D.C

Western Lake Superior Sanitary District. Blueprint for Mercury Elimination. World Wide Web URL: http://www.wlssd.duluth.mn.us. Accessed on 2001 February 12.