PROPOSED
TOTAL MAXIMUM DAILY LOADS (TMDLs)

For
Polychlorinated Biphenyls (PCBs)
In
Cheatham Reservoir

Cheatham Lake Watershed (HUC 05130202)
and
Lake Barkley Watershed (HUC 05130205)

Cheatham, Davidson, Dickson, Robertson, Sumner, and Williamson Counties, Tennessee

DRAFT

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LIST OF ABBREVIATIONS

ATTAINS	Assessment and TMDL Tracking Implementation System
BCF	Bioconcentration Factor
BMP	Best Management Practices
CFR	Code of Federal Regulations
DWR	Division of Water Resources
GIS	Geographic Information System
HRT	Hydraulic Retention Time
HUC	Hydrologic Unit Code
LA	Load Allocation
MDL	Method Detection Limit
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
MS4	Municipal Separate Storm Sewer System
NHD	National Hydrography Dataset
NPS	Non-point Source
NPDES	National Pollutant Discharge Elimination System
PCB	Polychlorinated Biphenyl
PLRG	Percent Load Reduction Goal
POR	Period of Record
RM	River Mile
TDEC	Tennessee Department of Environment & Conservation
TEF	Toxic Equivalent Factor
TMDL	Total Maximum Daily Load
USACE	United States Army Corp. of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WLA	Waste Load Allocation

SUMMARY SHEET

CHEATHAM RESERVOIR

Total Maximum Daily Load for Polychlorinated Biphenyls (PCBs) in Cheatham Lake Watershed (05130202)

Impaired Waterbody Information (Based on TDEC's Final 2024 List of Impaired and Threatened Waters)

State: Tennessee
Counties: Cheatham, Davidson, Dickson, Robertson, Sumner, and Williamson
Watershed: Cheatham Lake Watershed (HUC 05130202) and
Lake Barkley Watershed (HUC 05130205)
Constituents of Concern: Polychlorinated Biphenyls (PCBs)

Waterbody ID	Impaired Waterbody	Acres
TN05130202001_1000	Cheatham Reservoir (from Cheatham Dam to Marrowbone Creek)	2,264
TN05130202001_2000	Cheatham Reservoir (from Marrowbone Creek to Bordeaux Bridge)	2,449
TN05130202001_3000	Cheatham Reservoir (from Bordeaux Bridge to Woodland Street Bridge [downtown Nashville])	994
TN05130202001_4000	Cheatham Reservoir (from Woodland Street Bridge [downtown Nashville] to Stones River)	1,000
TN05130202001_5000	Cheatham Reservoir (from Stones River to Old Hickory Dam)	740

Designated Uses: Domestic water supply, fish & aquatic life, industrial water supply, irrigation, livestock watering & wildlife, and recreation.

Applicable Water Quality Standard: Most stringent numerical criteria applicable to recreation use classification

(PCBs): 0.00064 µg/L

Toxic Substances: The waters shall not contain toxic substances, whether alone or in combination with other substances, that will render the waters unsafe or unsuitable for water contact activities including the capture and subsequent consumption of fish and shellfish, or will propose toxic conditions that will adversely affect man, animal, aquatic life, or wildlife. Human health criteria have been derived to protect the consumer from consumption of contaminated fish and water. The water and organisms criteria should only be applied to those waters classified for both recreation and domestic water.

TMDL Development

General Analysis Methodology:

- Fish tissue samples are collected and analyzed for constituents of concern. Existing loads of PCBs in the water column are estimated from the fish tissue concentrations using the Bioconcentration Factors defined by the U.S. Environmental Protection Agency.

- Maximum allowable loads are based on the product of the mean pool volume and the water quality criteria established by the Tennessee Department of Environment and Conservation, Division of Water Resources.

- TMDLs are established by dividing the maximum allowable loads by the hydraulic retention time.

- Waste Load Allocations (WLAs) are derived for point source dischargers of PCBs, if any.

- Load Allocations are established for non-point sources using a mass-balance approach.

Critical Conditions: Methodology takes into account all flow conditions.

Seasonal Variation: Methodology addresses all seasons.

Margin of Safety (MOS): 20% (Explicit).

TMDLs and Allocations for Cheatham Reservoir

Waterbody ID	Impaired Waterbody	Pollutant	TMDL	MOS	WLA	LA	*Required Overall Load Reduction**
			[lb/day]	[lb/day]	[lb/day]	[lb/day]	*[%]*
TN05130202001_1000	Cheatham Reservoir	PCBs	0.0874	0.0175	0.00	0.0699	*94.3*
TN05130202001_2000							
TN05130202001_3000							
TN05130202001_4000							
TN05130202001_5000							

*Note: Load reduction required to achieve TMDL.

TOTAL MAXIMUM DAILY LOADS (TMDLs) FOR POLYCHLORINATED BIPHENYLS (PCBs) CHEATHAM RESERVOIR

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

A watershed is an area of land that drains all of the streams and rainfall to a common outlet or pourpoint. Watersheds vary in size and shape. A standardized system for organizing and collecting hydrologic data was developed in the mid-1970s by the United States Geological Survey (USGS). The system divided and subdivided the United States into successively smaller hydrologic units based on surface features (Seaber, et al, 1987). The hierarchical Hydrologic Unit Code (HUC) consists of two-digit numbers for each of the nested hydrologic unit levels. The Cheatham Lake watershed is part of the Ohio Region or HUC-2 05. The Ohio Region is sub-divided into fourteen Sub-Regions. The Cheatham Lake watershed is part of the Cumberland Sub-Region or HUC-4 0513. The Cumberland Sub-Region has a drainage area of approximately 17,700 mi^2. The Cumberland Sub-Region is sub-divided into the Upper Cumberland Accounting Unit or HUC-6 051301 and the Lower Cumberland Accounting Unit or HUC-6 051302. Each Accounting Unit is further sub-divided into Cataloging Units or HUC-8s.

Cheatham Reservoir is a portion of the Cumberland River created by the presence of Cheatham Dam. United States Army Corp. of Engineers (USACE) maintains the reservoir. Most of the Cheatham Reservoir is located within the Cheatham Lake Watershed, with a small portion located in the Lake Barkley Watershed. (The portion located in the Lake Barkley Watershed is identified as HUC 05130205-0302 in the figures.) The Cheatham Lake Watershed is located in middle Tennessee (ref.: Figure 1) and includes parts of Cheatham, Davidson, Robertson, Sumner, and Williamson Counties. The Cheatham Lake Watershed, HUC 05130202, has approximately 773 miles of streams (based on EPA's National Hydrography Dataset [NHD] Medium Resolution [1:100,000]) and 7,500 reservoir acres, and has a drainage area of approximately 647 square miles (mi^2).

Watershed land use distribution is based on the Multi-Resolution Land Characteristic (MRLC) databases derived from Landsat Thematic Mapper digital images from approximately 2021. Although changes in the land use of the Cheatham Lake Watershed have occurred since 2021

as a result of rapid development, this is the most current land use data available. Table 1 summarizes land use for the Cheatham Lake Watershed, as shown in Figure 3.

