TOTAL MAXIMUM DAILY LOAD (TMDL) DEVELOPMENT

For

Total Mercury

in

Kinchafoonee Creek

(Flint River Watershed)

United States Environmental Protection Agency

Region 4 serving the southeast

In compliance with the provisions of the Federal Clean Water Act, 33 U.S.C §1251 et.seq., as amended by the Water Quality Act of 1987, P.L. 400-4, the U.S Environmental Protection Agency is hereby establishing a Total Maximum Daily Load (TMDL) for Mercury for Kinchafoonee Creek. Subsequent actions must be consistent with this TMDL.

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James D. Giattina, Director Date

Water Management Division

Table of Contents

Table of Figures

Table of Tables

TOTAL MAXIMUM DAILY LOAD (TMDL)

Total Mercury in Fish Tissue Residue

In the

In Kinchafoonee Creek 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 Kinchafoonee Creek in the Flint River basin, Georgia:

Kinchafoonee Creek

The calculated allowable load of mercury that may come into the identified segment of Kinchafoonee Creek without exceeding the applicable water quality standard is 1.68 kilograms per year. The applicable water quality standard is the State of Georgia's numeric interpretation of their narrative water quality standard for protection of human health from toxic substances. This interpretation provides that total mercury in Kinchafoonee Creek shall not exceed that level that will result in more than 0.3 mg/kg mercury in fish tissue residue.

1. Introduction

The U.S. Environmental Protection Agency (EPA) Region 4 is establishing this Total Maximum Daily Load (TMDL) for total mercury for Kinchafoonee Creek.

- Kinchafoonee Creek to confluence of the Flint River

This creek is listed on the State of Georgia's 2002 Section 303(d) list of impaired waters because mercury in certain species of fish tissue exceeds the Georgia Department of Natural Resources (GDNR) Fish Consumption Guidelines State's guidelines.

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, and the unrestricted use of the identified segment 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 Kinchafoonee Creek watershed.

2. Phased Approach to the TMDL

EPA recognizes that it may be appropriate to revise this TMDL based on information gathered and analyses performed after August 2002. 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 segment of the Kinchafoonee

Creek, if necessary, in 2012. The phased approach is appropriate for this TMDL because information on the actual contributions of mercury to the Flint River Basin from both point and nonpoint sources will be much better characterized in the future.

2.1. Phased Approach to Atmospheric Sources

The impairment of Kinchafoonee Creek is by mercury, largely due to the deposition of mercury from the atmosphere. This TMDL estimates that over 99 percent of the pollutant loads to the waterbodies come from the atmosphere (Section 6.1). An analysis of atmospheric deposition to the Upper Flint 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 Kinchafoonee Creek 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, less than 1 percent, of the mercury loading into Kinchafoonee Creek is due to discharges from water point sources (e.g., pipes) into the Kinchafoonee Creek 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 Kinchafoonee Creek 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 Kinchafoonee Creek 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. Also, EPA is currently developing legislation to establish additional controls on multiple air pollutants, including mercury, from electric utilities. EPA anticipates that this process will produce reductions in the atmospheric deposition of mercury that will enable achievement of water quality standards.

2.2. 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 Middle Georgia 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 Kinchafoonee Creek. This will allow EPA, as appropriate, to refine wasteload allocations provided in the TMDL.

Because the impairment of Kinchafoonee Creek 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 waterbodies. 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:

- 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 ten years to revise the Phase 1 TMDL, as necessary, to assure 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 Kinchafoonee Creek Basin will be reissued in 2013. Therefore, EPA intends to revise the TMDL one year prior to reissuance of permits in the Kinchafoonee Creek Basin.

3. Problem Definition

Kinchafoonee Creek is on the State of Georgia's 2002 Section 303(d) list. Kinchafoonee Creek is listed because mercury in the tissue of largemouth bass, yellow bullhead, spotted sucker and chain pickerel exceeded 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 of 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 of 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 Kinchafoonee Creek: yellow bullhead, chain pickerel, and bass (once a month), suckers (once a week).

The methodology used by the State of Georgia in the development of the fish consumption guidelines targets specific species and size of fish, and uses a conservative risked-based approach in determining whether consumption guidance is warranted for a particular waterbody. EPA supports the State of Georgia's approach to establishing consumption guidelines as an appropriate way to inform the public of the potential risks in eating certain size and species fish.

4. Applicable Water Quality Standard

TMDLs are established at levels necessary to attain and maintain the applicable narrative and numeric 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 numeric criterion for the protection of human health from methylmercury. The State's regulations provide a narrative water quality standard in which waters are to be free from toxics. Since mercury may cause toxicity in humans, a numeric "interpretation" of the narrative water quality standard is necessary to assure that a TMDL will protect human health. EPA defers to the State water quality standard or criterion as the applicable water quality standard for development of the TMDL. States may establish (or interpret) their applicable water quality standards for protection of human health at a numeric concentration different from their fish consumption guidelines. The State of Georgia has made a numeric interpretation of their narrative water quality standard for toxic substances at a numeric concentration of no more than 0.3 mg/kg methylmercury in fish tissue. (See the July 2001 letter from the State to EPA.) This numeric interpretation protects the "general population" which is the population that consumes 17.5 grams per day or less of freshwater fish. This approach is consistent with EPA's recently adopted guidance value for the protection of human health from methylmercury described in the document entitled, "Water Quality Criterion for the Protection of Human Health: Methylmercury". (EPA 2001) The waterbody is determined to be when the weighted fish consumption concentration is greater than 0.3 mg/kg. The methodology uses a "weighted consumption" approach that assumes that 10.2 grams per day (58.3%) of the total fish consumption is trophic level 3 fish (e.g., catfish and sunfish), and 7.3 grams per day (41.7%) are trophic level 4 fish (e.g., largemouth bass). See Equation 4-1 below.

