2012 305(b) Report
The Status of Water Quality in Tennessee

Division of Water Resources
Tennessee Department of Environment and Conservation

The 2012 305(b) Report is dedicated
to the long and productive careers of:

Paul E. Davis and
Garland P. Wiggins

Director and Deputy Director
(1988-2012)

of the
Tennessee Division of Water
Pollution Control

2012 305(b) Report
The Status of Water Quality in Tennessee

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Prepared by:

Gregory M. Denton
Michael H. Graf
Deborah H. Arnwine
Linda K. Cartwright

Geo-Indexing of Water Quality Information by:

Richard E. Cochran

Tennessee Department of Environment and Conservation
Division of Water Resources
401 Church Street
L&C Annex, 6th Floor
Nashville, Tennessee 37243-1534
615-532-0625

Cover Photo: Cummins Falls on the Blackburn Fork State Scenic River. *Photo courtesy of Jim McCullough.*

Table of Contents

2012 305(b) Report — Page

List of Tables — Page

List of Figures — Page

2012 305(b) Report
Status of Water Quality in Tennessee

Introduction to Tennessee's Water Quality

This report was prepared by the Planning and Standards Section, Division of Water Resources (formerly Water Pollution Control), Tennessee Department of Environment and Conservation (TDEC) to fulfill the requirements of both federal and state laws. Section 305(b) of the Federal Water Pollution Control Act, commonly called the Clean Water Act, requires a biennial analysis of water quality in the state. The Tennessee Water Quality Control Act also requires that the division produce a report on the status of water quality.

TDEC's goals for the 305(b) Report include:

- Describing the water quality assessment process (Chapter 1).
- Categorizing waters in the State by placing them in the assessment categories suggested by federal guidance (Chapter 2).
- Determining causes and sources of pollution (Chapters 3 and 4)
- Identifying waterbodies that pose eminent human health risks due to elevated bacteria levels or contamination of fish (Chapter 5).