The Cheatham Lake watershed lies within one Level III ecoregion (Interior Plateau) and contains four Level IV subecoregions as shown in Figure 3 (USEPA, 1997):

- The **Western Pennyroyal Karst (71e)** is a flatter area of irregular plains, with fewer perennial streams, compared to the open hills of the Western Highland Rim (71f). Small sinkholes and depressions are common. The productive soils of this notable agricultural area are formed mostly from a thin loess mantle over residuum of Mississippian-age limestones. Most of the region is cultivated or in pasture; tobacco and livestock are the principal agricultural products, with some corn, soybeans, and small grains. The natural vegetation consisted of oak-hickory forest with mosaics of bluestem prairie. The barrens of Kentucky that extended south into Stewart, Montgomery, and Robertson counties, were once some of the largest natural grasslands in Tennessee.
- The **Western Highland Rim (71f)** is characterized by dissected, rolling terrain of open hills, with elevations of 400 to 1000 feet. The geologic base of Mississippian-age limestone, chert, and shale is covered by soils that tend to be cherty, acidic, and low to moderate in fertility. Streams are characterized by coarse chert gravel and sand substrates with areas of bedrock, moderate gradients, and relatively clear water. The oak-hickory natural vegetation was mostly deforested in the mid to late 1800's, in conjunction with the iron ore related mining and smelting of the mineral limonite, but now the region is again heavily forested. Some agriculture occurs on the flatter areas between streams and in the stream and river valleys: mostly hay, pasture, and cattle, with some cultivation of corn and tobacco.
- The **Outer Nashville Basin (71h)** is a more heterogeneous region than the Inner Nashville Basin, with more rolling and hilly topography and slightly higher elevations. The region encompasses most of the outer areas of the generally non-cherty Ordovician limestone bedrock. The higher hills and knobs are capped by the more cherty Mississippian-age formations, and some Devonian-age Chattanooga shale, remnants of the Highland Rim. The region's limestone rocks and soils are high in phosphorus, and commercial phosphate is mined. Deciduous forests with pasture and cropland are the dominant land covers. Streams are low to moderate gradient, with productive nutrient-rich waters, resulting in algae, rooted vegetation, and occasionally high densities of fish. The Nashville Basin as a whole has a distinctive fish fauna, notable for fish that avoid the region, as well as those that are present.
- The **Inner Nashville Basin (71i)** is less hilly and lower than the Outer Nashville Basin. Outcrops of the Ordovician-age limestone are common, and the generally shallow soils are redder and lower in phosphorus than those of the Outer Basin. Streams are lower gradient than surrounding regions, often flowing over large expanses of limestone bedrock. The most characteristic hardwoods within the Inner Basin are a maple-oak-hickory-ash association. The limestone cedar glades of Tennessee, a unique mixed grassland/forest/cedar glades vegetation type with many endemic species, are located primarily on the limestone of the Inner Nashville Basin. The more xeric, open characteristics and shallow soils of the cedar glades also result in a distinct distribution of amphibian and reptile species.