Equation 4-1 Weighted Fish Tissue Calculation to Determine Impairment

$$Weighted\ Fish\ Tissue\ Concentration = (Avg\ Trophic\ 4\ Conc.*41.7\%) + (Avg\ Trophic\ 3*58.3\%)$$

where:

Avg. Trophic 4 Concentration = 0.42 mg/kg
Avg. Trophic Level 3 Concentration = 0.23 mg/kg

EPA collected site-specific data from the Kinchafoonee Creek on ambient mercury in fish tissue and in the water column in June/July 2002 at 2 locations in the lower Kinchafoonee Creek. Using Equation 4-1, site-specific fish tissue concentration data collected in the Kinchafoonee Creek yields a weighted fish tissue concentration of 0.3 mg/kg which is right at the threshold of impairment as determined by the Georgia methodology. When EPA's data is included with Georgia's fish tissue data the trophic weighted average exceeds the criterion of 0.3 mg/kg.

5. TMDL Target

In order to establish the TMDL, the maximum allowable concentration of total mercury in the ambient water must be determined that will prevent accumulation of methylmercury in fish tissue above the applicable water quality standard of 0.3 mg/kg level. To determine this allowable ambient water concentration, EPA referred to the "Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health" (EPA 2000). The methodology ~~is~~ expressed below (Equation 5-1):

Equation 5-1 Water Quality Standard Calculation

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

where:

WQS = 2.2 ng/l
Reference Dose = 0.0001 mg/kg/day MeHg
RSC = 0.000027mg/kg/day MeHg (Relative Source Contribution from Saltwater Species)
Body Weight = 70 kg
Units Conversion = 1.0E6
Consumption Rate = 0.0175 kg/day Fish
Weighted Bioaccumulation Factor = 3,277,727
Fraction of the Total Mercury as Methylmercury = 0.04 as measured

In the determination of the allowable ambient water concentration, EPA used the recommended national values from the Human Health Methodology, including the reference dose of 0.0001-mg/k/day methylmercury; a standard average 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 used site-specific data from the Kinchafoonee Creek collected in June/July of 2002. (See Section 6.3.) From this site-specific data, EPA determined a representative "weighted" bioaccumulation factor (BAF). This BAF was calculated by taking the average calculated BAF from each of the two trophic levels to determine a "weighted" BAF based upon the different consumption rates for trophic levels, and a the measured fraction methylmercury of 0.04. Using this approach, an allowable concentration of total mercury in the ambient water of Kinchafoonee Creek for the protection of human health is 2.2 nanograms per liter (parts per trillion). This concentration or less in the ambient water will prevent the bioaccumulation of mercury in fish tissue above 0.3 mg/kg. The site-specific data for total mercury in the water column collected during the monitoring in 2002 was 1.6 to 3.2 ng/l.

6. Background

The Kinchafoonee Creek watershed is located in mideastern Georgia (USGS Hydrologic Unit Code (HUC) 3070107). The Kinchafoonee Creek watershed is presented in Figure 1.