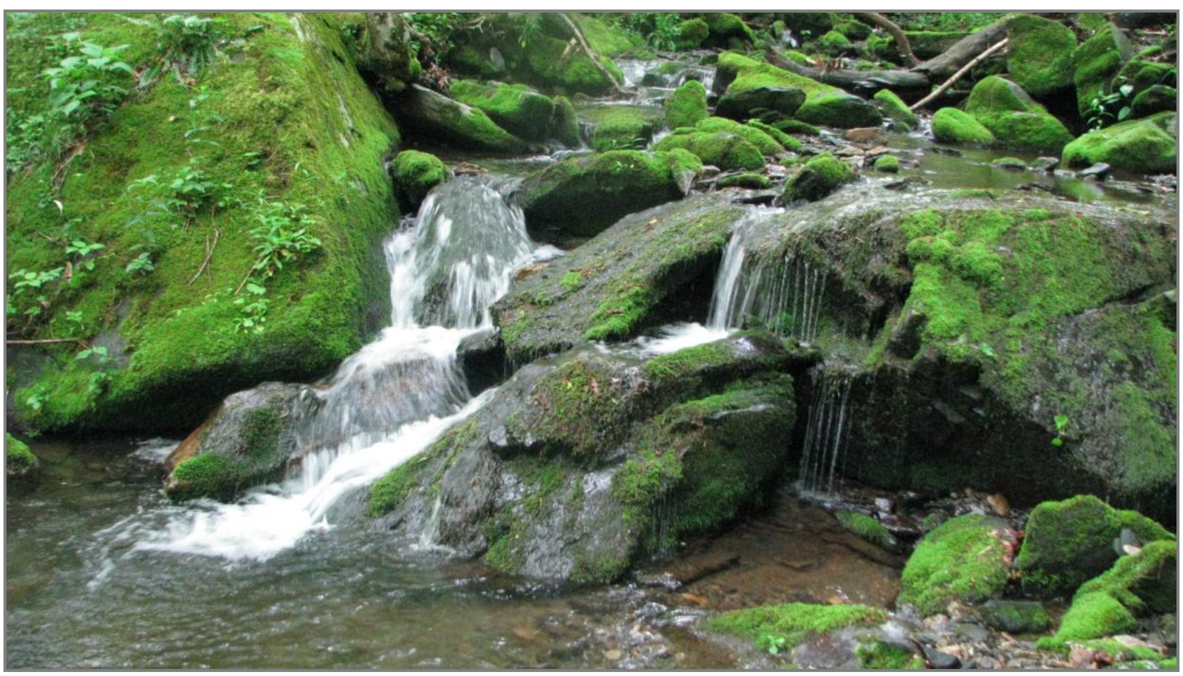

Photo provided by Johnson City Field Office, TDEC

Acknowledgments

The authors would like to express appreciation to the Division of Water Resources staff of TDEC's regional Environmental Field Offices (EFOs) who collected stream, river, and reservoir data documented in this report. The managers of the staff in these offices during the period covered by this report were:

Terry Templeton	Memphis EFO
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Ryan Owens	Columbia EFO
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The division acknowledges the support of the Department of Health, Environmental Laboratories which performed the majority of chemical and biological analysis associated with this report. Dr. Bob Read is the laboratory director.

The information compiled in this 2012 water quality assessment document included data provided by many state and federal agencies. These agencies include Tennessee Department of Health (TDH), Tennessee Valley Authority (TVA), U. S. Environmental Protection Agency (EPA), Tennessee Wildlife Resources Agency (TWRA), U.S. Army Corps of Engineers (USACE), and U.S. Geological Survey (USGS). The division is grateful for their assistance and cooperation.

Photo provided by Nashville Environmental Field Office, TDEC

Executive Summary

The *Clean Water Act*, Section 305(b) (US Congress, 2002) and the *Tennessee Water Quality Control Act* (Tennessee Secretary of State, 1999) both require a biennial report about the status of water quality in the state. This report satisfies those requirements.

The Division of Water Resources is entrusted with protecting the people's right to enjoy clean water. In order to reach this goal, the division works to establish clean water objectives, monitor surface water, and determine if the waters of the state support their intended uses.

Water Quality Standards

There are seven designated uses for the waterways of the state. Those uses are defined in Rules of Tennessee Department of Environment and Conservation, Division of Water Pollution Control Chapter 1200-4-4. A different rule, Chapter 1200-4-3 identifies specific water quality criteria, both numeric and narrative, and establishes the state's antidegradation policy, which deals with prevention of future damage to water quality. Water quality standards are established for individual streams by identifying the most stringent criteria for each assigned use, considering the streams antidegradation status. These rules can be reviewed at http://tn.gov/sos/rules/1200/1200.htm.

Monitoring Programs

Tennessee has an abundance of water resources with over 60,000 miles of rivers and streams and over 570,000 lake and reservoir acres. However, this vast system of streams, rivers, reservoirs and wetlands requires efficient use of Tennessee's monitoring resources.

TDEC's watershed approach serves as an organizational framework for systematic assessment of the state's water quality. By viewing the entire drainage area or watershed as a whole, the department is better able to schedule water quality monitoring, assessment, and permitting activities, plus and stream restoration efforts. This unified approach affords a more in-depth study of each watershed and encourages coordination of public and governmental organizations. The watersheds are assessed on a five-year cycle that coincides with permit issuance.

In addition to systematic watershed monitoring, sample data fulfill other information needs within the division. Some of these other needs include continuation of the ecoregion reference stream monitoring, Total Maximum Daily Load (TMDL) generation, complaint investigation, antidegradation evaluations, trend analysis, compliance monitoring, and special studies.

Assessment Process

Using a standardized assessment methodology, monitoring data from individual streams are compared to water quality standards. Violations of water quality standards are identified and the degree to which each individual waterbody meets its designated uses is determined. Assessment categories recommended by EPA are used to characterize water quality.

Assessment results are compiled and reported to the public periodically. The principal vehicles for this water quality assessment reporting are the 305(b) Report and the 303(d) List.

Water Quality

Over half of the stream miles and almost all the large reservoirs have recently been monitored and assessed. Waters without data collected within the last five years are usually identified as not assessed unless previously identified as impaired. About 58 percent of assessed streams and 68 percent of assessed reservoir acres are found to be fully supporting of designated uses. The remainder of the assessed waterbodies are impaired to some degree and therefore, not supporting of all designated uses.