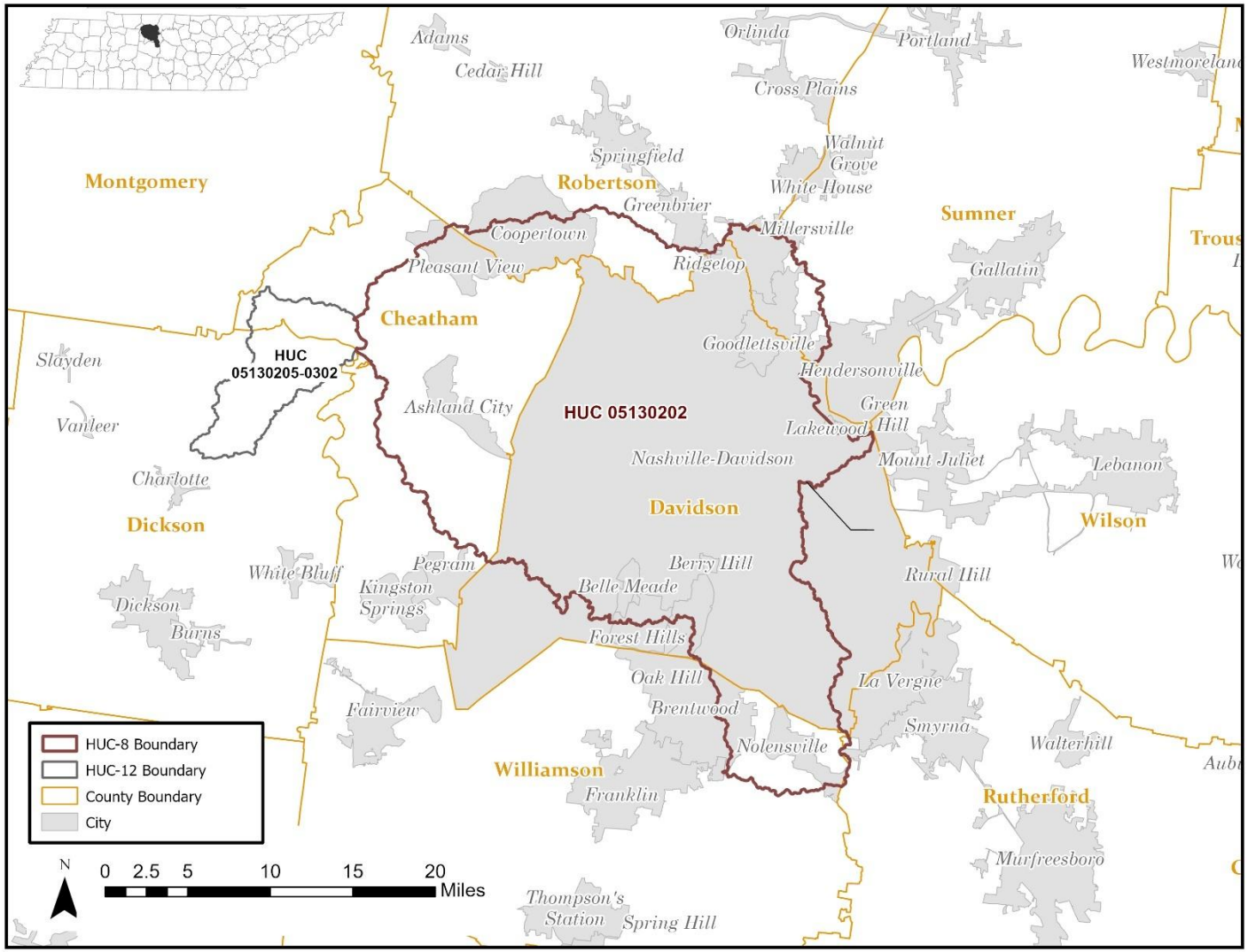

Figure 1. Location of Cheatham Lake Watershed

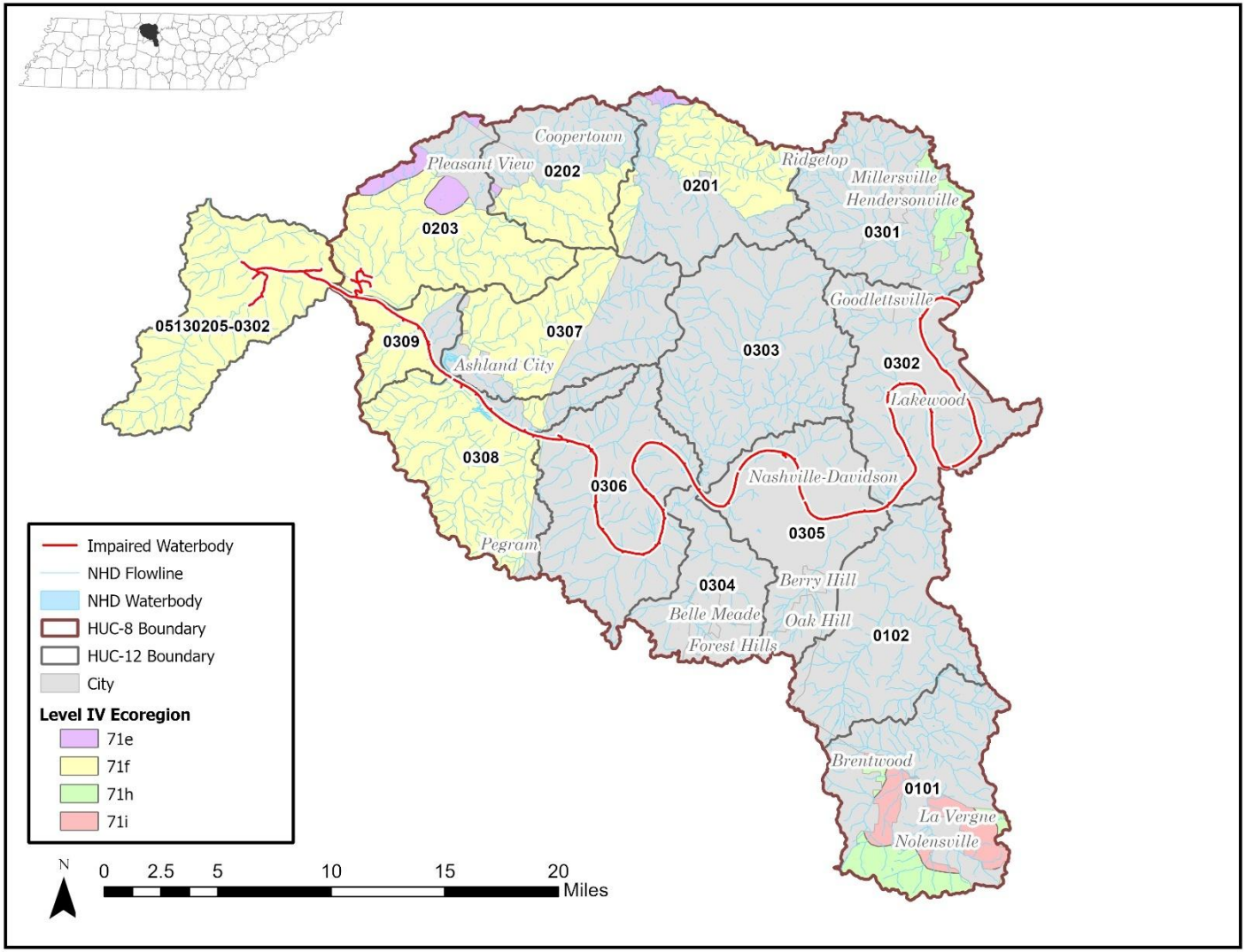

Figure 2. Level IV Ecoregions in the Cheatham Lake Watershed

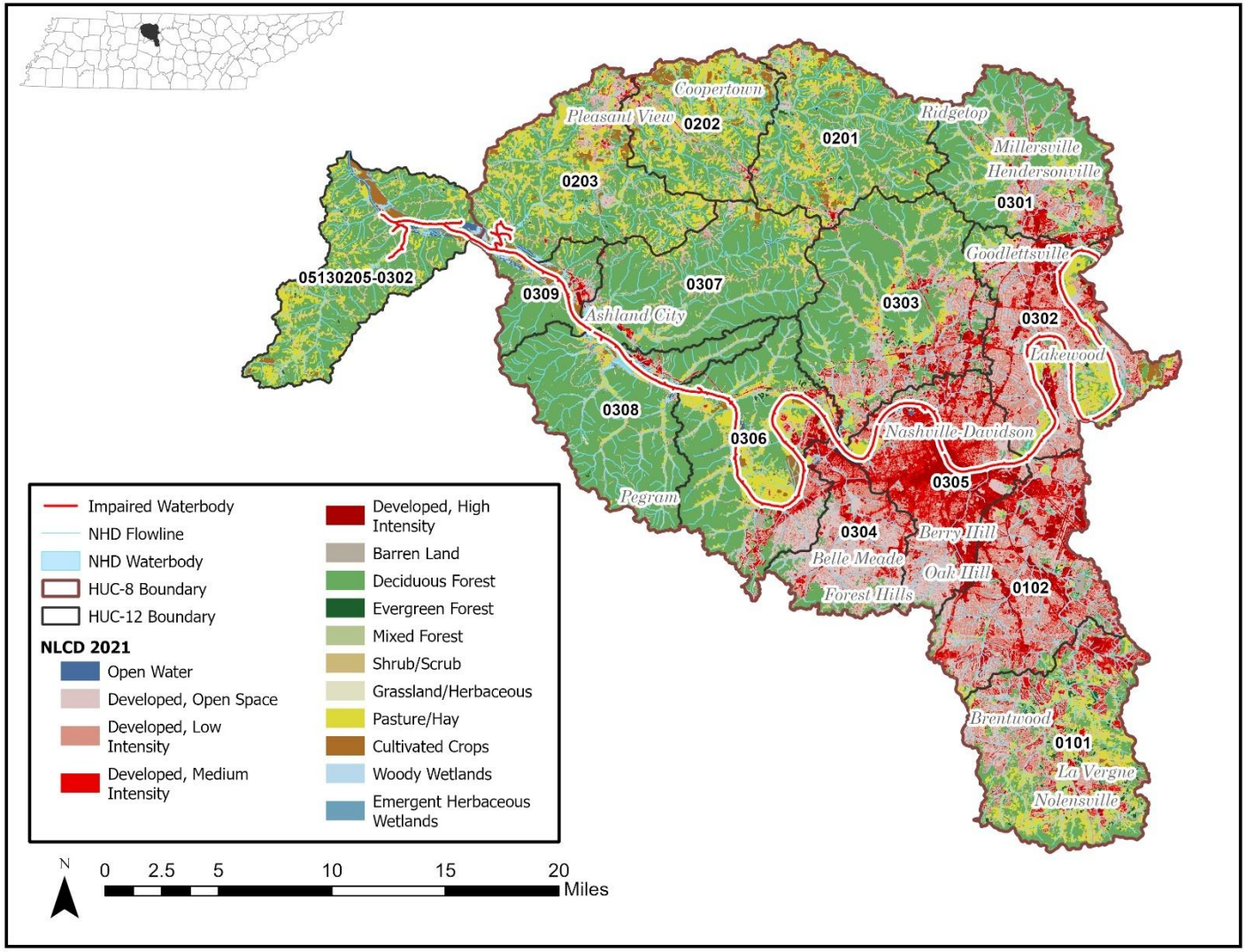

Figure 3. Land Use in the Cheatham Lake Watershed

Table 1. NLCD Land Use Distribution – Cheatham Lake Watershed (05130202)

Land use	Cheatham Lake Watershed	
	[acres]	[%]
Open Water	5,469	1.32
Developed Open Space	51,959	12.5
Low Intensity Development	44,211	10.7
Medium Intensity Development	27,761	6.70
High Intensity Development	15,621	3.77
Barren Land (Rock/Sand/Clay)	704	0.17
Deciduous Forest	165,988	40.1
Evergreen Forest	5,221	1.26
Mixed Forest	24,488	5.91
Shrub/Scrub	1,367	0.33
Grassland/Herbaceous	2,403	0.58
Pasture/Hay	60,288	14.6
Cultivated Crops	6,174	1.49
Woody Wetlands	1,409	0.34
Emergent Herbaceous Wetlands	1,243	0.30
Total	414,308	100.0

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

3.0 PROBLEM DEFINITION

TDEC's Final 2024 List of Impaired and Threatened Waters (TDEC, 2024), was approved by EPA, Region 4 on April 24, 2024. This list identified a number of waterbodies in the Cheatham Lake Watershed as not fully supporting designated use classifications due, in part, to elevated levels of polychlorinated biphenyls (PCBs) in fish tissue samples (see Table 2 & Figures 4 and 5). The designated use classifications for these waterbodies include domestic water supply, industrial water supply, fish and aquatic life, irrigation, livestock watering & wildlife, recreation, and navigation.

3.1 Polychlorinated Biphenyls (PCBs)

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

PCBs were manufactured in the United States from the 1920s 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, 2000).

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

> 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).