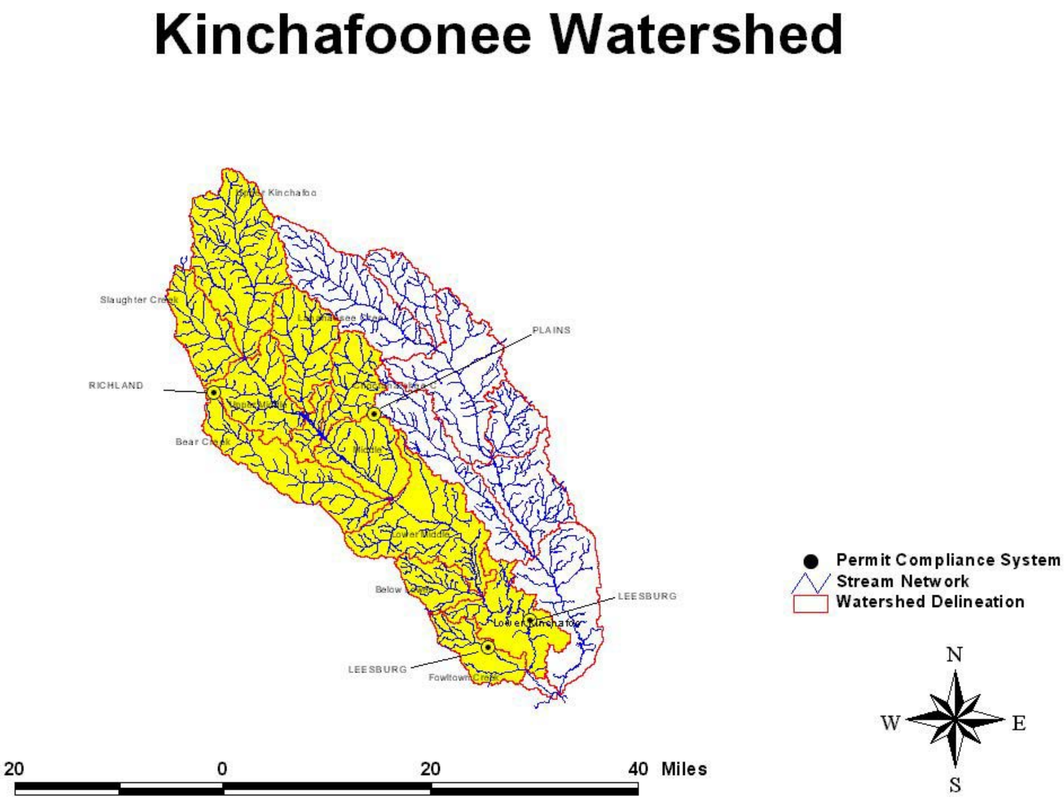

Figure 1 Kinchafoonee Creek Watershed

The Kinchafoonee Creek watershed has been divided into 11 subwatersheds for this TMDL, representing all of the major tributaries to the Kinchafoonee Creek. A total mercury load will be determined for each of these subwatersheds to determine the impact of atmospheric deposition on the Kinchafoonee Creek.

The watershed contains several different types of landuses. The landuses for the Kinchafoonee Creek watershed are given in Figure 2. Different landuses collect and distribute mercury at different rates as a function of runoff and erosion.

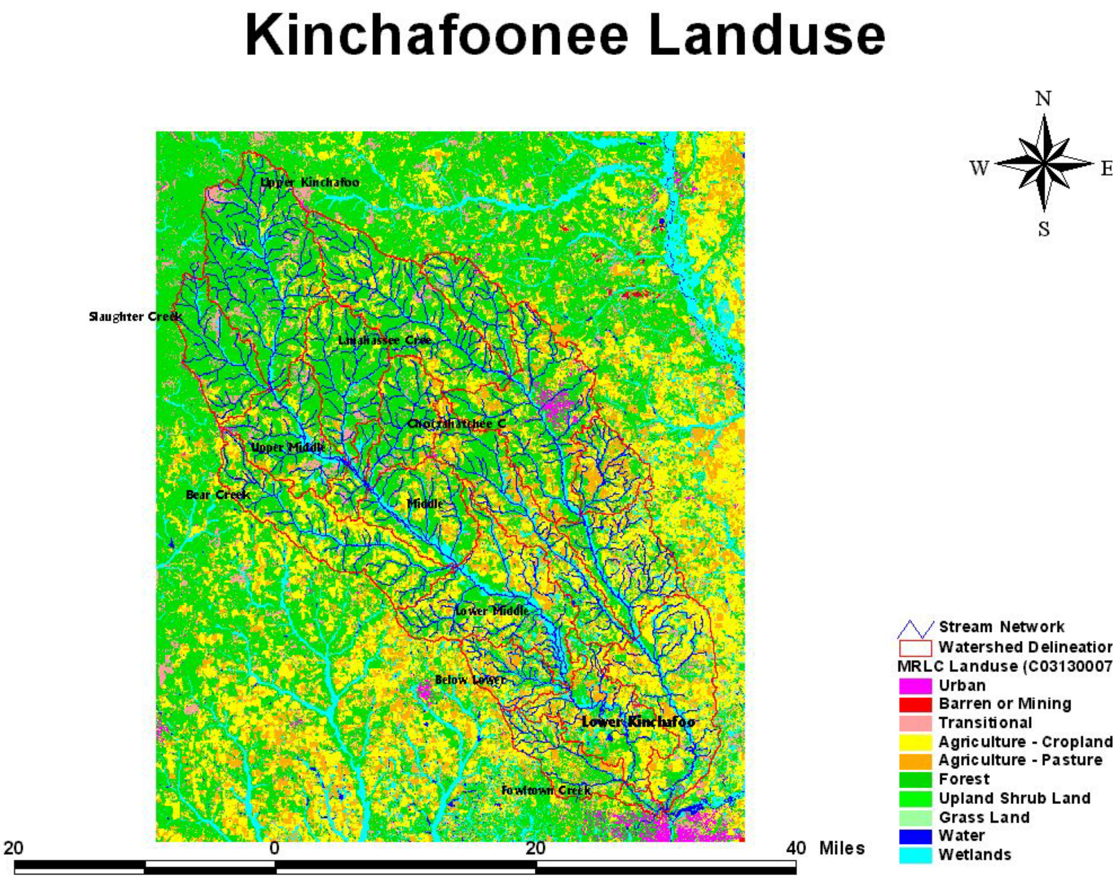

Figure 2 Kinchafoonee Creek Watershed Landuses

This TMDL covers all waterbodies in the Kinchafoonee Creek watershed. Because the spatial distribution of mercury contamination is not completely known in the streams and creeks throughout the watershed, and fish move throughout the watershed, this TMDL is developed to protect all streams and creeks in the entire watershed from unacceptable accumulations of mercury in fish tissue. As discussed in previous sections of this document, the State of Georgia has issued a Fish Consumption Guideline for various segment of the Kinchafoonee Creek and tributaries. This guideline was issued due to elevated levels of mercury found in fish flesh collected in the watershed.

