TOTAL MAXIMUM DAILY LOADS (TMDLs)

For Dioxins and Polychlorinated Biphenyls (PCBs) in Chattanooga Creek

Lower Tennessee River Watershed (HUC 06020001)
Hamilton County, Tennessee

FINAL

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LIST OF ABBREVIATIONS

ATSDR	Agency for Toxic Substances and Disease Registry
ADB	Assessment Database
BCF	Bioconcentration Factor
BMP	Best Management Practices
CAS	Chemical Abstract Service
CDD	Chlorinated Dibenzo-p-Dioxin
CDF	Chlorinated Dibenzofuran
CFR	Code of Federal Regulations
CFS	Cubic Feet Per Second
HHC	Human Health Criteria
HUC	Hydrologic Unit Code
LA	Load Allocation
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
MS4	Municipal Separate Storm Sewer System
NHD	National Hydrography Dataset
NPL	National Priorities List
NPS	Non-point Source
NPDES	National Pollutant Discharge Elimination System
PCB	Polychlorinated Biphenyl
PPB	Parts per Billion (1×10^{-9})
PPM	Parts per Million (1×10^{-6})
PPQ	Parts per Quadrillion (1×10^{-15})
PPT	Parts per Trillion (1×10^{-12})
RI/FS	Remedial Investigation and Feasibility Study
ROD	Record of Decision
RM	River Mile
TDEC	Tennessee Department of Environment & Conservation
TDSWM	Tennessee Division of Solid Waste Management
TEF	Toxic Equivalent Factor
TMDL	Total Maximum Daily Load
USEPA	United States Environmental Protection Agency
USFDA	United States Food and Drug Administration
USGS	United States Geological Survey
WLA	Waste Load Allocation
WWTF	Wastewater Treatment Facility

SUMMARY SHEET

LOWER TENNESSEE RIVER WATERSHED (HUC 06020001)

Total Maximum Daily Loads for Dioxins and Polychlorinated Biphenyls (PCBs) As Identified on the State of Tennessee's *2008 303(d) List*

Impaired Waterbody Information:

State: Tennessee
Counties: Hamilton
Watershed: Lower Tennessee River Watershed (HUC 06020001)
Constituents of Concern: Dioxins and Polychlorinated Biphenyls (PCBs)

Impaired Waterbody Addressed in This Document:

Waterbody ID	Impaired Waterbody	Miles
TN060200011244_1000	Chattanooga Creek	8.4

Designated Uses:

The designated use classifications for segments of the Chattanooga Creek addressed in these TMDLs include fish and aquatic life, industrial water supply, irrigation, livestock watering & wildlife, and recreation.

Target Criteria:

Fish tissue concentrations, calculated from the formulas used for fish advisories, will be used as the target criteria.

Pollutant	Target Criteria (mg/kg)
Dioxins	5.0E-06
PCBs	0.0200

General TMDL Analysis Methodology:

- Composite fish tissue samples were collected and analyzed for the constituents of concern.
- The TMDLs are expressed in lbs/day as a function of flow. To assist with implementation, the TMDLs are also expressed as a maximum water column concentration (in μg/L) and as a maximum fish tissue concentration (in mg/kg), which are equivalent to the target criteria.
- Waste Load Allocations (WLAs) are derived for point source dischargers of dioxins and PCBs.
- Load Allocations are established for non-point sources using a mass-balance approach.

Critical Conditions:

The methodology takes into account that the pollutants are contained in the sediment. The methodology addresses all seasons.

Margin of Safety:

5% (Explicit)

Summary of TMDLs, WLAs, and LAs

Waterbody ID	Pollutant	WLAs	LAs[1]	MOS[1]	TMDLs		
					Maximum Load[1]	Maximum Water Column Concentration[2]	Maximum Fish Tissue Concentration[2]
		(lbs/day)	(lbs/day)[3]	(lbs/day)[3]	(lbs/day)[3]	(μg/L)	(mg/kg)
TN060200011244_1000	Dioxins	0	Q * 5.12E-09	Q * 2.70E-10	Q * 5.39E-09	1.0E-06	5.0E-06
	PCBs	0	Q * 3.28E-06	Q * 1.73E-07	Q * 3.45E-06	0.00064	0.0200

1 The LA, MOS, and the Maximum Load TMDL are expressed as a function of flow (Q), where Q represents the annual average flow of Chattanooga Creek at the pour point of the segment.

2 The TMDL is also expressed in terms of maximum allowable water column concentration and maximum fish tissue concentration because TDEC recognizes that these values provide information that potentially will be more useful regarding TMDL implementation efforts than the values that are expressed in terms of an allowable load.

3 Lbs/day calculated as an annual average.

TOTAL MAXIMUM DAILY LOADS (TMDLs) FOR DIOXINS AND PCBs IN CHATTANOOGA CREEK LOWER TENNESSEE RIVER WATERSHED (HUC 06020001)

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology-based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Impaired waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those waterbodies that are not attaining water quality standards. State water quality standards consist of designated use(s) for individual waterbodies, appropriate numeric and narrative water quality criteria protective of the designated uses, and an antidegradation statement. The TMDL process establishes the maximum allowable loadings of pollutants for a waterbody that will allow the waterbody to maintain water quality standards. The TMDL may then be used to develop controls for reducing pollution from both point and non-point sources in order to restore and maintain the quality of water resources (USEPA, 1991).

2.0 WATERSHED DESCRIPTION

This document presents details of TMDL development for waterbodies in the Lower Tennessee River Watershed, identified on the Final 2008 303(d) List as not supporting designated uses due to dioxins and PCBs. Portions of the Lower Tennessee River Watershed lie in Tennessee, Alabama, and Georgia. This document addresses only impaired waterbodies in Tennessee.

The Lower Tennessee River Watershed (HUC 06020001) is located in Eastern Tennessee as shown in Figure 1. The Lower Tennessee River Watershed lies within two Level III ecoregions (Ridge and Valley, Southwestern Appalachians) and contains eight Level IV ecoregions as shown in Figure 2 (USEPA, 1997):

- The **Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f)** form a heterogeneous region composed predominantly of limestone and cherty dolomite. Landforms are mostly low rolling ridges and valleys, and the solids vary in their productivity. Landcover includes intensive agriculture, urban and industrial, or areas of thick forest. White oak forests, bottomland oak forests, and sycamore-ash-elm riparian forests are the common forest types, and grassland barrens intermixed with cedar-pine glades also occur here.

- The **Southern Shale Valleys (67g)** consist of lowlands, rolling valleys, slopes and hilly areas that are dominated by shale materials. The northern areas are associated with Ordovician-age calcareous shale, and the well-drained soils are often slightly acid to neutral. In the south, the shale valleys are associated with Cambrian-age shales that contain some narrow bands of limestone, but the soils tend to be strongly acid. Small farms and rural residences subdivide the land. The steeper slopes are used for pasture

or have reverted to brush and forested land, while small fields of hay, corn, tobacco, and garden crops are grown on the footslopes and bottomland.

- The **Southern Sandstone Ridges (67h)** encompasses the major sandstone ridges with areas of shale and siltstone. The steep, forested ridges have narrow crests with soils that are typically stony, sandy, and of low fertility. The chemistry of streams flowing down the ridges can vary greatly depending on the geological material. The higher elevation ridges are in the north, including Wallen Ridge, Powell Mountain, Clinch Mountain and Bays Mountains. White Oak Mountain in the south has some sandstone on the west side, with abundant shale and limestone. Grindstone Mountain, capped by the Grizzard Group sandstone, is the only remnant of Pennsylvanian-age strata in the ridge and valley of Tennessee.