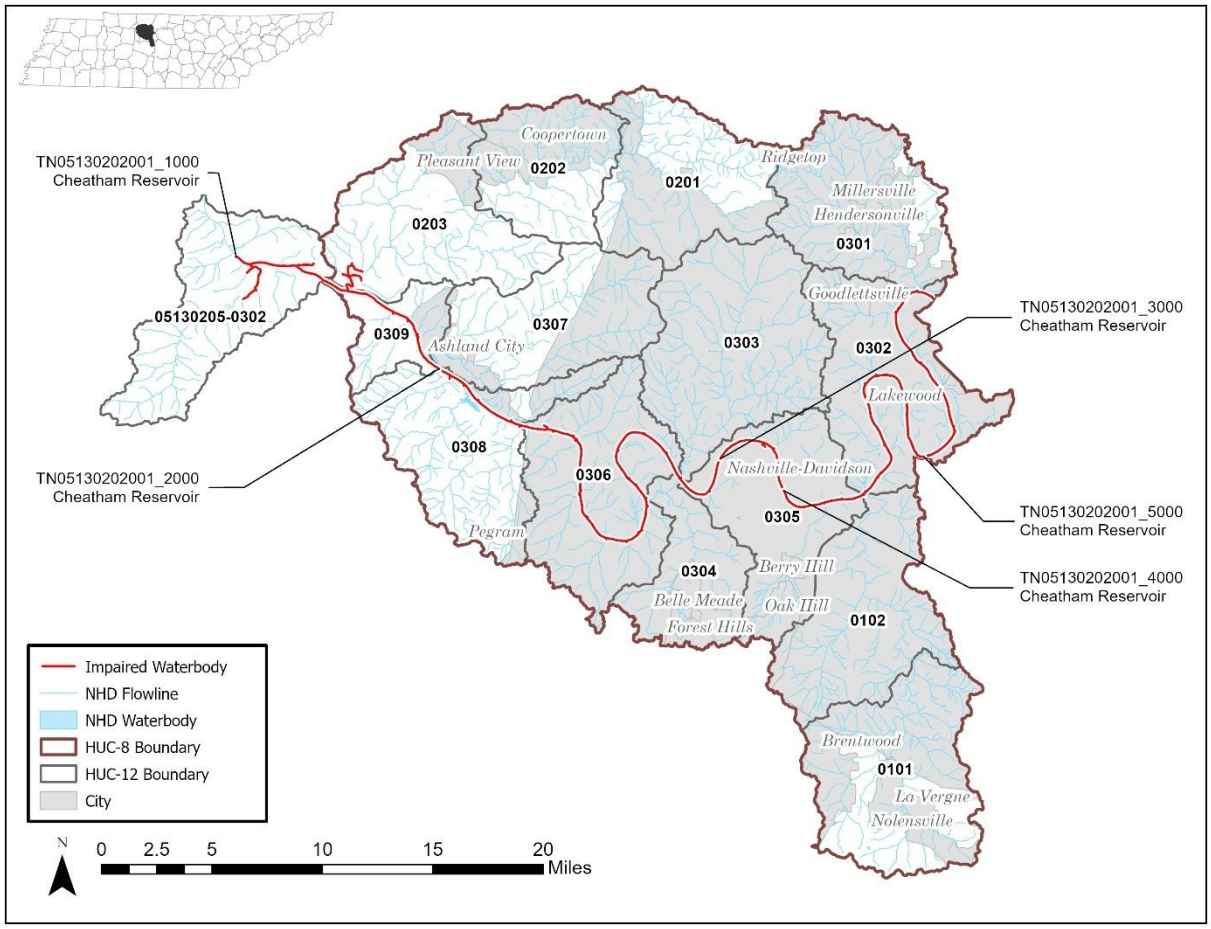

Figure 4. Location of Cheatham Reservoir PCB Impairments (as documented on the *2024 List of Impaired and Threatened Waters*)

Table 2. *2024 List of Impaired and Threatened Waters* - Stream Impairment Due to PCBs

Waterbody ID	Waterbody	Miles/ Acres	Cause (Pollutant)	Source (Pollutant)	Assessment Comments
TN05130202001_1000	Cheatham Reservoir (Cheatham Dam to Marrowbone Creek)	2,264 ac	PCBs in Fish Tissue	Source Unknown	Precautionary fishing advisory for catfish due to PCBs.
TN05130202001_2000	Cheatham Reservoir (Marrowbone Creek to Bordeaux Bridge)	2,449 ac	PCBs in Fish Tissue	Source Unknown	Precautionary fishing advisory for catfish due to PCBs.
TN05130202001_3000	Cheatham Reservoir (Bordeaux Bridge to Woodland St. Bridge)	994 ac	PCBs in Fish Tissue	Source Unknown	Precautionary fishing advisory for catfish due to PCBs.
TN05130202001_4000	Cheatham Reservoir (Woodland St. Bridge to Stones River)	1,000 ac	PCBs in Fish Tissue	Source Unknown	Precautionary fishing advisory for catfish due to PCBs.
TN05130202001_5000	Cheatham Reservoir (Stones River to Old Hickory Dam)	740 ac	PCBs in Fish Tissue	Source Unknown	Precautionary fishing advisory for catfish due to PCBs.

4.0 TARGET IDENTIFICATION

These TMDLs are being proposed for Cheatham Reservoir, which is impaired because PCBs in fish tissue samples were detected at levels that exceed the applicable water quality criteria. In order for a TMDL to be established, a numeric "target" protective of the uses of the water must be identified to serve as the basis for the TMDL. Numerical criteria, applicable for PCBs, is established by *State of Tennessee Water Quality Standards, Chapter 0400-40-03, General Water Quality Criteria* (TDEC, 2024a). Fish tissue target criteria will be used in this TMDL because, in the State of Tennessee, assessment of waterbody segments for impairment due to 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. Values based on the water quality criteria for the recreation designated use classification will be used for this TMDL because they are the most stringent criteria. Water quality criteria have also been established for the domestic water supply designated use. However, those criteria are significantly higher (0.5 µg/L) and, therefore, less stringent and less protective.

Table 3. Fish Tissue Target Criteria

Pollutant	Water Quality Criteria	Target Criteria (mg/kg)
PCBs	0. 00064 µg/L	0.0198

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, 1998). Fish tissue data were available from the sites shown in Figure 5. According to the methodology outlined in Section 7.1, the water column concentrations and the existing loads of PCBs in the water column were calculated from all fish tissue data, including both individual and composite samples. Only three congeners (1248, 1254, and 1260) were detected in fish tissue samples. The total PCB concentration was calculated from detected values of each congener. When none of the three congeners were detected in a sample, the concentration was assumed to be one-half of the Method Detection Limit (MDL) for total PCB. If the MDL for total PCB was not available, the concentration was assumed to be one-half of the MDL for Aroclor 1260.

The existing concentration of PCBs in the water column was estimated using the Bioconcentration Factor defined by the U.S. Environmental Protection Agency (ref.: Appendix A). These data are presented in Table 4. The weighted average of PCB concentrations for each fish species was calculated for the entire period of record (POR) as well as for the most recent sampling period. The species with the highest weighted average are highlighted in red. None of the fish species with the highest weighted average for the POR (Smallmouth Buffalo) were collected during the most recent sampling period. Therefore, the fish species with the highest weighted average for the most recent sampling period (Channel Catfish) will be used to determine the existing load.

The existing water column concentration was calculated to be 0.0111 µg/L, which is greater than the 0.00064 µg/L target value.

Water samples were also collected and analyzed for three locations in the Cheatham Reservoir during 2025. All samples were reported below the MDL of 0.11 µg/L. While this is above the water quality criteria for the recreation designated use, it is below the water quality criteria for the drinking water supply designated use.