6.1. Source Assessment

A TMDL evaluation must examine all known potential sources of the pollutant in the watershed, including point sources, nonpoint sources, and background levels. The source assessment is used as the basis of development of a model and the analysis of TMDL allocation options. This TMDL analysis includes contributions from point sources, nonpoint sources and background levels. The point sources in the Kinchafoonee watershed, which could potentially have mercury in their discharge, are listed in Table 2.

Table 2 Permitted Facilities in Kinchafoonee Creek

Facility	Permit #
Leesburg Pond	GA0026638
Plains WPCP	GA0020931
Richland WPCP	GA0021539
Kinchafoonee Creek WPCP	GA0026603
Martin Marietta	GA0048968
Tri County High School	GAPID1000

6.2. Watershed Background Load

Significant atmospheric sources of mercury often cause locally elevated areas of atmospheric deposition downwind. Mercury emitted from man-made sources usually contains both gaseous elemental mercury (Hg (0)) and divalent mercury (Hg(II)). Hg (II) forms, because of their solubility and their tendency to attach to particles, redeposit relatively close to their source (probably within a few hundred miles) whereas Hg (0) remains in the atmosphere much longer.

Based on a review of the Mercury Study Report to Congress, significant potential point sources of airborne mercury include coal-fired power plants, waste incinerators, cement and limekilns, smelters, pulp and paper mills, and chlor-alkali factories (USEPA, 1997).

Atmospheric deposition is a major source of mercury in many parts of the country. In a study of trace metal contamination in reservoirs in New Mexico, it was found that 80 percent of mercury found in surface waters was coming from atmospheric deposition (Popp et al., 1996). In other remote areas (Wisconsin, Sweden, and Canada) atmospheric deposition has been identified as the primary (or possibly only) contributor of mercury to the waterbodies (Watras et al., 1994; Burke et al., 1995; Keeler et al., 1994).

6.2.1. 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. The RELMAP model, which was used to predict these deposition rates, was based upon an outdated emissions inventory and did not include other foreign airsheds (i.e. Mexico and others). Other data, presented below, has been relied on for this TMDL.

6.2.2. Mercury Deposition Network

The objective of the Mercury Deposition Network (MDN) is to develop a national database of weekly concentrations of total mercury in precipitation and the seasonal and annual flux of total mercury in wet deposition. The data will be used to develop information on spatial and seasonal trends in mercury deposited to surface waters, forested watersheds, and other sensitive receptors. Locations of the MDN sampling stations are shown on Figure 3.

The EPA Region 4 Air Program reviewed the MDN data for sampling station GA09. This data was compared with the RELMAP deposition predictions and was found to be substantially higher. Using the MDN data, the average annual wet deposition rate was determined to be 12.4 ug/sq. meter and the dry deposition rate was determined to be 6.2 ug/sq. meter.

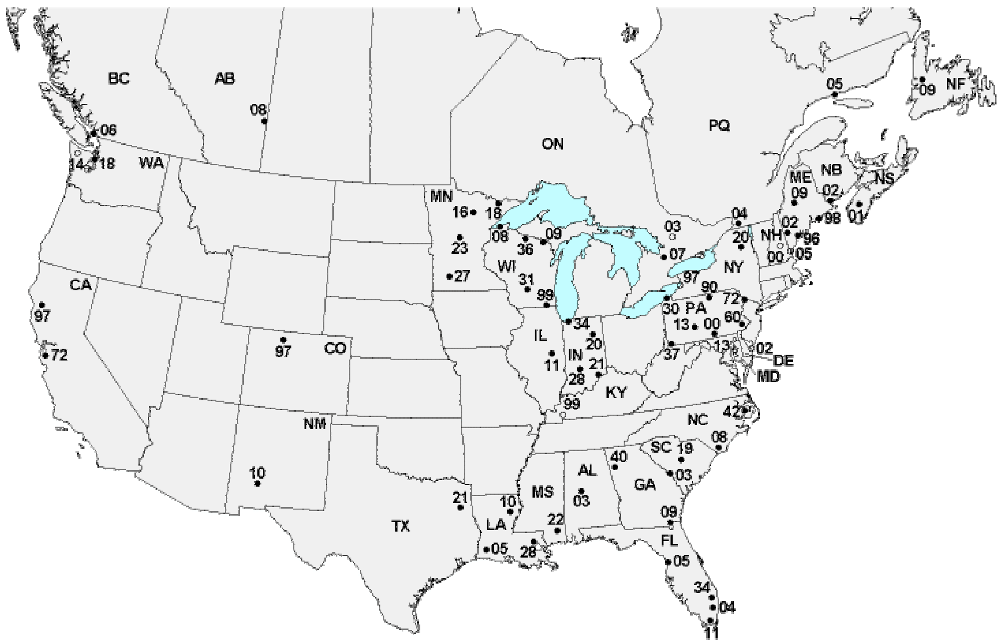

Figure 3 Mercury Deposition Network Sampling Locations

6.3. Available Monitoring Data

The State of Georgia's Environmental Protection Division and the Wildlife Resources Division routinely monitor water and fish tissue in State waters. Focused monitoring work for the Flint River, in accordance with the Georgia river basin planning cycle, was conducted in 1998. The metals sampling and analysis work is done by contract with the United States Geologic Survey (USGS). Water samples were collected and analyzed for metals including mercury by the USGS in the Flint River basin. Mercury analysis methodology for water samples at that time had a detection limit of 200 ng/l (parts per trillion). This methodology was used by EPA, the USGS and the states in the environmental monitoring programs. Mercury was not detected in water samples from the Flint in 1998.