Causes and Source of Pollution

Once it has been determined that a stream, river, or reservoir is not fully supporting of its designated uses, it is necessary to determine what the pollutant is (cause) and where it is coming from (source). The most common causes of pollution in rivers and streams are sediment/silt, habitat alteration, pathogens, and nutrients. The main sources of these pollutants are agriculture, hydrologic modification, municipal dischargers, and construction. The leading causes of pollution in reservoirs and lakes are metals, low dissolved oxygen, and organic substances, like PCBs, dioxins, and chlordane. The principal sources of problems in reservoirs and lakes are the historical discharge of pollutants that have accumulated in sediment and fish flesh, plus atmospheric deposition. Other sources include agriculture, hydrologic modifications, municipal dischargers, and construction.

Advisories

When streams or reservoirs are found to have significantly elevated bacteria levels or when fish tissue contaminant levels exceed risk-based criteria, it is the responsibility of the Department of Environment and Conservation to post warning signs so that people will be aware of the potential threat to their health. In Tennessee, the most common reason for a stream or river to be posted is mercury in fish tissue, followed by the presence of high levels of bacteria. In lakes and reservoirs, the most common reason is accumulated PCBs, chlordane, dioxins, or mercury in fish tissue.

Statutory Requirements

Tennessee first created a water pollution regulatory organization in 1927. In 1929, the scope of that agency was expanded to include stream pollution studies to protect potential water supplies. A Stream Pollution Study Board charged with evaluating all available water quality data in Tennessee and locating the sources of pollution was appointed in 1943. The stream pollution study was completed and submitted to the General Assembly in 1945. Subsequently, the General Assembly enacted Chapter 128, Public Acts of 1945.

The 1945 law was in effect until the Water Pollution Control Act of 1971 was passed. In 1972, the Federal Clean Water Act was enacted into law. According to the Act, states are required to assess water quality and report the results to EPA and the public biennially. The Tennessee General Assembly revised the Water Quality Control Act in 1977 and the Department began statewide stream monitoring that same year.

In 1985, the Division of Water Quality Control was divided into the Divisions of Water Pollution Control and Water Supply. In 2012, the Divisions of Water Pollution Control, Ground Water Protection, and Water Supply merged into the Division of Water Resources. The division monitors, analyzes, and reports on the quality of Tennessee's water. It is also responsible for the non-coal surface mining program, permitting of wastewater discharges, review of wastewater construction plans, facility inspections, compliance monitoring, and enforcement of regulations. Stream channel modifications, wetland alterations or gravel dredging are also regulated.

Other duties of the Division of Water Resources are to ensure that public drinking water supplies are safe. The division also regulates the construction of non-federal dams, enforces the Water Resources Act, monitors water withdrawals, approves on-site wastewater treatment systems, and regulates the licensing of well drillers and pump setters.

> *Recognizing that the waters of Tennessee are the property of the state and are held in public trust for the use of the people of the state, it is declared to be the public policy of Tennessee that the people of Tennessee, as beneficiaries of this trust, have a right to unpolluted waters. In the exercise of its public trust over the waters of the state, the government of Tennessee has an obligation to take all prudent steps to secure, protect, and preserve this right.* (The Tennessee Water Quality Control Act, 1999)

In addition to the federal requirements, the Tennessee Water Quality Control Act of 1977 requires the Division of Water Resources to produce a report to the governor and the general assembly on the status of water quality in the state. The 2012 305(b) Report serves to fulfill the requirements of both the federal and state laws, which emphasize the identification and restoration of impaired waters.

This report covers only surface waters in Tennessee. Another document *Tennessee Ground Water 305(b) Water Quality Report* is available online at http://www.tn.gov/environment/water.

Tennessee at a Glance

Tennessee is one of the most biodiverse inland states in the nation. Geography ranges from the Appalachian Mountains in the east to the Mississippi River floodplains in the west. Elevations vary from 6,643 feet at Clingman's Dome in the Great Smoky Mountains National Park, to less than 200 feet near Memphis.