- The **Southern Dissected Ridges and Knobs (67i)** contain more crenulated, broken, or hummocky ridges, compared to smoother, more sharply pointed sandstone ridges. Although shale is common, there is a mixture and interbedding of geologic materials. The ridges on the east side of Tennessee's Ridge and Valley tend to be associated with the Ordovician-age Sevier shale, Athens shale, and Holston and Lenoir limestones. These can include calcareous shale, limestone, siltstone, sandstone, and conglomerate. In the central and western part of the ecoregion, the shale ridges are associated with the Cambrian-age Rome Formation: shale and siltstone with beds of sandstone. Chestnut oak forests and pine forests are typical for the higher elevations of the ridges, with areas of white oak, mixed mesophytic forest, and tulip on the lower slopes, knobs, and draws.

- The **Cumberland Plateau (68a)** tablelands and open low mountains are about 1000 feet higher than the Eastern Highland Rim (71g) to the west, and receive slightly more precipitation with cooler annual temperatures than the surrounding lower-elevation ecoregions. The plateau surface is less dissected with lower relief compared to the Cumberland Mountains (69d) or the Plateau Escarpment (68c). Elevations are generally 1200-2000 feet, with the Crab Orchard Mountains reaching over 3000 feet. Pennsylvanian-age conglomerate, sandstone, siltstone, and shale is cover by well-drained, acid soils of low fertility. Bituminous coal that has been extensively surface and underground mined underlies the region. Acidification of first and second order streams is common. Stream siltation and mine spoil bedload deposits continue as long-term problems in these headwater systems. Pockets of severe acid mine drainage persist.

- The **Sequatchie Valley (68b)** is structurally associated with an anticline, where erosion of broken rock to the south of the Crab Orchard Mountains scooped out the linear valley. The open, rolling, valley floor, 600-1000 feet in elevation, is generally 1000 feet below the top of the Cumberland Plateau. A low, central, cherty ridge separates the west and east valleys of Mississippian to Ordovician-age limestones, dolomites, and shales. Similar to parts of the Ridge and Valley (67f), this is an agriculturally productive region, with areas of pasture, hay, soybeans, small grain, corn, and tobacco.

- The **Plateau Escarpment (68c)** is characterized by steep, forested slopes with high velocity, high gradient streams. Local relief is often 1000 feet or more. The geologic strata include Mississippian-age limestone, sandstone, shale, and siltstone, and Pennsylvanian-age shale, siltstone, sandstone, and conglomerate. Streams have cut down into the limestone, but the gorge talus slopes are composed of colluvium with huge angular, slabby blocks of sandstone. Vegetation community types in the ravine and gorges include mixed oak and chestnut oak on the upper slopes, mesic forests on the middle and lower slopes (beech-tulip popular, sugar maple-basswood-ash-buckeye), with hemlock along rocky streamsides and river birch along floodplain terraces.

- The **Southern Table Plateaus (68d)** include Sand Mountain and Lookout Mountain in northwest Georgia. While it has some similarities to the Cumberland Plateau (68a) in Tennessee with its Pennsylvanian-age sandstone caprock, shale layers, and coal-bearing strata, this ecoregion is lower in elevation, has a slightly warmer climate, and has more agriculture. Although the Georgia portion is mostly forested, primarily with mixed oak and oak-hickory communities, elevations decrease to the southwest in Alabama and there is more cropland and pasture. The plateau surface is less dissected with lower relief compared to the Plateau Escarpment (68c), and it is slightly cooler with more precipitation than in the nearby lower elevations of 67f.