In June of 1998 EPA promulgated Method 1631 for mercury in water for data gathering and compliance monitoring under the Clean Water Act and Safe Drinking Water Act. (See 64 CFR 30417.) This method has a detection limit of 0.5 ng/l (parts per trillion). The availability of this methodology has made detection of mercury in the water column possible. Since low concentrations of mercury in water can lead to significant accumulation of mercury in fish tissue, it was necessary for EPA to sample the Kinchafoonee Creek using

Method 1631 to determine the ambient concentration in the River.

6.3.1. EPA Region 4 Data

Because little ambient mercury data exists for the Flint watershed, EPA Region 4 sampled the Kinchafoonee Creek watershed in July 2002. The purpose of this data collection effort was to collect data needed for the development of this mercury TMDL. The sample locations for the Kinchafoonee Creek watershed are illustrated in Figure 4. Water column, sediment and fish tissue samples were taken from the mainstem of the Kinchafoonee Creek. The following sections provide the results of the field sampling for mercury.

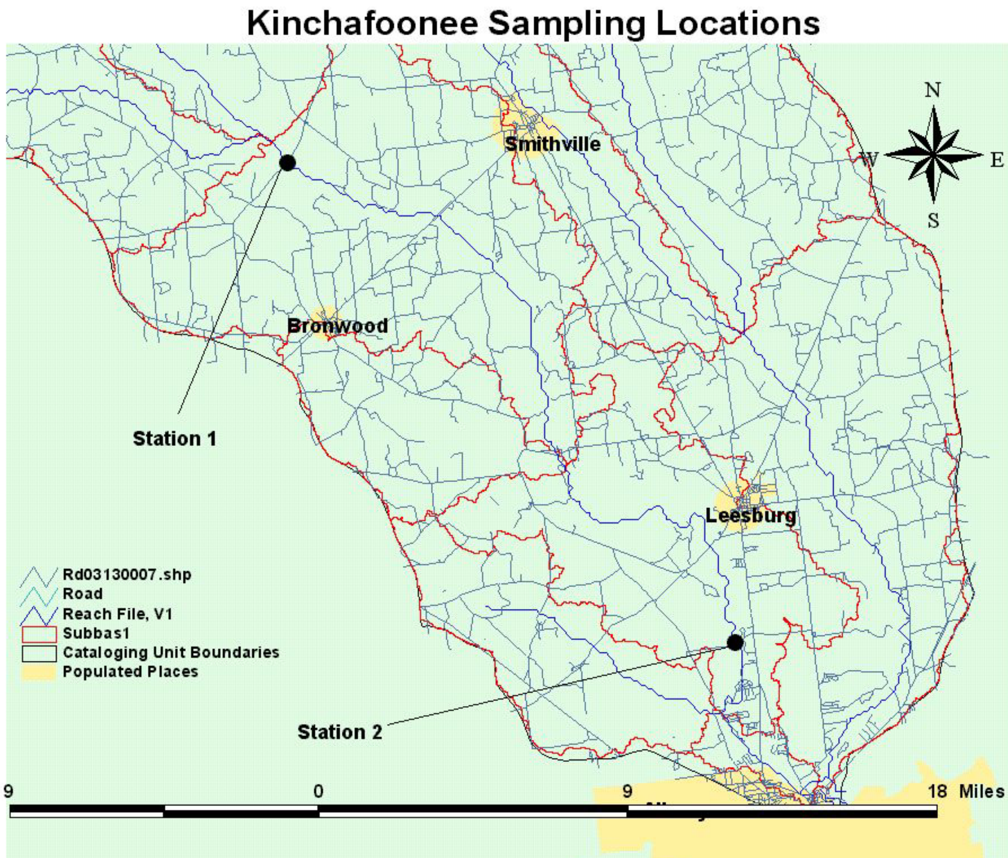

Figure 4 Kinchafoonee Creek Watershed Sample Locations

6.3.2. 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 detection limit 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 3 provides the measured mercury concentrations in the water column in the receiving waterbodies of the Kinchafoonee watershed.

Table 3 Water Column Mercury Concentrations

Station	Total Mercury (ng/l)	MeHg (ng/l)	Percent Methyl
Kinchafoonee 1	3.2	0.12	4%
Kinchafoonee 2	1.6	0.07	5%

6.3.3. Sediment/Soil Data

Samples of river 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. 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 4 provides the mercury concentrations associated with soils collected during the summer of 2002.