Fish tissue samples were collected at the following locations:

- CUMBE152.0CH – Cheatham Reservoir near Pardue Pond Wildlife Refuge
- CUMBE185.7DA – Cheatham Reservoir at Bordeaux Bridge, Nashville
- CUMBE191.1DA – Cheatham Reservoir at Shelby Street Bridge, Nashville
- CUMBE206.7DA – Lytle Farms area u/s Stones River d/s Old Hickory Dam

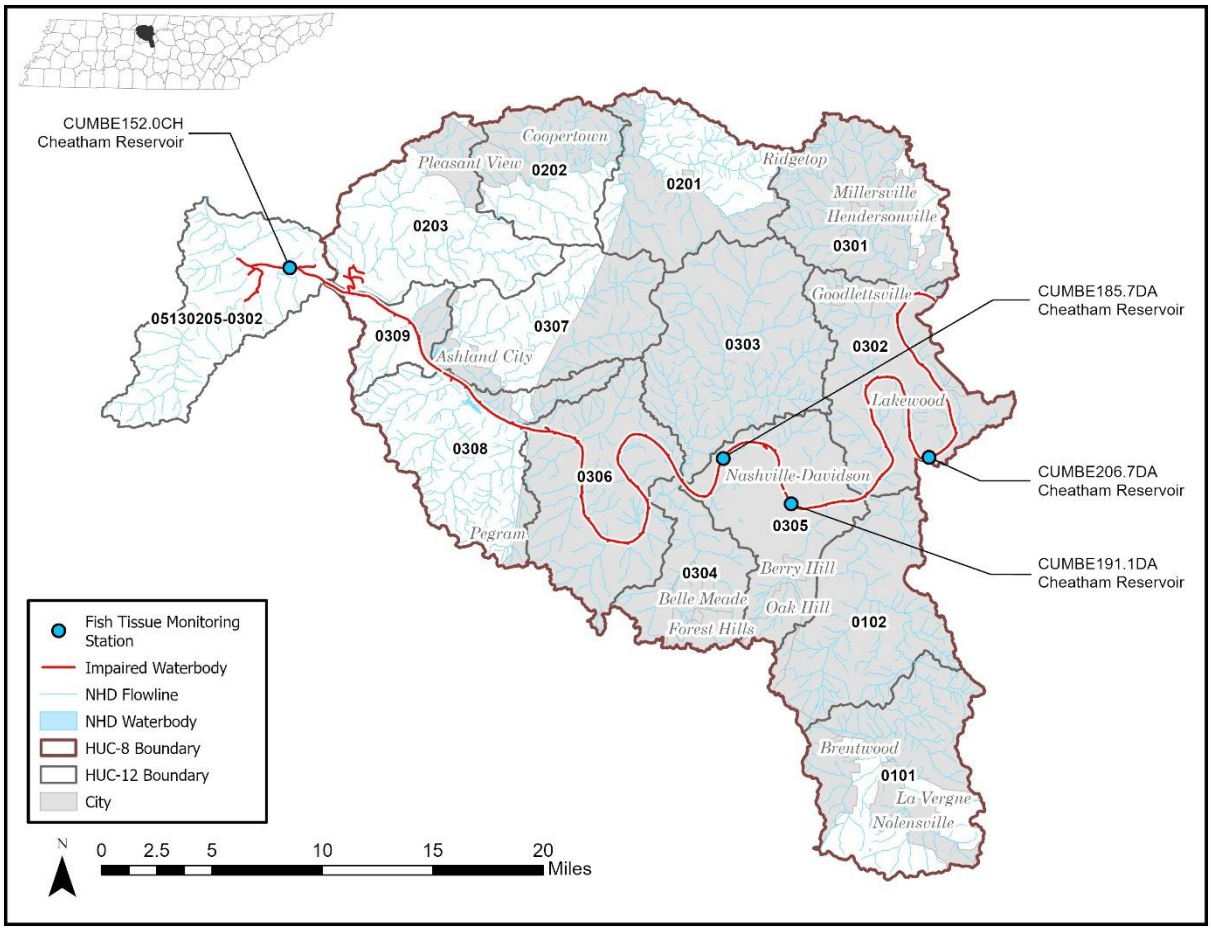

Figure 5. Fish Tissue and Water Quality Monitoring Sites in Cheatham Reservoir

Table 4. Existing Concentrations of PCBs in Cheatham Reservoir Calculated from Fish Tissue Samples

Fish Species	Sample Year	Sampling Site Location	Number of Fish in Sample	Aroclor 1248 in Fish Sample (ppm)	Aroclor 1254 in Fish Sample (ppm)	Aroclor 1260 in Fish Sample (ppm)	Total PCBs in Fish Sample (ppm)	Calculated Water Column Concentration (µg/L)
Black Redhorse	1991	Cumberland RM 185.7	2	ND	ND	ND	0.078	
	1991	Cumberland RM 191.1	2	ND	0.183	0.347	0.53	
		Weighted Average (POR)					**0.304**	**0.0097**
		Weighted Average (2020-25)					**NA**	**NA**
Blue Catfish	2020	Cumberland RM 185.7	1	ND	0.0093	ND	0.0093	
	2021	Cumberland RM 185.7	3	0.026	0.093	0.15	0.269	
	2022	Cumberland RM 206.7	1	0.013	0.03	0.018	0.061	
	2022	Cumberland RM 206.7	1	0.013	0.025	0.012	0.05	
	2022	Cumberland RM 152.0	1	ND	0.0092	ND	0.0092	
		Weighted Average (POR)					**0.1338**	**0.0043**
		Weighted Average (2020-25)					**0.1338**	**0.0043**

Table 4 (cont'd). Existing Concentrations of PCBs in Cheatham Reservoir Calculated from Fish Tissue Samples

Fish Species	Sample Year	Sampling Site Location	Number of Fish in Sample	Aroclor 1248 in Fish Sample (ppm)	Aroclor 1254 in Fish Sample (ppm)	Aroclor 1260 in Fish Sample (ppm)	Total PCBs in Fish Sample (ppm)	Calculated Water Column Concentration (µg/L)
Channel Catfish	1991	Cumberland RM 185.7	1	ND	0.886	0.409	1.295	
	1992	Cumberland RM 185.7	1	0.128	ND	0.163	0.291	
	1992	Cumberland RM 191.1	1	ND	ND	0.214	0.214	
	1997	Cumberland RM 191.1	5	ND	ND	0.101	0.101	
	1997	Cumberland RM 185.7	5	ND	ND	0.114	0.114	
	2020	Cumberland RM 185.7	2	ND	0.029	0.026	0.055	
	2020	Cumberland RM 191.1	3	ND	ND	1.6	1.6	
	2021	Cumberland RM 185.7	2	0.012	0.019	0.034	0.065	
	2021	Cumberland RM 191.1	1	ND	0.06	0.085	0.145	
	2021	Cumberland RM 191.1	3	ND	0.051	0.064	0.115	
	2022	Cumberland RM 206.7	2	0.015	0.045	0.076	0.136	
	2022	Cumberland RM 206.7	3	ND	0.02	0.021	0.041	
	2022	Cumberland RM 152.0	2	0.023	0.087	0.19	0.3	
	2022	Cumberland RM 152.0	1	0.011	0.017	0.0084	0.0364	
		Weighted Average (POR)					**0.2949**	**0.0095**
		Weighted Average (2020-25)					**0.3453**	**0.0111**

Table 4 (cont'd). Existing Concentrations of PCBs in Cheatham Reservoir Calculated from Fish Tissue Samples