Figure 1 Location of the Lower Tennessee River Watershed

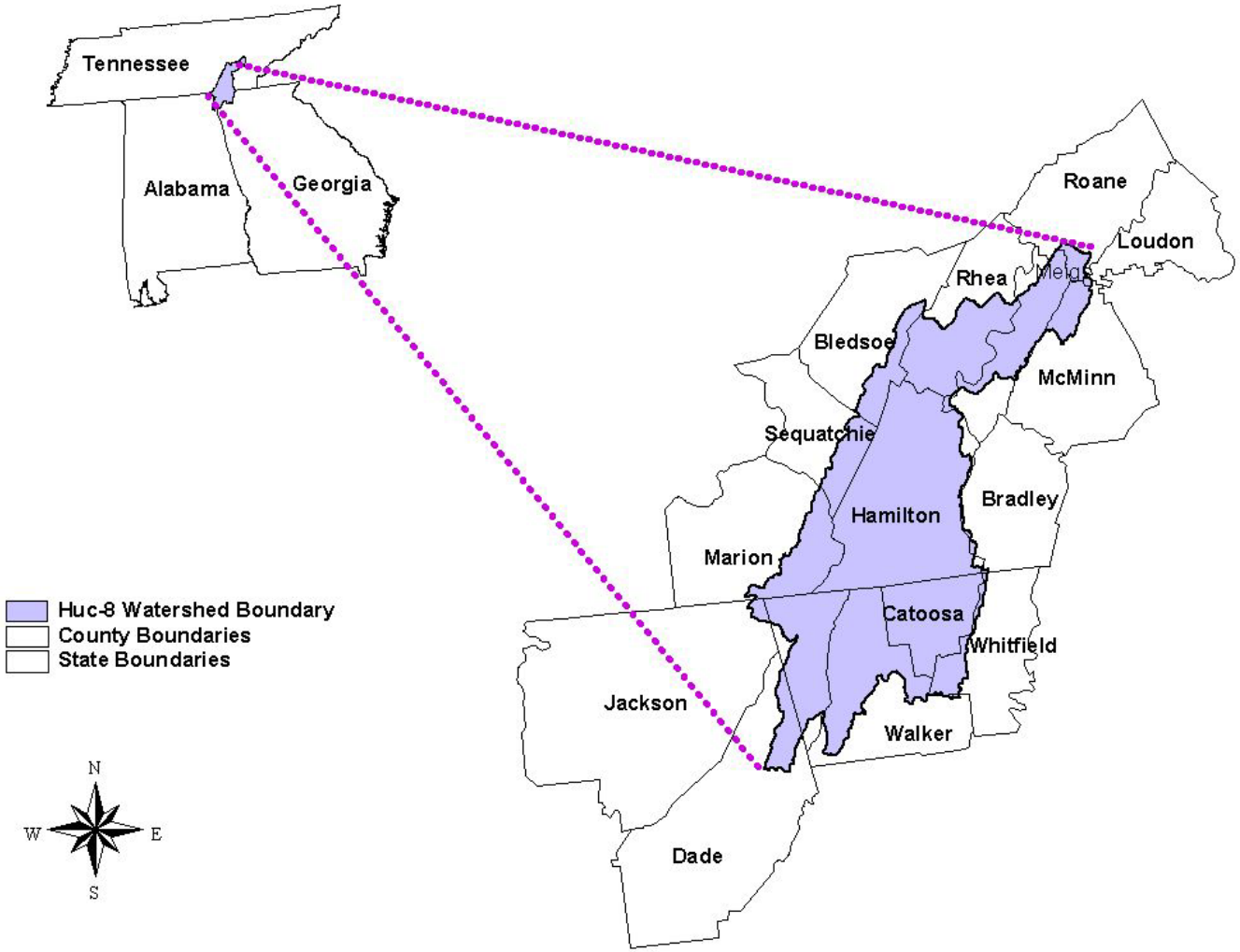
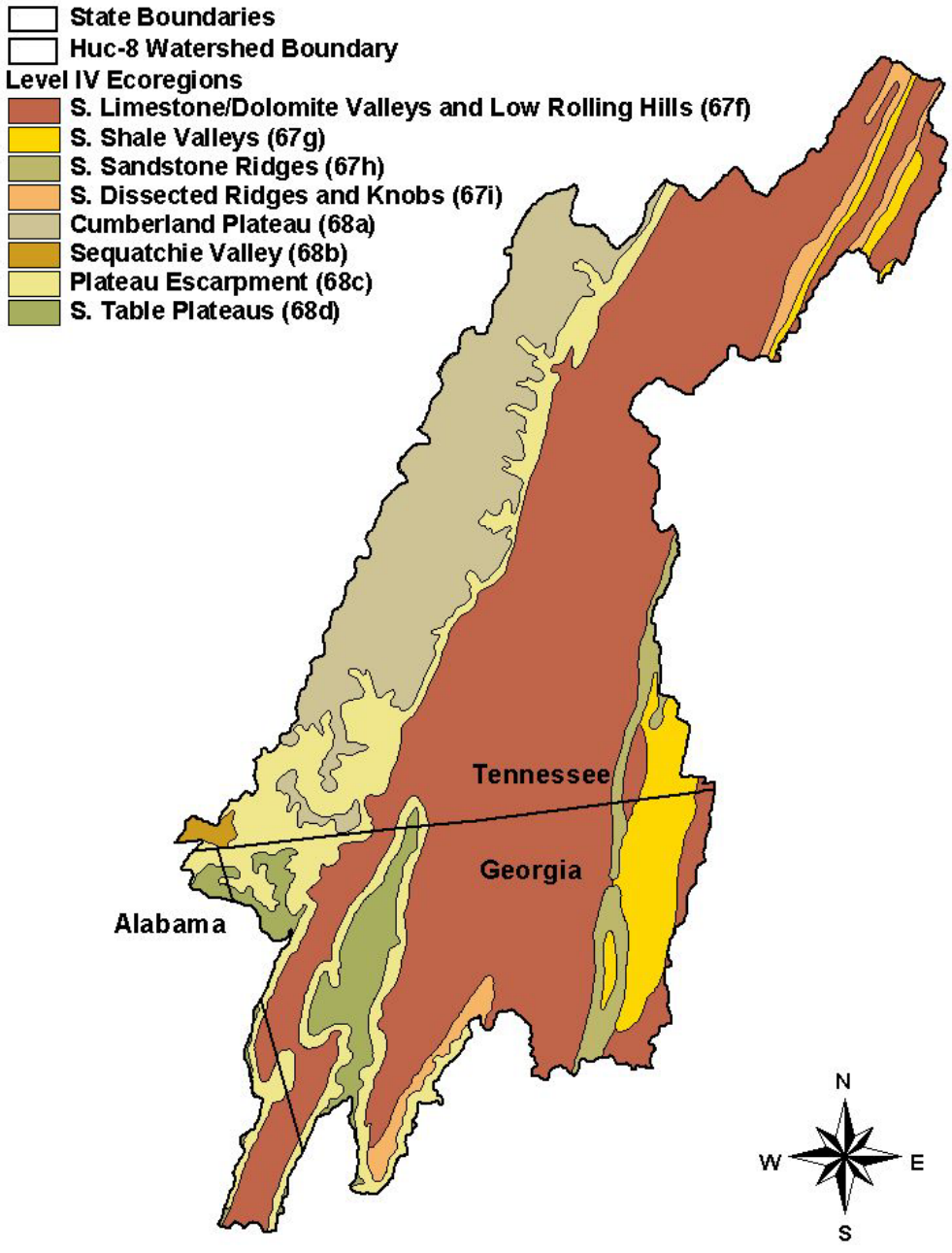


Figure 2 Level IV Ecoregions in the Lower Tennessee River Watershed



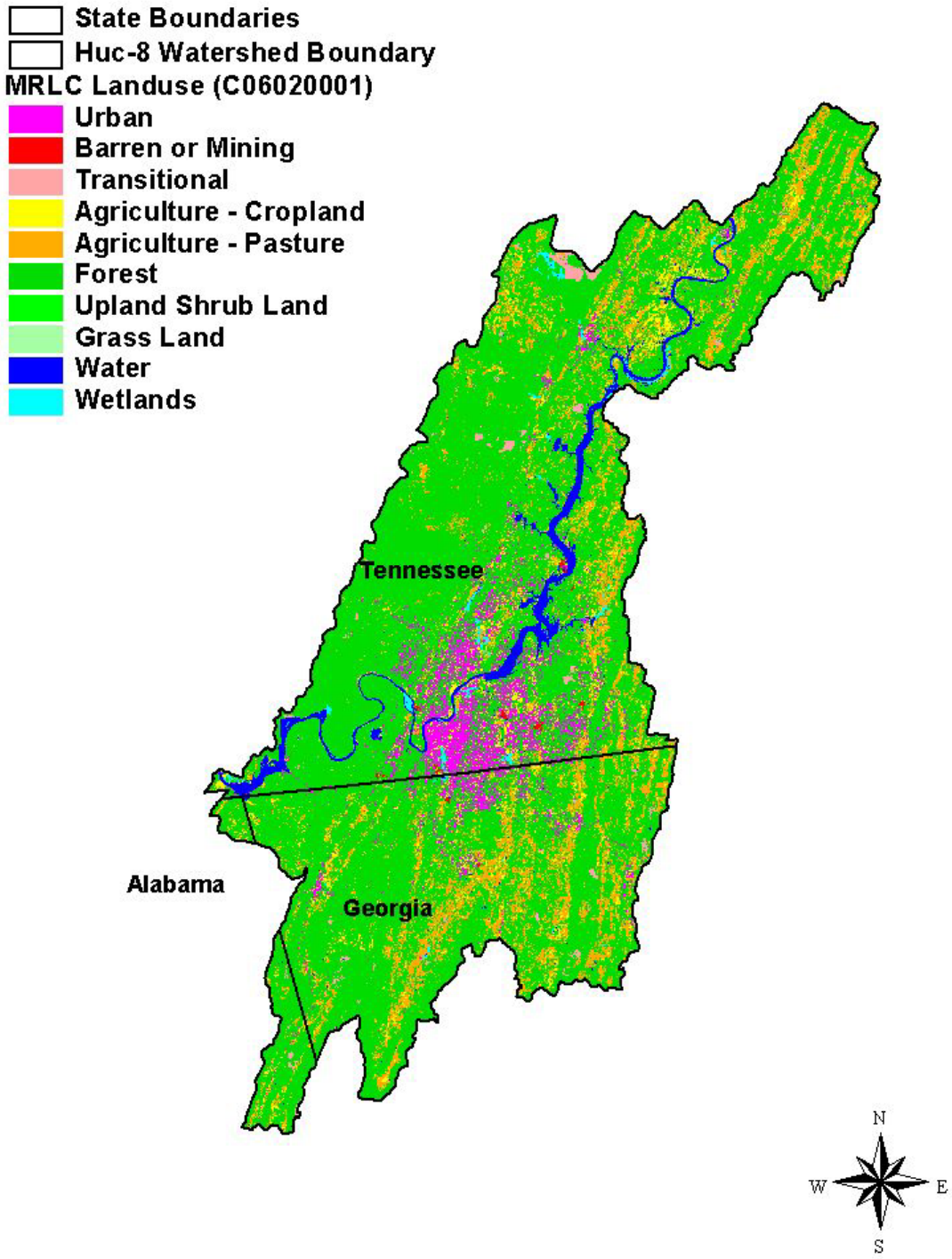
The Tennessee portion of the Lower Tennessee River Watershed drains approximately 1,214 square miles (TDEC, 2006). The entire watershed, including Tennessee, Alabama, and Georgia, drains approximately 1,870 square miles. Watershed land use distribution is based on the 1992 Multi-Resolution Land Characteristic (MRLC) satellite imagery databases. Land use for the Lower Tennessee River Watershed is summarized in Table 1 and in Figure 3.