The average statewide precipitation is over 50 inches annually. Most of this rainfall is received between November and May. Historically the driest month is October. The average summer high temperature is 91 degrees Fahrenheit, while the average winter low temperature is 28 degrees Fahrenheit.

Tennessee's population is growing rapidly. According to the 2010 Census, Tennessee's population is over 6,346,105, which is an 11.5 percent increase in population from the 2000 Census (Secretary of State, 2005). This puts a greater burden on the state's waterways. Tennessee has over 60,000 stream miles and more than 570,000 lake acres. Several large reservoirs are shared with bordering states including Reelfoot Lake (KY) Pickwick Lake (AL), Kentucky Lake (KY), Lake Barkley KY), Guntersville Lake (AL), South Holston Lake (VA), and Dale Hollow Lake (KY).

Middle Prong Little Pigeon River in Sevier County – *Photo provided by Knoxville EFO*

Tennessee Facts

State population (2010 Census)	6,346,105
Largest Cities (2010 Census)	
Memphis	646,889
Nashville	601,222
Knoxville	178,874
Chattanooga	167,674
Clarksville	132,929
Murfreesboro	108,755
Jackson	65,211
Johnson City	63,152
Number of Counties	95
State Surface Area (square miles)	42,244
Number of Major Basins	13
Number of Level III Ecoregions	8
Number of Level IV Ecoregions	31
Number of Watersheds (HUC8)	55
Number of Stream Miles Forming State Border	213
(The Mississippi River forms most of the stream miles shared by another state.)	
Stream Miles Statewide (NHD)	60,394
Largest Rivers at Low Flow (7Q10 in ft^3/sec.)	
Mississippi River at Memphis	109,000
Tennessee River at South Pittsburg	12,500
Cumberland River at Dover	2,280
Hiwassee River above Charleston	1,220
Little Tennessee River at Calderwood	1,200
Holston River at Surgoinsville	762
French Broad River near Knoxville	722
South Fork Holston River at Kingsport	550
Duck River above Hurricane Mills	477
Obion River at Megelwood	357
Lake Acres Statewide	572,063
Largest Lakes (size in acres)	
Kentucky Reservoir (Tennessee portion)	117,500
Watts Bar Reservoir	39,000
Barkley Reservoir (Tennessee portion)	37,000
Chickamauga Reservoir	35,400
Estimated Acres of Wetlands	787,000

Cost of Water Pollution

Water pollution is a problem for everyone. The average American uses 140 to 160 gallons of water per day for sanitation, drinking, and many other human needs, such as recreation, transportation, and irrigation. Polluted water must be purified before it can be used for these purposes.

On average, treatment and delivery of tap water costs between $4 and $10 per 1,000 gallons. The more polluted water is, the more it costs per gallon to treat. There are other costs associated with water pollution as well.

When the water is no longer safe for recreational activities, the community loses an important resource. Two of the most obvious costs of water pollution are the expenses of health care and loss of productivity while people are ill. The biggest health risks encountered in polluted waters are from pathogens and contaminated fish. Individuals who swim in waters polluted by pathogens can become sick. People, especially children and pregnant women, who eat contaminated fish are at a higher risk for cancer and other health problems than those who do not eat contaminated fish. Subsistence fishermen are faced with the loss of their primary protein source.

When people can no longer eat fish from rivers, streams, and lakes, there is a potential for economic loss in the community. Commercial fishermen lose income when it is no longer legal to sell the fish they catch. As the fishermen move out of the community to find another place to fish, local business can decline.

Another cost of water pollution is the expense associated with keeping waters navigable. Commercial navigation as a means to move goods and services around the country is one of the most economical methods of transportation. As channels fill with sediment from upland erosion, commercial navigation becomes less practical. Silt deposits also reduce the useful lifespan of lakes and reservoirs. They become filled with silt, which decreases the depth of the water until dredging is required or the lake or reservoir is completely filled.

Clean water is important to everyone.