Fish Species	Sample Year	Sampling Site Location	Number of Fish in Sample	Aroclor 1248 in Fish Sample (ppm)	Aroclor 1254 in Fish Sample (ppm)	Aroclor 1260 in Fish Sample (ppm)	Total PCBs in Fish Sample (ppm)	Calculated Water Column Concentration (µg/L)
Common Carp	1991	Cumberland RM 191.1	1	ND	0.357	0.151	0.508	
	1991	Cumberland RM 191.1	1	ND	0.319	0.121	0.440	
	1991	Cumberland RM 191.1	1	ND	0.119	0.077	0.196	
	1991	Cumberland RM 191.1	1	ND	0.348	0.219	0.567	
	1992	Cumberland RM 185.7	1	ND	ND	0.097	0.097	
	1992	Cumberland RM 185.7	1	ND	ND	0.102	0.102	
	1992	Cumberland RM 185.7	1	ND	ND	0.12	0.12	
	1992	Cumberland RM 185.7	1	ND	ND	0.066	0.066	
	1992	Cumberland RM 185.7	1	ND	ND	0.069	0.069	
	1992	Cumberland RM 191.1	1	ND	ND	0.214	0.214	
	1992	Cumberland RM 191.1	1	ND	ND	0.109	0.109	
	1992	Cumberland RM 191.1	1	ND	ND	0.049	0.049	
	1992	Cumberland RM 191.1	1	ND	ND	0.033	0.033	
	1997	Cumberland RM 191.1	5	0.191		0.322	0.513	
	1997	Cumberland RM 185.7	3	ND	ND	0.065	0.065	
		Weighted Average (POR)					**0.2538**	**0.0081**
		Weighted Average (2020-2025)					**NA**	**NA**

Table 4 (cont'd). Existing Concentrations of PCBs in Cheatham Reservoir Calculated from Fish Tissue Samples

Fish Species	Sample Year	Sampling Site Location	Number of Fish in Sample	Aroclor 1248 in Fish Sample (ppm)	Aroclor 1254 in Fish Sample (ppm)	Aroclor 1260 in Fish Sample (ppm)	Total PCBs in Fish Sample (ppm)	Calculated Water Column Concentration (µg/L)
Drum	1997	Cumberland RM 191.1	5	ND	ND	ND	0.055	
	1997	Cumberland RM 185.7	5	ND	ND	ND	0.055	
	2022	Cumberland RM 152.0	3	0.011	0.02	ND	0.031	
		Weighted Average (POR)					**0.0495**	**0.0016**
		Weighted Average (2020-2025)					**0.0310**	**0.0010**
Largemouth Bass	1997	Cumberland RM 191.1	2	ND	ND	0.088	0.088	
	1997	Cumberland RM 185.7	1	ND	ND	ND	0.055	
	2020	Cumberland RM 191.1	1	ND	ND	0.41	0.41	
	2022	Cumberland RM 206.7	1	ND	0.011	0.011	0.000	
	2022	Cumberland RM 206.7	5	ND	ND	ND	0.0041	
	2022	Cumberland RM 152.0	4	0.0084	0.023	0.018	0.0494	
	2022	Cumberland RM 152.0	4	ND	0.012	ND	0.012	
		Weighted Average (POR)					**0.0516**	**0.0.0017**
		Weighted Average (2020-2025)					**0.0465**	**0.0015**

Table 4 (cont'd). Existing Concentrations of PCBs in Cheatham Reservoir Calculated from Fish Tissue Samples

Fish Species	Sample Year	Sampling Site Location	Number of Fish in Sample	Aroclor 1248 in Fish Sample (ppm)	Aroclor 1254 in Fish Sample (ppm)	Aroclor 1260 in Fish Sample (ppm)	Total PCBs in Fish Sample (ppm)	Calculated Water Column Concentration (µg/L)
Smallmouth Bass	1997	Cumberland RM 185.7	3	ND	ND	ND	0.055	
	2020	Cumberland RM 185.7	1	ND	0.011	0.0088	0.0198	
	2020	Cumberland RM 191.1	4	ND	0.017	0.029	0.046	
	2021	Cumberland RM 185.7	5	0.012	0.018	0.021	0.051	
	2021	Cumberland RM 191.1	5	0.0089	0.019	0.072	0.0999	
		Weighted Average (POR)					**0.0624**	**0.0020**
		Weighted Average (2020-2025)					**0.0639**	**0.0020**
Smallmouth Buffalo	1991	Cumberland RM 185.7	4	ND	ND	ND	0.0785	
	1991	Cumberland RM 191.1	4	ND	0.146	0.128	0.274	
	1992	Cumberland RM 185.7	2	1.85	ND	0.523	2.373	
	1997	Cumberland RM 185.7	5	ND	ND	0.173	0.173	
		Weighted Average (POR)					**0.4681**	**0.0150**
		Weighted Average (2020-2025)					**NA**	**NA**

Table 4 (cont'd). Existing Concentrations of PCBs in Cheatham Reservoir Calculated from Fish Tissue Samples

Fish Species	Sample Year	Sampling Site Location	Number of Fish in Sample	Aroclor 1248 in Fish Sample (ppm)	Aroclor 1254 in Fish Sample (ppm)	Aroclor 1260 in Fish Sample (ppm)	Total PCBs in Fish Sample (ppm)	Calculated Water Column Concentration (µg/L)
Spotted Bass	1992	Cumberland RM 191.1	1	ND	ND	0.046	0.046	
	1992	Cumberland RM 191.1	1	ND	ND	0.055	0.055	
	1992	Cumberland RM 191.1	1	ND	ND	0.202	0.202	
	1997	Cumberland RM 191.1	3	ND	ND	0.127	0.127	
	1997	Cumberland RM 185.7	7	ND	ND	ND	0.055	
	2021	Cumberland RM 191.1	2	ND	0.039	0.16	0.199	
	2022	Cumberland RM 206.7	3	ND	ND	ND	0.0041	
	2022	Cumberland RM 206.7	9	ND	ND	ND	0.0041	
	2022	Cumberland RM 152.0	2	ND	ND	ND	0.0041	
		Weighted Average (POR)					**0.0526**	**0.0017**
		Weighted Average (2020-2025)					**0.0285**	**0.0009**

Note: Data presented is for PCB Aroclors 1248, 1254, and 1260 – all other Aroclors were below detection limits.
ND = Not Detected
NA = Not Applicable (no samples in time period)

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.

Under the Clean Water Act, sources are classified as either point or nonpoint sources. Under Title 40 Code of Federal Regulations (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. Point sources can be described by three broad categories: 1) NPDES regulated municipal and industrial wastewater treatment plants (WWTPs); 2) NPDES regulated industrial and municipal stormwater discharges; and 3) NPDES regulated Concentrated Animal Feeding Operations (CAFOs). A TMDL must provide Waste Load Allocations (WLAs) for all NPDES regulated point sources. Nonpoint sources (NPS) are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. For the purposes of this TMDL, all sources of pollutant loading not regulated by NPDES permits are considered NPS. The TMDL must provide a Load Allocation (LA) for these sources.

6.1 Point Sources

There are numerous permitted dischargers in the Cheatham Lake Watershed. However, there are currently no permitted point source dischargers with existing allocations for PCBs in the Cheatham Lake Watershed.

6.2 Non-point Sources

Assessments have not determined the source of PCB impairments in Cheatham Reservoir. There are no National Priorities List (NPL) sites located in the Cheatham Lake Watershed. Examination of the Tennessee Division of Remediation's (DOR) dataviewer (https://dataviewers.tdec.tn.gov/dataviewers/f?p=211:7:3073381774772) indicates several sites in Davidson County in which PCBs are listed as a Contaminant of Concern. (See Figure 6). These sites are participating in a voluntary program managed by DOR and are involved in activities ranging from site characterization to remedial action. While some of these sites may have been sources of PCBs in the past, none of the sites are currently discharging PCBs. Therefore, none of the sites are current sources of impairment.