Table 4 Sediment/Soil Mercury Concentrations

		Total Mercury		Methyl Mercury	
Station	Waterbody	Sediment ug/kg	Surface Soil ug/kg	Sediment ug/kg	Surface Soil ug/kg
Kinchafoonee 1	Kinchafoonee	0.11	0.03	0.21	0.24
Kinchafoonee 2	Kinchafoonee	0.11	0.05	0.68	0.10

6.3.4. Fish Tissue Data

Samples of fish were taken from the Kinchafoonee Creek within the same area as the water column and sediment samples. Trophic level four fish (largemouth bass) and trophic level 3 (sunfish) were targeted in the collection. The fish fillets obtained during EPA's sampling effort were analyzed for total mercury. Table 5 provides the individual fish data. The fish tissue mercury concentration will be used to determine a site-specific weighted bioaccumulation factor (BAF) for trophic level 3 and 4, and to determine the appropriate target for the TMDL.

Table 5 Fish Tissue Mercury Data

Fish Type	Fish Length (mm)	Fish Weight (g)	Total Mercury (mg/kg)
Largemouth Bass	305	360	0.43
Longnose Gar	633	481	0.35
Redfin Pickerel	385	358	0.66
Chain Pickerel	336	193	0.48
Warmouth Bass	200	195	0.28
Largemouth Bass	385	720	0.67
Largemouth Bass	405	911	0.50
Largemouth Bass	300	381	0.48
Shoal Bass	155	85	0.16
Spotted Gar	445	256	0.46
Bluegill Sunfish	146	60	0.29
Bluegill Sunfish	135	55	0.20
Bluegill Sunfish	105	23	0.21
Redbreast Sunfish	181	88	0.30
Redbreast Sunfish	74	166	0.19
Channel Catfish	470	1015	0.21
Channel Catfish	385	512	0.16
Redear Sunfish	202	126	0.24
Black Crappie	273	274	0.42
Black Crappie	225	139	0.19

7. Numeric Targets and Sources - Model Development

The link between the fish tissue end-point 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 end-point and identified sources. This provides the basis for estimating total assimilative capacity of the river and any needed load reductions. In this TMDL, models of watershed loading of mercury are combined 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 concentration of mercury) and the mercury loads to the water. The loading capacity is then determined by the linkage analysis as a mercury-loading rate that is consistent with meeting the end-point fish tissue 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. Because of the limited amount of data available for the Kinchafoonee Creek watershed to calibrate a detailed dynamic watershed runoff model, a more simplistic approach is taken to determine the mercury contributions to the Kinchafoonee Creek from the surrounding watershed and atmospheric components. Therefore, a scoping-level analysis of the watershed mercury load, based on an annual mass balance of water and sediment loading from the watershed is used for the TMDL development.

Watershed-scale loading of water and sediment was simulated using the Watershed Characterization System (WCS). 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, runoff, can then be used to estimate pollutant delivery to the receiving waterbody from the watershed. This estimate is based on pollutant concentrations in wet and dry deposition and processed by soils in the watershed and ultimately delivered to the receiving waterbody by runoff, erosion and direct deposition.

7.2. Water Quality Fate and Transport Model

WASP5 (Ambrose, et al., 1993) was chosen to simulate mercury fate in the Kinchafoonee Creek. 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 up to 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 while achieving the water quality target protective of human health through fish consumption. This TMDL determines the maximum load of total mercury that can enter the Kinchafoonee Creek watershed within a year and still achieve a water column concentration for total mercury at or below the 2.2 ng/l target concentration as determined in the Target Identification Section.

8.1. Critical Condition Determination

EPA's derivations of human health criteria assume that effects of mercury are a long-term exposure to water column concentrations that lead to the accumulation of mercury in the fish tissue. The TMDL utilizes an average annual flow to determine the TMDL. Furthermore, the period of record for climate data stations in the watershed are used to calculate an annual average load of mercury to the system.

8.2. Seasonal Variation

Wet deposition is greatest in the winter and spring seasons. Mercury is expected to fluctuate based on the amount and distribution of rainfall, and variability of localized and distant atmospheric sources. While a maximum daily load is established in this TMDL, the average annual load is of greatest significance since mercury bioaccumulation and the resulting risk to human health that results from mercury consumption is a long-term process. Thus, daily or weekly inputs are less meaningful than total annual loads over many years. The use of an annual load allows for integration of short-term or seasonal variability.

Methylation of mercury is expected to be highest during the summer. High temperatures and static conditions result in hypoxic and/or conditions that promote methylation. Based on this enhanced methylation and high predator feeding activity 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.

Because the water quality target was determined using data from a one-time sampling event under a single condition, the water quality target calculation could be re-visited when more data is available to determine the annual average condition.

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.
- Assigning a 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 standards can be achieved solely by controlling air sources. By assigning this 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, these reductions help 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 Kinchafoonee Creek 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

The TMDL development will integrate the watershed loading with receiving water fate and transport of mercury. Annual average loads and flows will be used to evaluate current loading conditions and to determine what the loads would have to be to achieve the water quality target.

9.1. Model Results

Both the nonpoint source runoff model and the receiving waterbody model were used to determine the maximum load that could occur and protect fish from accumulating mercury to unacceptable levels. This section provides detailed information on how the models were applied, how the watershed and waterbody were broken down into segments (computational boxes) and how the mercury was 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 watershed model were determined by a comparison between the RELMAP model results as reported in the Mercury Report to Congress and the Mercury Deposition Network sample collection site located in the Okefenokee Swamp. Yearly average dry deposition rates of 6.4 µg/sqm and wet deposition rates of 12.4 µg/sqm are used in the model. These deposition rates were interpreted from the MDN data. The WCS model was used to calculate the total load of mercury entering the mainstem portion of the Kinchafoonee Creek from the sub basins delineated in Figure 1. The predicted annual loads are given in Table 6.