Photo provided by Jimmy Smith, TDEC, Nashville EFO

Chapter 1
Water Quality Assessment Process

Using a standardized assessment methodology, existing monitoring data from individual streams are compared to water quality standards in order to categorize the degree of use support (Chapter 2). Violations of water quality standards are identified. Individual assessments are stored in an electronic format, assessment information is compiled into reports such as the 305(b), and geographic referencing tools are used to prepare interactive maps that can be accessed by the public. Since the 2010 305(b) report was published, Group 3 and 4 watersheds have been assessed.

A. Water Quality Standards

The *Tennessee Water Quality Control Act* (Tennessee Secretary of State, 1999) identifies the Water Quality, Oil & Gas Board as the entity responsible for the promulgation of clean water goals. Federal law requires that the water quality standards be revisited at least every three years. Division staff provide technical assistance to the board in the development of criteria and the identification of appropriate use-classifications. Public participation is a vital part of the goal-setting process.

The specific water quality standards are established in *Rules of Tennessee Department of Environment and Conservation Division of Water Pollution Control*, Chapter 1200-4-3, General Water Quality Criteria and Chapter 1200-4-4, Use Classifications for Surface Water (Tennessee Department of Environment and Conservation, Water Quality, Oil & Gas Board, 2007).

Water quality standards have three sections. The first section establishes seven designated uses for Tennessee waterways: Fish and Aquatic Life, Recreation, Irrigation, Livestock Watering and Wildlife, Domestic Water Supply, Navigation, and Industrial Water Supply. The second section identifies numeric or narrative water quality criteria to protect each of the designated uses. The final section is an antidegradation policy designated to protect existing water uses and prevent future damage to water quality.

All waterbodies are classified for multiple uses and may have several criteria for each substance or condition (pollutants). When multiple criteria are assigned for different uses on a stream, the regulation states that the most stringent criterion must be met. The combination of classified uses, the most stringent criterion for those uses, and the requirements of the antidegradation policy create the water quality standard for each pollutant in a waterbody segment.

1. Stream Use Classifications

> **Tennessee's Current Stream-Use Classifications:**
>
> 1. Fish and aquatic life
> 2. Recreation
> 3. Irrigation
> 4. Livestock watering and wildlife
> 5. Drinking water supply
> 6. Navigation
> 7. Industrial water supply

The Tennessee Water Quality, Oil & Gas Board is responsible for the designation of beneficial uses of waterbodies. All streams, rivers, lakes, and reservoirs in Tennessee are classified for at least two public uses: protection of fish and aquatic life and recreation. These minimum use classifications comply with the goals of the federal act, which requires that all waters provide for the "protection and propagation of a balanced population of …fish and wildlife, and allow recreational activities in and on the water" (U.S. Congress, 2000).

Most waterbodies are also classified for irrigation and livestock watering and wildlife. Three additional classifications apply to specific waterbodies. The drinking water supply designation is assigned to waterbodies currently or likely to be used as domestic water sources in the future. The navigation and industrial water supply classifications are usually limited to waters currently being used for those purposes, but can be expanded to other waters as needed.

a. Fish and Aquatic Life (FAL) – This use classification is assigned to all waterbodies for the protection of fish and other aquatic life such as aquatic insects, snails, clams, and crayfish. While Tennessee does not currently have a system that creates tiers of aquatic life protection (e.g., warm water vs. cold water fisheries), the state has developed regional interpretations of some criteria such as nutrients and biological integrity. Additionally, trout waters have more stringent criteria for dissolved oxygen and temperature.

b. Recreation – All waterbodies in Tennessee are classified for the protection of the public's ability to swim, wade, and fish. Threats to recreational uses of streams include the loss of aesthetic values due to algae or turbidity, elevated pathogen levels, and the accumulation of dangerous levels of metals or organic compounds in fish tissue.

c. Irrigation - This use classification is assigned to most waterways to protect the ability of farmers to use streams or reservoirs as a source of water to irrigate crops.

d. Livestock Watering and Wildlife – This use classification protects waters to be used as an untreated drinking water source for livestock and wildlife.

e. Drinking Water Supply –This use classification is assigned to waterbodies that are currently or are likely to be used for domestic water supply.

f. **Navigation** – This classification is designated to protect navigational rivers and reservoirs from any alterations that would adversely affect commercial transport of goods by barges or other large boats.

g. **Industrial Water Supply** - This classification is assigned to waters currently used for industrial purposes. If needed, additional waters may be designated as industrial water supplies.