This TMDL will consider contaminated sediment in the reservoir bed as the primary source of PCB contamination in Cheatham Reservoir. According to the U.S. Environmental Protection Agency, this pollutant has a very low solubility in water and low volatility, and it is contained in sediments that serve as reservoirs from which this pollutant may be released over a long period of time (USEPA, 1999).

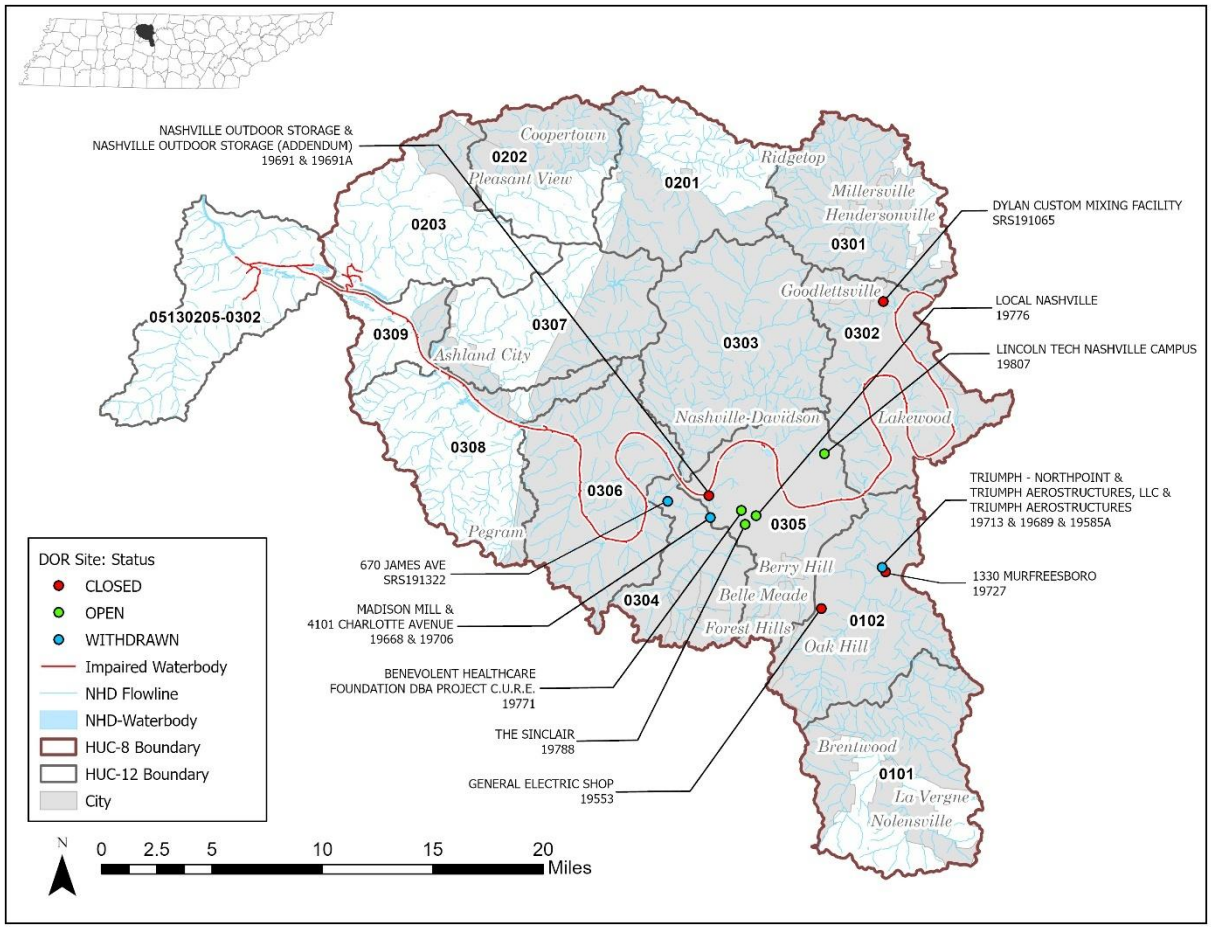

Figure 6. DOR Sites in Davidson County with PCBs as a Contaminant of Concern

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 Analysis Methodology

TMDL analyses were performed at various sites to evaluate waterbodies identified as impaired on the *2024 List of Impaired and Threatened Waters* (TDEC, 2024) due to elevated levels of PCBs in fish tissue samples. The TMDL for PCBs in the water column, and the corresponding required load reduction, were calculated according to the following procedure:

- Fish tissue samples were collected and analyzed as defined in *The Results of Fish Tissue Monitoring in Tennessee 1992-1997* (TDEC, 1998).

- The weighted average of the concentrations of PCBs in the fish tissue samples was calculated. If several species were analyzed from the same waterbody, the fish species with the highest weighted average (ref.: Table 4) was used to estimate the concentration of PCBs in the water column:

$$C_{water} = \frac{C_{fish}}{BCF} \times 1{,}000$$

Where C_{fish}= Fish tissue concentration (mg/kg)
C_{water} = Water column concentration (µg/L)
BCF = Bioconcentration factor (31,200 L/kg)
1,000 = Conversion factor (µg/mg)

- Assuming uniform distribution, the existing total PCB load of the reservoir was computed as the product of the mean pool volume and the calculated water column concentration (ref.: Section 5.0). Cheatham Reservoir has a 2-foot operating band rather than a separate summer and winter elevation. Therefore, the pool volume at maximum elevation will be used.:

$$\text{Existing Load} = C_{water} \times \text{Pool Volume} \times \text{Unit Conversion Factor}$$

- The maximum allowable amount of PCBs in the reservoir at any time, was determined by the product of the water quality target concentration (ref.: Section 4.0) and the pool volume at maximum elevation:

  $$\text{Maximum Allowable Load} = C_{target} \times \text{Mean Pool Volume} \times \text{Unit Conversion Factor}$$

- The TMDL was calculated by dividing the maximum allowable load of PCBs in the reservoir at any time by the hydraulic retention time (HRT).

$$\text{TMDL} = \frac{\text{Maximum Allowable Load}}{\text{HRT}}$$

- A percent reduction, corresponding to the TMDL, was computed based on the existing load and the maximum allowable load:

$$\%\ \text{Reduction} = \frac{(\text{Existing Load}) - (\text{Maximum Allowable Load})}{(\text{Existing Load})} \times 100\%$$

- A 20% explicit margin of safety was incorporated into the TMDL.
- Waste load and load allocations were calculated using the TMDL value.

7.2 Margin of Safety

There are two methods for incorporating a Margin of Safety (MOS) into 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 20% explicit margin of safety was utilized to account for uncertainties.

7.3 Critical Conditions and Seasonal Variation

Critical conditions were incorporated into the TMDL analysis by using all of the fish tissue monitoring data.

PCBs can persist in the environment for many years and since there are no known sources of additional PCBs loading, the mass of PCBs contained in the reservoir bed is assumed to be constant over short periods of time. So the concentration of PCBs should be inversely proportional to the volume of water in the reservoir. Determination of PCB loads using the mean pool volume accounts for periods when the PCB concentrations would theoretically be the greatest. Therefore, the TMDLs will provide year-round protection of water quality standards.