Table 6 Annual Average Total Mercury Load from each Sub Basin

Watershed Name	Area (ha)	Total Hg Load (mg)	Load (mg) /ha	Impervious Surface (mg/yr)	Sediment (mg/yr)	Runoff (mg/yr)	Deposition on Water (mg/yr)
Upper Kinchafoonee	2.84	329695	115959	107510	86019	124323	11844
Slaughter Creek	1.12	123491	110267	36463	33932	46329	6768
Lanahassee Creek	1.34	170537	127000	44347	64818	54604	6768
Choctahatchee Creek	0.97	147000	152002	38662	58193	39992	10152
Upper Middle	1.35	228485	169596	61284	94446	55834	16920
Middle	1.27	192309	151791	32588	100491	53847	5076
Bear Creek	1.85	391101	211347	42858	238187	86368	23688
Lower Middle	2.32	376958	162645	59271	170214	103482	43992
Lower Kinchafoonee	1.49	319580	214826	48391	147386	79223	42300
Fowltown Creek	0.8	158135	198007	31657	66036	41730	18612

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 loads from each of the sub basins are passed onto the water quality model as an annual load.

9.1.2. Water Quality Model

The WASP5 toxic chemical program TOXI5 was set up to simulate mercury in the mainstem of the Kinchafoonee Creek. The mainstem of the river was divided into 6 reaches. Each reach was further divided into 2 vertical compartments representing surface water and surficial sediment. The 2 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 solids classes were simulated sand and silt. 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 monomethylmercury, 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 7.

Table 7 Specified and Calculated Reaction Rates and Coefficients

Component	Reaction	Compartment	Coefficient Value
Hg^0	Volatilization	Water	1.0 - 3.9 day^{-1} (calc)
	Oxidation	Water	0.001 day^{-1}
Hg(II)	Reduction	Water	0.05 day^{-1} (surface) 0.074 - 0.090 (calc)
	Methylation	Water	0.001 day^{-1}
	Methylation	Sediment	0.00002 day^{-1}
	Partitioning to silt	Water, Sediment	2 H 10^5 L/kg
	Partitioning to sand	Water, Sediment	4.8 H 10^4 L/kg
	Partitioning to DOC	Water, Sediment	2 H 10^4 L/kg
MeHg	Demethylation to Hg(II)	Sediment	0.0001 day^{-1}
	Demethylation to Hg^0	Water	0.1 day^{-1} (surface) 0.074 - 0.090 (calc)
	Partitioning to silt	Water, Sediment	2 H 10^5 L/kg
	Partitioning to sand	Water, Sediment	1 H 10^3 L/kg
	Partitioning to DOC	Water, Sediment	2 H 10^5 L/kg

The Kinchafoonee Creek simulation was conducted using annual average flow and load. The average flow simulation was run for 20 years, so that steady-state conditions are achieved in the water and surficial sediment. The flows, depths, velocities, and volumes used for annual average conditions are summarized in Table 8.

Table 8 Flows, Depths, Velocities and Volumes used in WASP Model

From	To	Length (m)	Depth (m)	Width (m)	Volume (cm)	Flow (cms)
Upstream Boundary	Upper Kinchafoonee	13356.12	0.51083	22.70769	154927.9	2.78
Upper Kinchafoonee	Slaughter Creek	13356.12	0.51083	22.70769	154927.9	2.78
Slaughter Creek	Lanahassee Creek	5455.016	0.65035	32.21663	114294	3.92
Lanahassee Creek	Choctahatchee Creek	7348.312	0.8692	46.81409	299008.8	6.69
Choctahatchee Creek	Upper Middle	7348.312	0.8692	46.81409	299008.8	6.69
Upper Middle	Middle	4111.016	1.14995	62.37115	294857.3	9.33
Middle	Bear Creek	15587.45	1.23566	64.54088	1243108	13.10
Bear Creek	Lower Middle	15743.03	1.71261	97.33983	2624445	22.23
Lower Middle	Lower Kinchafoonee	15743.03	1.71261	97.33983	2624445	22.23
Lower Kinchafoonee	Fowltown Creek	15743.03	1.71261	97.33983	2624445	22.23
Fowltown Creek	Flint River	5723.075	1.79148	103.2052	1058139	24.26

The Watershed Characterization System 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. These loadings to the tributary network are subject to reduction and volatilization losses in transport to the mainstem. Average reduction factors were calculated for each tributary inflow using a reduction rate constant of 0.001 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.

Table 9 provides the predicted water column concentrations under annual average load and flow for the Kinchafoonee Creek. 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 target.