Designated uses are goals, not necessarily a documentation of the current use of that waterbody. Even if a stream or reservoir is not currently used for a given activity, if classified, it should be protected for that use in the future. All streams that are not specifically listed in 1200-4-4 are classified for fish and aquatic life, recreation, irrigation, and livestock watering and wildlife. This regulation can be viewed or downloaded from the Tennessee Secretary of State's webpage, at http://www.tn.gov/sos/rules/1200/1200-04/1200-04-04.pdf.

2. Water Quality Criteria

The Tennessee Water Quality, Oil & Gas Board has assigned specific water quality criteria to each designated use. These criteria establish the water quality needed to support each use. Since every waterbody has multiple uses, it may have multiple applicable criteria. The standard for each stream is based on the most stringent criterion for the uses assigned to it. The most stringent criteria are for the protection of fish and aquatic life, recreation, or drinking water.

a. **Fish and Aquatic Life (FAL)** – FAL criteria are designed to protect aquatic life from acute and chronic toxicity. Acute toxicity refers to the level of contaminant that causes death in an organism in a relatively short period of time. Chronic toxicity refers to a lower level of contamination that causes death or other ill effects (such as reproductive failure) over a longer period of time. Since Tennessee does not perform primary research into the toxic effects of pollutants, reliance is placed on EPA's published national criteria, which are based on the following types of research:

- Toxicity tests performed on lab animals.
- The number of cancer incidences in animals after exposure to a substance.
- A substance's tendency to concentrate in the food chain.

FAL have the most protective numeric criteria for many parameters including: dissolved oxygen, pH, temperature, many toxic substances, and flow. FAL also have narrative criteria with regional numeric interpretations for nutrients, biological integrity and habitat.

b. Recreation – These criteria are established to protect the public's ability to swim and wade in Tennessee waters and to safely eat fish they catch. If fish tissue have dangerous levels of metals or organic substances, or if streams are found to have elevated bacteria levels, warning signs are posted to inform the public concerning the potential health risk. See Chapter 5 for additional information on advisories.

For two parameter categories, pathogens and carcinogens, recreational criteria tend to be the most protective. *E. coli* is used as the primary indicator of risk due to pathogens. Criteria for carcinogens are designed to prevent the accumulation of dangerous levels of metals or organic compounds in the water or sediment that may ultimately accumulate in fish tissue. The criteria also identify the procedure to be used when evaluating fish tissue contamination and for the decision process for stream posting.

c. Irrigation – These criteria protect waters to be used for agricultural irrigation purposes. Most of the irrigation criteria are narrative.

d. Livestock Watering and Wildlife – These criteria protect waters to be used as untreated drinking water sources for livestock and wildlife. Most of the livestock watering and wildlife criteria are narrative.

e. Drinking Water Supply – These criteria protect waters used as domestic water supplies from substances that might cause a public health threat, if not removed by conventional water treatment. Since many contaminants are difficult and expensive to remove, it is more cost effective to keep pollutants from entering the water supply in the first place. For this purpose, the surface water criteria adopt the Maximum Contaminant Levels (MCLs) suggested by EPA for finished water as goals for surface waters used for source waters.

f. Navigation – These criteria protect waterways used for commercial navigation. Navigation criteria are narrative.

g. Industrial Water Supply- These criteria protect waters used as water supplies for industrial purposes. Criteria for pH, total dissolved solids, and temperature are numerical. The remaining industrial water supply criteria are narrative.