Table 1 Land Use Distribution – Lower Tennessee River Watershed

Land Use	Area		% of watershed
	acres	mi^2	
Bare Rock/Sand/Clay	41	0.064	0.00
Deciduous Forest	475,555	742.82	39.73
Emergent Herbaceous Wetlands	1,329	2.08	0.11
Evergreen Forest	151,404	236.49	12.65
High Intensity Commercial/Industrial/Transportation	15,710	24.54	1.31
High Intensity Residential	6,407	10.01	0.54
Low Intensity Residential	37,949	59.28	3.17
Mixed Forest	254,057	396.84	21.23
Open Water	34,967	54.62	2.92
Other Grasses (Urban/recreational; e.g. parks, lawns)	12,242	19.12	1.02
Pasture/Hay	147,402	230.24	12.31
Quarries/Strip Mines/Gravel Pits	1,321	2.06	0.11
Row Crops	41,952	65.53	3.50
Transitional	11,326	17.70	0.95
Woody Wetlands	5,303	8.28	0.44
Total	**1,196,966**	**1,869.67**	**100.00**

Note: A spreadsheet was used for this calculation and values are approximate due to rounding.

Figure 3 Land Use in the Lower Tennessee River Watershed



3.0 PROBLEM DEFINITION

The State of Tennessee's 2008 303(d) List (TDEC, 2008a) identified segment TN060200011244_1000 of Chattanooga Creek in the Lower Tennessee River Watershed as not fully supporting designated use classifications due, in part, to elevated levels of dioxins and polychlorinated biphenyls (PCBs) in fish tissue samples. An excerpt from the 2008 303(d) List is presented in Table 2. The impaired segment is shown in Figure 4. Note that there is a fishing advisory for Chattanooga Creek from the mouth to the Georgia state line (7.7 miles) (TDEC, 2008).

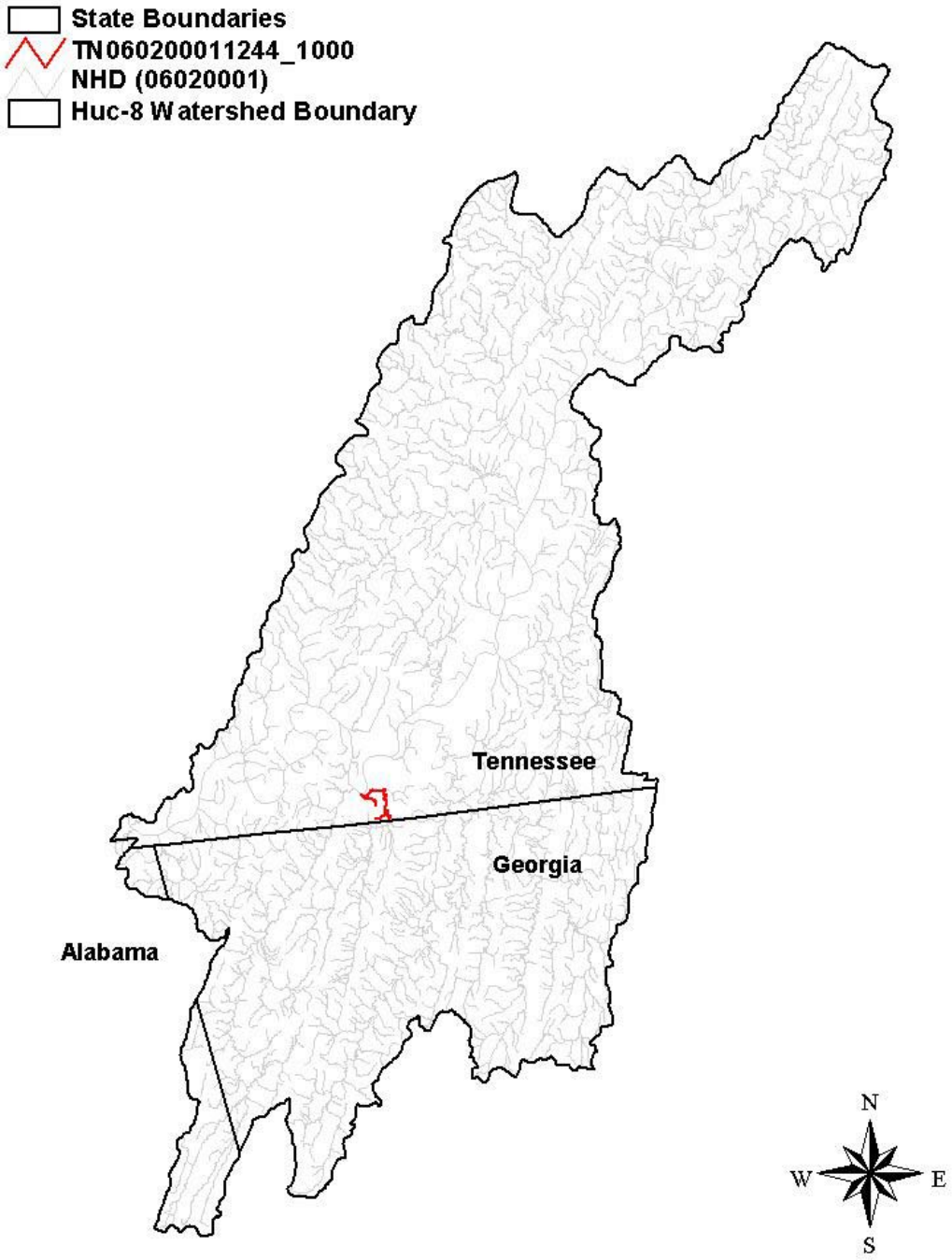
The designated use classifications for the Chattanooga Creek include fish and aquatic life, industrial water supply, irrigation, livestock watering and wildlife, and recreation.

Table 2 Final 2008 303(d) List for Stream Impairment Due to Dioxins and PCBs

Waterbody ID	Impacted Waterbody	River Miles Impaired	Cause (Pollutant)	Pollutant Source
TN060200011244_1000 Chattanooga Creek from Nickajack Reservoir to Hooker Road.	Chattanooga Creek	8.4	PCBs Dioxins Low dissolves oxygen Escherichia coli Other Anthropogenic Habitat Alterations Oil and Grease	Combined Sewer Overflows Discharges from MS4 area Municipal High Density Area Spills Contaminated Sediment

Note: There is a fishing advisory for Chattanooga Creek from the mouth to the Georgia state line (7.7 miles).