7.4 TMDLs for the Impaired Waterbody

For Cheatham Reservoir, the pool volume (at a maximum elevation of 386 feet) is 111,418 ac-ft and the hydraulic retention time is 2.2 days (Wigner, 2025). TMDLs were derived according to the methodology described in Section 7.1.

$$\text{Maximum Allowable Load} = 0.000636\ \mu g/L \times 111{,}418\ \text{ac-ft} \times (1.23\times10^{6})\ L/\text{ac-ft} \times (2.205\times10^{-9})\ lb/\mu g$$

$$\text{Maximum Allowable Load} = 0.192\ lb$$

$$\text{TMDL} = 0.192\ lb / 2.2\ \text{days} = 0.0874\ lb/\text{day}$$

Using the estimated water column concentration specified in Section 5.0, the existing load was calculated:

$$\text{Existing Load} = 0.0111\ \mu g/L \times 111{,}418\ \text{ac-ft} \times (1.23\times10^{6})\ L/\text{ac-ft} \times (2.205\times10^{-9})\ lb/\mu g = 3.354\ lb$$

The percent reduction corresponding to the TMDL was computed from the existing load and maximum allowable load:

$$\%\ \text{Reduction} = \frac{(3.354\ lb) - (0.192\ lb)}{(3.354\ lb)} \times 100\% = 94.3\%$$

The TMDL values represent the maximum allowable daily loading of PCBs. Furthermore, these values assume that the pollutants will be uniformly distributed throughout the waterbody. Such conditions may or may not exist, and in either case the localized concentration of either pollutant in Cheatham Reservoir should not exceed water quality target values. The TMDLs and percent reductions are summarized in Table 6.

7.5 Development of Waste Load Allocations and Load Allocations

7.5.1 Waste Load Allocations

There are currently no permitted point source dischargers with existing allocations for PCBs. Discharge of PCBs is not allowed without an NPDES permit. Therefore, waste load allocations of zero are being provided.

7.5.2 Load Allocations

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,

$$LA = TMDL - MOS$$

Incorporating the 20% MOS into the TMDL restricts the PCB loading in Cheatham Reservoir to 0.0699 lb/day. The allocations for Cheatham Reservoir are also provided in Table 6.

Table 6 TMDLs and Allocations for Cheatham Reservoir

Waterbody ID	Impaired Waterbody	Pollutant	TMDL	MOS	WLA	LA	*Required Overall Load Reduction**
			[lb/day]	[lb/day]	[lb/day]	[lb/day]	*[%]*
TN05130202001_1000	Cheatham Reservoir	PCBs	0.0874	0.0175	0.00	0.0699	*94.3*
TN05130202001_2000							
TN05130202001_3000							
TN05130202001_4000							
TN05130202001_5000							

*Note: Load reduction required to achieve TMDL.

8.0 IMPLEMENTATION PLAN

8.1 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.

Cheatham Reservoir was listed as impaired on the *2024 List of Impaired and Threatened Waters* because it was not fully supporting designated use classifications due, in part, to elevated levels of PCBs. Contaminated sediments are the likely source for contamination in the Cheatham Reservoir.

There are generally two options to prevent PCBs contained in the sediment from being released to the reservoir: 1) avoid disturbing the sediment or 2) remediate contaminated sites. TDEC recommends using option 1 whenever possible. If the sediment must be disturbed, remediation efforts will be necessary to control the load of PCBs in the reservoir so that the water quality criteria are not exceeded. Strategies to identify sites with elevated levels of PCBs may be helpful for implementing controls to prevent the contaminants from being released into the reservoir.

8.2 Evaluation of TMDL Effectiveness

The effectiveness of these TMDLs will be assessed as data become available. PCBs should become less biologically available through decay and biodegradation over time, or further isolation from being buried by clean sediment. As less of the contaminants become biologically available, the concentrations of PCBs measured in fish tissue samples should theoretically decline. Watershed monitoring and assessment activities will provide information by which the effectiveness of 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 PCBs in Cheatham Reservoir will be placed on Public Notice for a 35-day period and comments solicited. The public notice process includes:

1) Notice of the proposed TMDLs will be posted on the Tennessee Department of Environment and Conservation website. The announcement will invite public and stakeholder comment and provide a link to a downloadable version of the TMDL document.

2) Notice of the availability of the proposed TMDLs (similar to the website announcement) will be sent to the Division of Water Resources Public Notice e-mail distribution list, which includes over 190 interested persons or groups who have requested this information.

3) Letters will be sent via e-mail to local interagency and stakeholder groups in the TMDL watershed advising them of the proposed PCB TMDLs, stating the document's availability on the TDEC website, and notifying them that a copy of the draft TMDL will be provided upon request. Letters will be sent to the following partners:

   Cumberland River Compact
   Harpeth Conservancy
   Natural Resources Conservation Service
   Tennessee Department of Agriculture
   Tennessee Wildlife Federation
   Tennessee Wildlife Resources Agency
   The Nature Conservancy
   United States Army Corps of Engineers
   United States Fish and Wildlife Service
   United States Geological Survey

4) Letters will be sent via e-mail to those MS4s that are wholly or partially located in PCB-impaired subwatersheds. The letters will advise them of the availability of the proposed TMDLs, provide a link to a downloadable version of the TMDL document, and notify them that a copy of the draft TMDL document will be provided on request. Letters will be sent to the following MS4s:

   City of Nashville/Davidson County, Tennessee (TNS068047)
   Tennessee Dept. of Transportation (TNS077585)

Documentation of Public Notice will be included in Appendix B of the Final Approved TMDL.

10.0 FURTHER INFORMATION

Further information can be found on the TDEC TMDL Program web page.

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

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APPENDIX A

Development of Fish Tissue Concentrations Equivalent to Water Quality Criteria for PCBs

In the State of Tennessee, assessment of waterbody segments for impairment due to PCBs are based on fish tissue concentrations. Public fishing advisories are also based upon fish tissue concentrations. Therefore, for the purpose of this TMDL, PCB concentrations from fish tissue samples will be converted to their equivalent water column concentrations.

PCB Methodology

The formula for calculating the fish tissue concentration requiring a fish advisory is established by *State of Tennessee Water Quality Standards, Chapter 0400-40-03, General Water Quality Criteria, March 2024* (TDEC, 2024a). Section 0400-40-03-.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 equivalent fish tissue concentrations were calculated for the waterbodies not designated for domestic water supply, see Table A-1.

Table A-1. Equivalent Fish Tissue Concentrations for Waterbodies Not Designated for Domestic Water Supply

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

All segments of the Cheatham Reservoir are also designated for domestic water supply (DWS). For waterbodies designated for DWS, the ingestion rate (I) must be adjusted to account for the combined intake of fish and water.

$$I2 = FI + WI \quad \text{(Equation A-5)}$$

Where:

FI = Fish Intake; 17.5 g/day will be used (USEPA, 2002)
WI = Water Intake, 2 L/day will be used (USEPA, 2002)

The water intake can be converted to an equivalent fish intake using information from Equation A-4:

$$WI = 2\ L/Day * CF1 / BCF \quad \text{(Equation A-6)}$$

Therefore:

$$I2 = 17.5 + (2 * CF1 / BCF) \quad \text{(Equation A-7)}$$

Using Equation A-3 and A-4, published values for q and BCF, and substituting I2 for I, the equivalent fish tissue concentrations for waterbodies designated for domestic water supply were calculated:

Table A-2. Equivalent Fish Tissue Concentrations for Waterbodies Designated for Domestic Water Supply

Pollutant	q	C_{fish}	BCF	C_{water}
	(kg-day/mg)	(mg/kg)	(L/kg)	(μg/L)
PCB	2.0	0.0198	31,200	0.000636

Comparison of the fish tissue concentrations in Tables A-1 and A-2 to the water quality criteria established in Section 0400-40-03-.03 (4) (j) for “Organisms Only” and “Water & Organisms” respectively confirms that the values are equivalent. The State of Tennessee has also established numeric criteria for the fish & aquatic life (FAL) and domestic water supply (DWS) designated uses. For Total PCBs, the FAL criterion (0.014 μg/L) and the DWS criterion (0.5 μg/L) are greater than the recreation criterion. Therefore, the criterion for the recreation designated use will be applied for PCBs because it is more stringent.

APPENDIX B

Public Notice Documentation