General Water Quality Criteria for surface waters in Tennessee are listed in Rules of TDEC, Chapter 1200-4-3 (TDEC-WQOGB, 2007). A copy of these regulations can be viewed or downloaded at the Tennessee Secretary of State's home page at

http://tn.gov/sos/rules/1200/1200-04/1200-04-03.20110531.pdf

3. Antidegradation Policy

The third section of Tennessee water quality standards contains the antidegradation policy, which protects existing uses of all surface waters and provides a process for authorizing degradation in waters identified as high quality. Measureable degradation in impaired waters cannot be authorized for parameters of concern. In high quality waters, degradation can only be allowed if it is in the public interest and there are no other reasonable options. In 2006, the antidegradation statement was revised and the Tier designations were replaced by the categories below. Additional adjustments to this language were proposed in 2009, but have not yet been finalized.

a. **"Unavailable" conditions** exist where water quality is at, or fails to meet, the criterion for one or more parameters. In unavailable conditions, new or increased discharges of a substance that would contribute to a condition of impairment will not be allowed.

b. **"Available" conditions** exist where water quality is better than the applicable criterion for a specific parameter. In available conditions, new or additional degradation for that parameter will only be allowed if the applicant has demonstrated that the reasonable alternatives to degradation are not feasible." Additionally, the degradation must be in the public interest.

c. **Exceptional Tennessee Waters** are waters where no degradation will be allowed unless that change is justified due to necessary economic or social development and will not interfere with or become injurious to any classified uses existing in such waters.

   Exceptional Tennessee Waters are:

   - Waters within state or national parks, wildlife refuges, wilderness areas or natural areas.
   - State Scenic Rivers or Federal Wild and Scenic Rivers.
   - Federally-designated critical habitat or other waters with documented non-experimental populations of state or federally-listed threatened or endangered aquatic or semi-aquatic plants or animals.
   - Waters within areas designated Lands Unsuitable for Mining (as long as water resources were part of the justification for the designation).
   - Streams with naturally reproducing trout.
   - Waters with exceptional biological diversity as evidenced by a score of 40 or 42 on the Tennessee Macroinvertebrate Index (TMI) (or a score of 28 or 30 in subregion 73a), if the sample is considered representative of overall stream conditions.
   - Other waters with outstanding ecological or recreational value as determined by the department.

d. **Outstanding National Resource Waters (ONRWs)** - These exceptional Tennessee waters constitute an outstanding national resource due to their exceptional recreational or ecological significance (Table 1).

Table 1: Outstanding National Resource Waters

Waterbody	Portion Designated as ONRW
Little River	Portion within Great Smoky Mountains National Park
Abrams Creek	Portion within Great Smoky Mountains National Park
West Prong Little Pigeon River	Portion within Great Smoky Mountains National Park upstream of Gatlinburg
Little Pigeon River	From headwaters within Great Smoky Mountains National Park downstream to the confluence of Mill Branch
Big South Fork Cumberland River	Portion within Big South Fork National River and Recreation Area
Reelfoot Lake	Tennessee portion of the lake and its associated wetlands

According to the regulation, the portion of the Obed River designated as a federal wild and scenic river as of June 22, 1999 is an ONRW. However, if the current search for a regional water supply by the Cumberland Plateau Regional Water Authority results in a determination that it is necessary to use the Obed River as its source of drinking water, for that purpose the Obed shall be designated as an Exceptional Tennessee Water and any permit issued for that project, whether state, federal, or otherwise, shall be considered under the requirements for Exceptional Tennessee Waters.

A current list of known high quality waters, which includes both Exceptional Waters and Outstanding National Resource Waters is available on the state's website at http://tn.gov/environment/water.shtml. Additional high quality waters will be added to the list as they are identified.

Big South Fork Cumberland River is an Outstanding National Resource Water.

Photo provided by Michael Graf, PAS.

B. Water Quality Resource Management

In the early 1970's, the USGS delineated 55 hydrologic watershed boundaries within Tennessee. A watershed is the entire land area that drains into a particular watercourse or body of water. In 1996, the division adopted a watershed approach that reorganized existing programs and focused on place-based water quality management.

> It is important that watersheds are not confused with ecoregions. The watershed approach is an organizational monitoring framework. Ecoregions serve as a geographical framework for establishing water quality expectations.

The watershed approach is a decision making process that reflects a common strategy for information collection and analysis as well as a common understanding of the roles, priorities and responsibilities of all stakeholders within a watershed. Traditional activities like permitting, planning and monitoring are coordinated. A significant change from the past is that the watershed approach encourages integration of tradition regulatory (point source pollution) and non-regulatory (nonpoint source pollution) programs. When all pollution sources are considered together, agencies are better able to focus on those controls necessary to produce measurable improvements in water quality. This also results in a more efficient process. It encourages agencies to focus staff and financial resources on prioritized geographic location and makes it easier to coordinate between agencies and individuals with an interest in solving water quality problems.