Figure 4 Waterbody Impaired with Dioxins and PCBs (as documented on the Final *2008 303(d) List*)



3.1 Dioxins

Dioxins are a group of synthetic organic chemicals that contain 210 structurally related (congeners) chlorinated dibenzo-p-dioxins (CDD's) and chlorinated dibenzofurans (CDFs) (USEPA, 1999). Some polychlorinated biphenyls (PCBs) are also regarded as "dioxin-like" in nature. Each congener possesses different physical and chemical properties. As a result, there is a range of toxicity among these structurally related organics. 2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) is the most toxic of any dioxins. Toxic Equivalent Factors (TEFs) were derived to express the toxicity of other dioxins "as a fraction of the toxicity attributed to 2,3,7,8-TCDD" (ATSDR, 1998).

Dioxins are largely created as unintentional by-products of incomplete combustion and various chemical processes, like chlorine bleaching in pulp and paper mills, and as contaminants during the production of some chlorinated organic chemicals such as chlorinated phenols (USEPA, 1999). These chlorinated hydrocarbons are persistent environmental contaminants, with environmental half-lives ranging from years to several decades. According to *An Inventory of Sources and Environmental Releases of Dioxin-Like Compounds in the United States for the Years 1987, 1995, and 2000*, "dioxin-like compounds enter surface water from atmospheric deposition, stormwater runoff erosion, and discharges of anthropogenic wastes" (USEPA, 2006).

Humans are predominately exposed to dioxins through dietary intake. Dioxins have been demonstrated to bioaccumulate in the aquatic food chain; therefore, contaminated fish and shellfish are a primary route of exposure. The exposure to any dioxins is associated with a number of adverse effects. EPA has classified dioxins as Group B2 (probable carcinogen). Furthermore, experiments "have shown toxic effects to the liver, gastrointestinal system, blood, skin, endocrine system, immune system, nervous system, and reproductive system" (USEPA, 1999).

3.2 Polychlorinated Biphenyls (PCBs)

There are approximately 209 congeners of polychlorinated biphenyls. These 209 synthetic organic compounds vary not only in their physical and chemical properties, but also in their toxicity (USEPA, 1999a). PCBs were sold as a mixture that was based upon the percentage of chlorination. Aroclor 1248, 1254, and 1260 indicate the relative percentages 48, 54, and 60 percent respectively of chlorination contained in each of these mixtures.

PCBs were manufactured in the United States from the 1920's until 1979 when they were banned by the U.S. Environmental Protection Agency. Prior to this ban, PCBs were commonly used as coolants and lubricants in transformers, capacitors and other electrical equipment. The manufacturing ban on PCBs did not require all PCB-containing materials to be removed from use. Therefore, some PCBs may still be utilized commercially. So, although the production of PCBs has ceased, these chemicals are widely distributed throughout the environment (USEPA, 1999a). Some other products made before 1977 that may contain PCBs include old fluorescent lighting fixtures and electrical devices containing PCB capacitors and old microscope and hydraulic oils (ATSDR, 2001).

As stated in *Fact Sheet: Polychlorinated Biphenyls Update: Impact on Fish Advisories* (USEPA, 1999a):

> Currently, the major source of PCBs is environmental reservoirs from past releases. PCBs have been detected in soil, surface water, air, sediment, plants, and animal tissue in all regions of the earth. PCBs are highly persistent in the environment with reported half-lives in soil and sediment ranging from months to years.

Once in the sediment, PCBs can enter the aquatic food chain. PCBs are fat-soluble chemicals with the potential to concentrate in fish tissue. As a result, humans may be exposed to PCBs through the consumption of contaminated foods, primarily contaminated fish. Studies have demonstrated adverse health effects resulting from PCB exposure. PCBs are classified by EPA as Group B2 (probable carcinogen). PCBs have also been shown to be toxic to the immune system, the reproductive system, the nervous system, and the endocrine system (USEPA, 1999a).

4.0 TARGET IDENTIFICATION

In order for a TMDL to be established, a numeric "target" protective of the uses of the water body segments must be identified to serve as the basis for the TMDL. Fish tissue target criteria will be used in this TMDL because, in the State of Tennessee, assessment of waterbody segments for impairment due to dioxins and PCBs is based on fish tissue concentration. A detailed discussion of the calculations involved in the development of fish tissue target criteria, and the relationship of fish tissue concentrations to published numerical water column criteria, is included in Appendix A. For the purpose of this TMDL, target criteria expressed as the fish tissue concentrations are summarized in Table 3. These values are based on the water quality criteria for the recreation designated use classification.

Table 3 Fish Tissue Target Criteria

Pollutant	Target Criteria (mg/kg)
Dioxins	5.0E-06
PCBs	0.0200

5.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

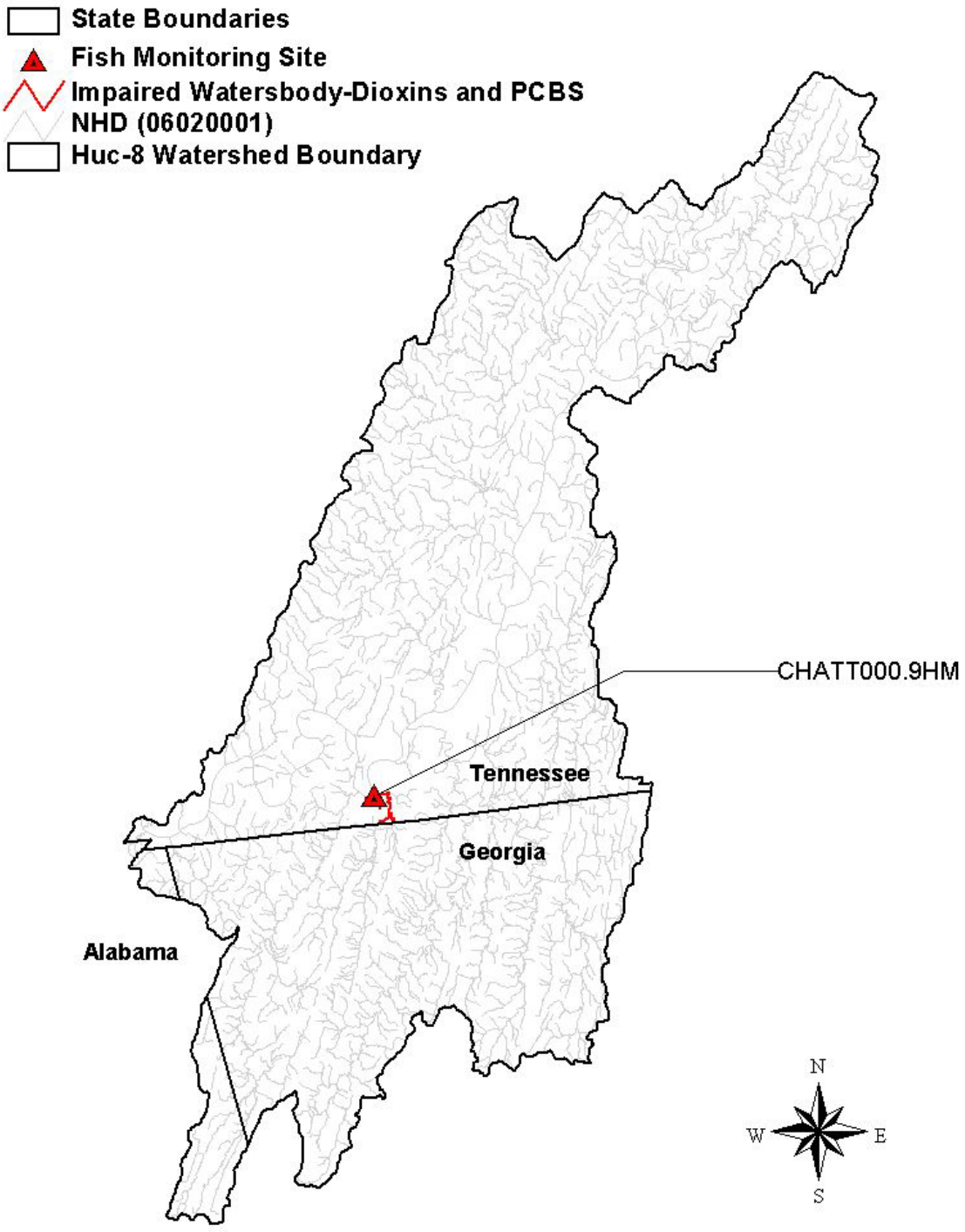
Fish tissue samples were collected and analyzed as defined in *The Results of Fish Tissue Monitoring in Tennessee 1992-1997* (TDEC). Fish tissue data were available from one station (CHATT000.9HM). Examination of the data shows exceedances of fish tissue target criteria established in Section 4.0. Table 4 presents a summary of the fish tissue monitoring results for these stations compared to the fish tissue target criteria.