Table 9 Predicted and Observed Mercury Concentrations under Annual Average Load and Flow

Calculated Concentrations	River Reach											
Total Mercury	**Obs**	1	2	3	4	5	6	7	8	9	10	11
Water Column (ng/l)	**3.2**	2.43	3.34	3.30	2.37	3.07	2.64	2.49	1.82	2.11	2.25	2.07
Sediment (ng/g)	**10**	4.84	6.65	6.57	4.72	6.12	5.25	4.95	3.61	4.19	4.47	4.24
Methylmercury (ng/l)												
Water Column	**0.1**	0.81	1.11	1.10	0.79	1.02	0.88	0.83	0.60	0.70	0.74	0.68

9.2. TMDL Determination

To determine the total maximum load that can come into the Kinchafoonee Creek the current loading conditions are evaluated and instream concentration is determined using the modeling approach described above. This allows the development of a relationship between load and instream mercury concentrations. 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 target of 2.4 ng/l. The TMDL is calculated as given below:

$$\frac{HighestSegmentConcentration}{CurrentAnnualAverageLoad} \cdot \frac{WaterQualityTarget}{TMDLLoad}$$

where:

Highest Segment Concentration = 3.34 ng/l
Current Annual Average Load= 2.44 kg/year
Water Quality Target= 2.2 ng/l

TMDL Load is calculated as 1.68 kg/year total mercury.

The estimated current loading of mercury to the Kinchafoonee Creek basin is 1.68 kg/year.

The percent reduction from atmospheric sources is calculated using the following equation:

$$\%Reduction = \frac{TMDL}{CurrentLoadings} * 100$$

where:

TMDL = Total allowable Annual Load derived in TMDL Calculation

Current Loadings = Sum of all loads from the Watershed

In order to achieve this TMDL, a 31% reduction of mercury from all sources is needed.

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, 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 target of 2.2 ng/l.

The calculated allowable load of mercury that can come into the Kinchafoonee Creek without exceeding the applicable water quality target of 2.2 ng/l is 1.68 kilograms/year. This assessment indicates that over 99% of the current loading of mercury is from atmospheric sources; therefore a 31% reduction from the current atmospheric loading is applied in deriving the LA and WLA. In the future when air deposition has been reduced by 31% to 1.68 kg/year, the contribution of the load from water point sources will be less than 1%. Therefore, the Load Allocation and Wasteload Allocation for the Kinchafoonee Creek is:

Load Allocation (atmospheric sources) = 1.66 kilograms/year

Wasteload Allocation (NPDES sources) = 0.02 kilograms/year

The estimated current loading of mercury to the Kinchafoonee Creek from the surrounding watershed is 2.44 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 (2.44 kg/year) and the calculated allowable load (1.68 kg/year) is 1.2 kilograms/year. Since 1.68 kg/year is 69% of the estimated current loading of mercury, it is estimated that a 31% reduction in total mercury loading is needed for the Kinchafoonee Creek to achieve a water column concentration of 2.2 ng/l.

10.1. Atmospheric Reductions

EPA estimates that over 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 is to be attained. Based on the total allowable load of 1.68 kilograms per year, a 31% reduction of mercury loading is needed to achieve the applicable water quality standard. An analysis conducted by the EPA Region 4 Air Program (Appendix A) concludes that an estimated 25% to 32% reduction in mercury deposition to the Kinchafoonee Creek watershed can be achieved by 2010 through full implementation of existing Clean Air Act Maximum Achievable Control Technologies (CAA MACT) and solid waste combustion requirements. (See Appendix A.) While these reductions will not achieve the load allocation provided in the TMDL, EPA is currently developing legislation to establish additional controls on multiple air pollutants, including mercury, from electric utilities. EPA anticipates that this process will produce reductions in the atmospheric deposition of mercury that will enable achievement of water quality standards.

It is anticipated 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 will be achieved.

10.2. Allocation to NPDES Point Sources

During EPA's sampling effort in Kinchafoonee Creek, three NPDES facilities that discharge to the impaired segment were monitored for mercury. These sources are considered to be "minor" dischargers since the effluent flow for each source is less than 1 MGD. Table 10 provides the results of the EPA sampling. Based on this sampling, this TMDL estimates that these sources contribute, in the aggregate, less than 1% of the current total mercury loadings to the watershed. When the TMDL is fully implemented, these sources will contribute less than 1%, in the aggregate, of the allowable load to the watershed. None of these sources have been designated as significant minor sources by the State of Georgia.

EPA has assigned to this NPDES point source a wasteload allocation equal to its current effluent discharge, subject to mercury characterization or minimization conditions as set out more fully below. EPA recognizes that this point source contributes only a minute share of the total mercury contributions to the watershed. However, EPA also recognizes that mercury is a highly persistent toxic pollutant that can bioaccumulate in fish tissue at levels harmful to human health. Therefore, EPA has determined, as a matter of policy, that NPDES point sources known to discharge mercury at levels above the amount present in their source water should reduce their loadings using appropriate, cost-effective mercury minimization measures. In particular, wastewater treatment plants can attain significant mercury reductions through source reduction efforts.

This TMDL assumes that the State of Georgia, as the permitting authority, will determine the necessary elements of a mercury characterization/minimization study plan, considering the size and nature of the affected WWCP.

Table 10 NPDES Permitted Facilities Wasteload Allocation

Minor Municipal	NPDES ID	MGD	Kg/Yr	% of TMDL Load
Leesburg Pond	GA0026638	0.3	0.0023	0.1%
Plains WPCP	GA0020931	0.12	0.0003	0.0%
Richland WPCP	GA0020729	0.3	0.0032	0.2%
Kinchafoonee Creek WPCP	GA0026603	0.25	0.0029	0.1%

11. References

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12. Appendix A. Analysis of Atmospheric Deposition of Mercury