The location of the monitoring site is shown in Figure 5. Fish tissue monitoring data for this site are tabulated in Appendix B.

Table 4 Fish Tissue Monitoring Data

Monitoring Station	Waterbody ID	Date Range	Pollutant	Data Points	Target (mg/kg)	Max. (mg/kg)	No. > target
CHATT000.9HM	TN060200011244_1000	1995-1997	Dioxins	9	5.0E-06	6.94E-06	3
		1990-1998	PCBs	28	0.0200	3.29	25

Figure 5 Fish Tissue Monitoring Site



6.0 SOURCE ASSESSMENT

An important part of the TMDL analysis is the identification of individual sources, source categories, or source subcategories of pollutants in the watershed and the amount of pollutant loading contributed by each of these sources. According to the Clean Water Act, sources are broadly classified as either point or non-point sources. Under 40 CFR §122.2, a point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. The National Pollutant Discharge Elimination System (NPDES) program regulates point source discharges. Regulated point sources include: 1) municipal and industrial wastewater treatment facilities (WWTFs); 2) storm water discharges associated with industrial activity (which includes construction activities); and 3) certain discharges from Municipal Separate Storm Sewer Systems (MS4s). For the purposes of these TMDLs, all sources of pollutant loading not regulated by NPDES are considered non-point sources.

6.1 Point Sources

There are numerous permitted dischargers in the Lower Tennessee River Watershed. However, there are currently no permitted point source dischargers with existing allocations for dioxins or PCBs in the Lower Tennessee River Watershed.

6.2 Non-point Sources

Assessments have determined that contaminated sediment is the source of dioxin and PCB impairments in Chattanooga Creek. There is one National Priorities List (NPL) site located in the Lower Tennessee River Watershed.

The Tennessee Products Superfund site (TND071516959) consists of the former Tennessee Products coal carbonization facility and its associated coal-tar dumping areas in Chattanooga Creek and its floodplain. The former coke plant is located at 4800 Central Avenue, south of Hamill/Hooker Road in Chattanooga, Tennessee. The coke plant operated from 1918 until 1987. Uncontrolled dumping of coal-tar wastes has contaminated the facility, groundwater underlying the facility, and surface water/sediment of Chattanooga Creek downstream of the facility. Coal-tar wastes are present along an approximate 2.5 mile reach of the Creek extending from just upstream of the Hamill Road Bridge to the downstream confluence with one of its tributaries, Dobbs Branch.

Environmental investigations have been conducted on Chattanooga Creek by EPA, the Tennessee Department of Environment and Conservation (TDEC), and others since 1973. Due to elevated levels of contamination in the sediments and surface waters, TDEC issued a health advisory for the Creek in 1983, and a fish consumption advisory in 1992. In August 1993, the Agency for Toxic Substances and Disease Registry (ATSDR) issued a Public Health Advisory for the Tennessee Products site based on the chemical and physical hazards presented by the coal-tar deposits. ATSDR recommended that nearby residents avoid contact with the coal-tar deposits and that the site be considered for inclusion on the National Priorities List (NPL). The site was listed on the NPL in September 1995.

In 1993, EPA fenced a section of the Creek to prevent public access. In 1994, EPA initiated a fund-lead Remedial Investigation//Feasibility Study (RI/FS) of the Chattanooga Creek study area. By November 1998, EPA completed a non-time critical removal action that focused on the

upper reach of Chattanooga Creek. This action removed coal-tar deposits and contaminated sediments along a one-mile section of Chattanooga Creek between Hamill Road and 1,200 feet north of the 38th Street bridge. Approximately 25,300 cubic yards of coal-tar and contaminated sediment were removed from the creek. In addition, 1,150 cubic yards of pesticide contaminated sediment was removed from the creek and disposed at a local municipal landfill.

EPA finalized the Record of Decision (ROD) in September 2002, and issued an Explanation of Significant Differences in August 2004. The selected remedial action includes excavation of visually impacted sediments from the middle reach of Chattanooga Creek and a spoil pile along the Northeast Tributary utilizing standard construction methods, consolidation and disposal of sediments and stabilization of disturbed creek banks. In May 2005, EPA entered into a Remedial Design/Remedial Action Consent Decree with the Chattanooga Creek Cleanup Committee . This Consent Decree recovered past response costs incurred by EPA and secured a commitment to perform the final phase of cleanup that involves approximately 1.9 miles of Chattanooga Creek from north of the 38th Street Bridge to the confluence with Dobbs Branch. Cleanup work required by the May 2005 Consent Decree was initiated in September 2005 and was finished in September 2007 (USEPA, 2008).

These TMDLs will consider contaminated sediment as the primary source of dioxins and PCBs in Chattanooga Creek. According to the U.S. Environmental Protection Agency, these pollutants have a very low solubility in water and low volatility and they are contained in sediments that serve as reservoirs from which these pollutants may be released over a long period of time (USEPA, 1999, 1999a, 2006).

7.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOADS

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), non-point source loads (Load Allocations) and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$TMDL = \Sigma WLAs + \Sigma LAs + MOS$$

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure.

7.1 Critical Conditions and Seasonal Variation

Critical conditions were incorporated into the TMDL analysis by using the entire period of record (1990-1998) for the fish tissue monitoring data. Fish tissue data were collected during a variety of seasons. Dioxin and PCB concentrations are not expected to fluctuate very much due to the fact that these pollutants are contained mainly in the sediment.

7.2 Determination of TMDLs

In this document, the TMDLs are daily loads expressed as a function of the annual average flow (daily loading function). The daily load is calculated by multiplying the water quality criterion by the annual average flow (represented by Q) and the required unit conversion factor.

Example: Water quality criterion for PCBs = 0.00064 μg/L
Conversion Factor = 5.39×10^{-3} (lbs-L-sec/(μg-ft^3-day))
Daily Load = Q * 3.45×10^{-6} lbs/day

The TMDLs were developed based on fish tissue target criteria which are the equivalent of the water quality criteria (See Appendix A for a more detailed explanation). For implementation purposes, the TMDLs are also expressed as maximum water column concentrations and maximum fish tissue concentrations

7.3 Margin of Safety

There are two methods for incorporating a Margin of Safety (MOS) in TMDL analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. In these TMDLs, a 5% explicit MOS was incorporated to account for uncertainties.

7.4 Determination of WLAs & LAs

There are currently no permitted point source dischargers with existing allocations for dioxins or PCBs. Waste load allocations of zero are being provided. The load allocation requires the contribution from non-point sources to be less than or equal to the TMDL target value. In the absence of point sources:

$$LA = TMDL - MOS$$

TMDLs, WLAs, and LAs are summarized in Table 5.

Table 5 TMDLs, WLAs, and LAs for the Lower Tennessee River Watershed

Waterbody ID	Pollutant	WLAs	LAs[1]	MOS[1]	TMDLs		
					Maximum Load[1]	Maximum Water Column Concentration[2]	Maximum Fish Tissue Concentration[2]
		(lbs/day)	(lbs/day)[3]	(lbs/day)[3]	(lbs/day)[3]	(μg/L)	(mg/kg)
TN060200011244_1000	Dioxins	0	Q * 5.12E-09	Q * 2.70E-10	Q * 5.39E-09	1.0E-06	5.0E-06
	PCBs	0	Q * 3.28E-06	Q * 1.73E-07	Q * 3.45E-06	0.00064	0.0200

1 The LA, MOS, and the Maximum Load TMDL are expressed as a function of flow (Q), where Q represents the annual average flow of the Chattanooga Creek at the pour point of the segment.

2 The TMDL is also expressed in terms of maximum allowable water column concentration and maximum fish tissue concentration because TDEC recognizes that these values provide information that potentially will be more useful regarding TMDL implementation efforts than the values that are expressed in terms of an allowable load.

3 Lbs/day calculated as an annual average.

8.0 IMPLEMENTATION PLAN

8.1 Point Sources

There are currently no NPDES permitted facilities in the Lower Tennessee River Watershed with an existing allocation to discharge dioxins or PCBs to the Chattanooga Creek.

8.2 Non-point Sources

The Tennessee Department of Environment & Conservation (TDEC) has no direct regulatory authority over most non-point source discharges. Voluntary, incentive-based mechanisms will be used to implement non-point source management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the impaired waterbody.

One segment of the Chattanooga Creek was listed as impaired on the *2008 303(d) List* because it was not fully supporting designated use classifications due, in part, to elevated levels of dioxins and PCBs. Contaminated sediment was identified as the likely source for dioxin and PCB contamination in Chattanooga Creek.

There are generally two options to prevent dioxins and PCBs contained in the sediment from being released to the waterbody: 1) avoid disturbing the sediment or 2) remediate contaminated sites. TDEC recommends using option one whenever possible. On the other hand, if the sediment must be disturbed, remediation efforts will be necessary to control the load of dioxins and PCBs so that the water quality criteria are not exceeded. Strategies to identify sites with elevated levels of dioxins and PCBs may be helpful for implementing controls to prevent the contaminants from being released into Chattanooga Creek. As less of the contaminants become biologically available the concentrations of dioxins, and PCBs measured in fish tissue samples should theoretically decline. Most importantly, continued fish tissue monitoring is advised to ensure that contamination decreases as time passes. This will help determine if additional loading is occurring.

8.3 Evaluation of TMDL Implementation Effectiveness

The effectiveness of these TMDLs will be assessed as data becomes available or when necessary. Watershed monitoring and assessment activities will provide information by which the effectiveness of dioxin and PCB load allocations can be evaluated. Continued fish tissue sampling will be necessary to monitor the efficacy of the proposed TMDLs. These results will be reevaluated during subsequent water quality assessment cycles as required by the Clean Water Act.

9.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed TMDLs for dioxins and PCBs in the Chattanooga Creek was placed on Public Notice for a 35-day period and comments were solicited. Steps taken in this regard included:

1) Notice of the proposed TMDLs was posted on the Tennessee Department of Environment and Conservation website. The notice invited public and stakeholder comments and provided a link to a downloadable version of the TMDL document.

2) Notice of the availability of the proposed TMDLs (similar to the website announcement) was be included in one of the NPDES permit Public Notice mailings, which was sent to interested persons or groups who have requested this information.

3) A letter was sent to identified water quality partners in the Lower Tennessee River Watershed advising them of the proposed dioxins and PCB TMDLs and their availability on the TDEC website. The letter also stated that a written copy of the Draft TMDL document would be provided upon request. A letter was sent to the following partners:

Natural Resources Conservation Service
Tennessee Department of Agriculture
Tennessee Water Sentinels
United States Fish and Wildlife Service
United States Geological Survey
Nature Conservancy
Southeast Tennessee RC&D Council

4) A draft copy of the proposed TMDLs was sent to the following MS4s:

TNS068063	City of Chattanooga
TNS075566	Hamilton County
TNS077585	Tennessee Department of Transportation

No comments were received during the public notice period.

10.0 FURTHER INFORMATION

Further information concerning Tennessee's TMDL program can be found on the Internet at the Tennessee Department of Environment and Conservation website:

http://www.state.tn.us/environment/wpc/tmdl/

Technical questions regarding these TMDLs should be directed to the following members of the Division of Water Pollution Control staff:

Vicki S. Steed, P.E., Watershed Management Section
E-mail: Vicki.Steed@state.tn.us

Sherry H. Wang, Ph.D., Watershed Management Section
E-mail: Sherry.Wang@state.tn.us

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APPENDIX A

Development of Target Criteria For PCBs and Dioxins

In the State of Tennessee, assessment of waterbody segments for impairment due to dioxins and PCBs is based on fish tissue concentrations. Public fishing advisories are also based upon fish tissue concentrations. Therefore, for the purpose of this TMDL, development of target criteria will be based on fish tissue concentration.

PCB Methodology

The formula for calculating the fish tissue concentration requiring a fish advisory is established by *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, October 2007* (TDEC, 2007). Section 1200-4-3-.03 (4) (l) is summarized below:

$$R = q * E \quad \text{(Equation A-1)}$$

where:

R = Plausible-upper-limit risk of cancer associated with a chemical in a fish species; in Tennessee, a risk level of 10^{-5} is used when considering a fish advisory
q = Carcinogenic Potency Factor for the specific chemical (kg-day/mg)
E = Exposure dose of the specific chemical (mg/kg-day) from the fish species

E is calculated based on the following formula:

$$E = C * I * X / W \quad \text{(Equation A-2)}$$

where:

C = Concentration of the chemical (mg/kg) in the edible portion of the fish species
I = Ingestion rate (g/day) of the fish species; 17.5 g/day will be used (USEPA, 2002)
X = Relative absorption coefficient; assumed to be 1.0
W = Average human mass (kg); 70 kg will be used (USEPA, 2002)

Combining equations A-1 and A-2 and solving for fish tissue concentration (C) results in the following equation:

$$C = (R * CF1 * W) / (q * I * X) \quad \text{(Equation A-3)}$$

where:

CF1 = Conversion Factor (1000 g/kg)

Once the fish tissue target concentration has been determined using Equation A-3, the corresponding water column concentration can be determined using the following equation:

$$C_{water} = [C_{fish} * CF2] / BCF \quad \text{(Equation A-4)}$$

where:

CF2 = Conversion Factor (1000 μg /mg)
BCF = Bioconcentration Factor (L/kg)

Using Equations A-3 and A-4 and published values for q and BCF (USEPA, 2002), the target fish tissue concentrations were calculated for the waterbody (TN06020001001244_1000).

Table A-1 Target Fish Tissue Concentrations

Pollutant	q	C_{fish}	BCF	C_{water}
	(kg-day/mg)	(mg/kg)	(L/kg)	(μg/L)
PCB	2.0	0.0200	31,200	0.00064

The fish tissue concentrations given in Table A-1 were calculated using the methodology developed on the previous page. These fish tissue concentrations are more stringent than the fish tissue concentrations calculated from the water column criteria established for the fish and aquatic life use classification. Therefore, the fish tissue concentrations in Table A-1 will be used as the target criteria for this TMDL.

Dioxin Methodology

For dioxin, a different methodology is used to determine water quality criterion and the fish advisory level. The fish tissue concentration requiring a fish advisory is based on the water quality criterion as established by *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, October 2007* (TDEC, 2007). The water quality criterion is based on a combination of EPA and USFDA assumptions and was approved by EPA in 1999. (For a more complete explanation, see *Dioxin Levels in Pigeon River Fish: 1996-2002* [TDEC, 2002]). The water criterion of 1 ppq is multiplied by the bioconcentration factor for dioxin and the appropriate conversion factor:

$$C_{fish} = [C_{water} * BCF] / CF2 \qquad \text{(Equation A-5)}$$

where:

CF2 = Conversion Factor (1000 μg/mg)
BCF = Bioconcentration Factor (5,000 L/kg)

The resulting fish tissue concentration is:

$$C_{fish} = [(1x10^{-6}\ \mu g/L) * (5000\ L/kg)] / (1000\ \mu g/mg) = 5x10^{-6}\ mg/kg$$

where:

$1\ ppq = 1x10^{-6}\ \mu g/L$

Therefore, the fish tissue concentration calculated from Equation A-5 ($5x10^{-6}$ mg/kg) will be used as the target criterion for this TMDL.

APPENDIX B

Fish Tissue Monitoring Data For Dioxins and PCBs

There was one site that provided fish tissue data for Chattanooga Creek. The location of this monitoring station is shown in Figure 5. Fish tissue data recorded at this site are tabulated in Tables B-1 and B-2.

In Table B-1, total dioxins were calculated as the sum of the concentrations of all polychlorinated dibenzo-p-dioxins (CDD) and and polychlorinated dibenzofuran (CDF) isomers after multiplication by the appropriate Toxic Equivalent Factor (TEF):

$$C_{dioxins} = \Sigma [C_i \times TEF_i]$$

where:

$C_{dioxins}$ = Total dioxins measured in fish tissue samples (ppt)
C_i = Concentration of isomer *i* in fish tissue samples (ppt)
TEF_i = Toxic Equivalent Factor specific for isomer *I*

The TEF approach compares the relative potential toxicity of each dioxin like compound in the mixture to the toxicity of 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD), the most toxic member of the group. The TEF for 2,3,7,8-TCDD is defined as unity; and the TEFs for all other polychlorinated dibenzo-p-dioxins (CDDs), polychlorodibenzofurans (CDFs), and certain coplanar polychlorinated biphenyls (PCBs) are defined with values that are less than one which reflects their lower toxic potency relative to 2,3,7,8 TCDD (USEPA, 2006).

The TEFs used in this TMDL were recommended by the EPA (USEPA, 2007).

In Table B-2, PCB data presented is for the sum of Aroclor 1248, 1254, and 1260.

Table B-1 Fish Tissue Monitoring Data for Dioxins

Monitoring Site ID	Date	Fish Species	Total Dioxins ppt	Total Dioxins mg/kg
CHATT000.9HM	1995	Channel Catfish	5.14	5.14E-06
	1995	Channel Catfish	5.83	5.84E-06
	1997	Largemouth Bass	0.91	9.14E-07
	1997	Channel Catfish	6.94	6.94E-06
	1997	Spotted Sucker	0.24	2.43E-07
	1997	Largemouth Bass	0.027	2.69E-08
	1997	Channel Catfish	2.40	2.40E-06
	1997	Channel Catfish	3.48	3.48E-06
	1997	Spotted Sucker	1.20	1.20E-06

Table B-2 Fish Tissue Monitoring Data for PCBs

Monitoring Site ID	Date	Fish Species	Total PCBs mg/kg
CHATT000.9HM	1990	Channel Catfish	1.43
	1990	Largemouth Bass	0.122
	1990	Carp	1.14
	1991	Channel Catfish	3.16
	1991	Channel Catfish	3.29
	1991	Channel Catfish	2.93
	1991	Channel Catfish	1.64
	1991	Channel Catfish	2.58
	1991	Channel Catfish	0.851
	1991	Largemouth Bass	0.264
	1991	Largemouth Bass	0.758
	1991	Largemouth Bass	0.222
	1991	Largemouth Bass	0.035
	1991	Spotted Sucker	ND
	1995	Channel Catfish	0.482
	1995	Channel Catfish	0.671
	1995	Spotted Sucker	ND
	1995	Largemouth Bass	ND
	1997	Largemouth Bass	0.087
	1997	Channel Catfish	0.434
	1997	Spotted Sucker	0.056
	1997	Largemouth Bass	0.029
	1997	Channel Catfish	0.336
	1997	Channel Catfish	0.157
	1997	Spotted Sucker	0.075
	1998	Channel Catfish	0.770
	1998	Largemouth Bass	0.399
	1998	Spotted Sucker	0.200

APPENDIX C

Public Notice Announcement

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDLS) FOR DIOXINS & POLYCHLORINATED BIPHENYLS FOR CHATTANOOGA CREEK IN THE LOWER TENNESSEE RIVER WATERSHED (HUC 06020001), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed Total Maximum Daily Loads (TMDLs) for dioxins and polychlorinated biphenyls (PCBs) for the Chattanooga Creek Watershed, located in eastern Tennessee. Section 303(d) of the Clean Water Act requires states to develop TMDLs for waters on their impaired waters list. TMDLs must determine the allowable pollutant load that the water can assimilate, allocate that load among the various point and nonpoint sources, include a margin of safety, and address seasonality.

Chattanooga Creek was identified on Tennessee's Final 2008 303(d) list as not supporting designated use classifications due to elevated levels of dioxins and polychlorinated biphenyls (PCBs) in fish tissue samples. Contaminated sediments are the source of pollutant causes associated with these impairments. Using a mass-balance approach, the TMDLs utilize Tennessee's general water quality criteria, fish tissue sampling data collected from the mouth of Chattanooga Creek, fish advisory calculations, Bioconcentration Factors defined by the U.S. Environmental Protection Agency, and an appropriate Margin of Safety (MOS) to establish dioxin and PCB loading levels which will result in lower fish tissue concentrations and the attainment of water quality standards.

The proposed dioxins and PCB TMDLs may be downloaded from the Department of Environment and Conservation website:

http://www.state.tn.us/environment/wpc/tmdl/

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Pollution Control staff:

Vicki S. Steed, P.E., Watershed Management Section
Telephone: 615-532-0707

Sherry H. Wang, Ph.D., Watershed Management Section
Telephone: 615-532-0656

Persons wishing to comment on the proposed TMDL are invited to submit their comments in writing no later than June 22, 2009 to:

Division of Water Pollution Control
Watershed Management Section
7th Floor, L & C Annex
401 Church Street
Nashville, TN 37243-1534

All comments received prior to that date will be considered when revising the TMDL for final submittal to the U.S. Environmental Protection Agency.

The TMDL and supporting information are on file at the Division of Water Pollution Control, 6th Floor, L & C Annex, 401 Church Street, Nashville, Tennessee. They may be inspected during normal office hours. Copies of the information on file are available on request.