Four main features are typical of the watershed approach:

- Identifying and prioritizing water quality problems in the watershed.
- Developing increased public involvement.
- Coordinating activities with other agencies
- Measuring success through increased and more efficient monitoring and data gathering.

The 55 watersheds in Tennessee have been divided into five groups based on the year of implementation in a five year cycle (Figure 1). Each group contains between 9 and 16 watersheds (Table 2 and figure 2). In 2012, adjustments were made in five watersheds to more evenly distribute monitoring resources.

- Pickwick Lake from cycle 2 to 1.
- Upper Cumberland (Cordell Hull) from cycle 4 to 5.
- Stones River from cycle 1 to 2.
- Collins River from cycle 2 to 3.
- Upper Duck River from cycle 3 to 4.

Activities for each group are based on its position in the cycle. One of the following six key activities is occurring in each of the five watershed group each year.

1. **Planning and Existing Data Review.** Existing data and reports from appropriate federal, state, and local agencies and citizen-based organizations are compiled and used to describe the current conditions and status of reservoirs, lakes, rivers and streams. Review of all exiting data and comparison of agency workplans guide the development of an effective monitoring strategy.

2. **Monitoring.** Field data are collected from reservoirs, lakes, rivers and streams. Three standard operating procedures (SOPs) have been developed to guide sampling techniques and quality control for macroinvertebrate surveys (TDEC, 2011), chemical and bacteriological sampling (TDEC, 2011), and periphyton sampling (TDEC, 2010). Watershed groups 1 and 5 have been monitored since the 2010 305(b) report was published.

3. **Assessment.** Monitoring data are used to determine if the streams, rivers, lakes, reservoirs, and wetlands support their designated uses based on stream classifications and water quality criteria. Causes and sources of impairment are identified for waterbodies that do not meet their designated uses. Following the assessment, a public meeting is conducted to inform the public of the most recent results. Watershed groups 3 and 4 have been assessed since the 2010 305(b) report was published. These assessments are included in this report.

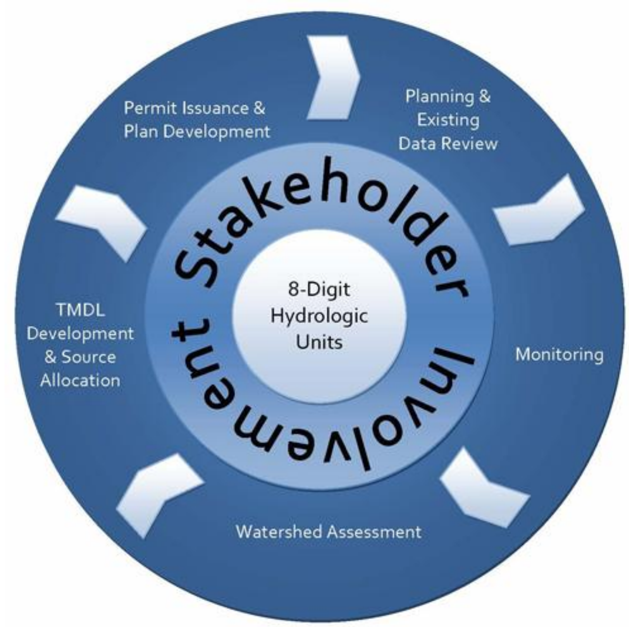


Figure 1: Watershed Cycle

4. **Total Maximum Daily Load (TMDL) Development/Source Allocation.** TMDLs are studies that determine the point and nonpoint source contributions of a pollutant in the watershed. The TMDL program locates, quantifies and identifies continuing pollution problems in impacted waters and then proposes solutions. Monitoring data are used to determine pollutant effluent limits for permitted dischargers releasing wastewater to watersheds. Limits are set to assure that water quality is protected.   TMDL documents may recommend regulatory or other actions required to resolve pollution problems.

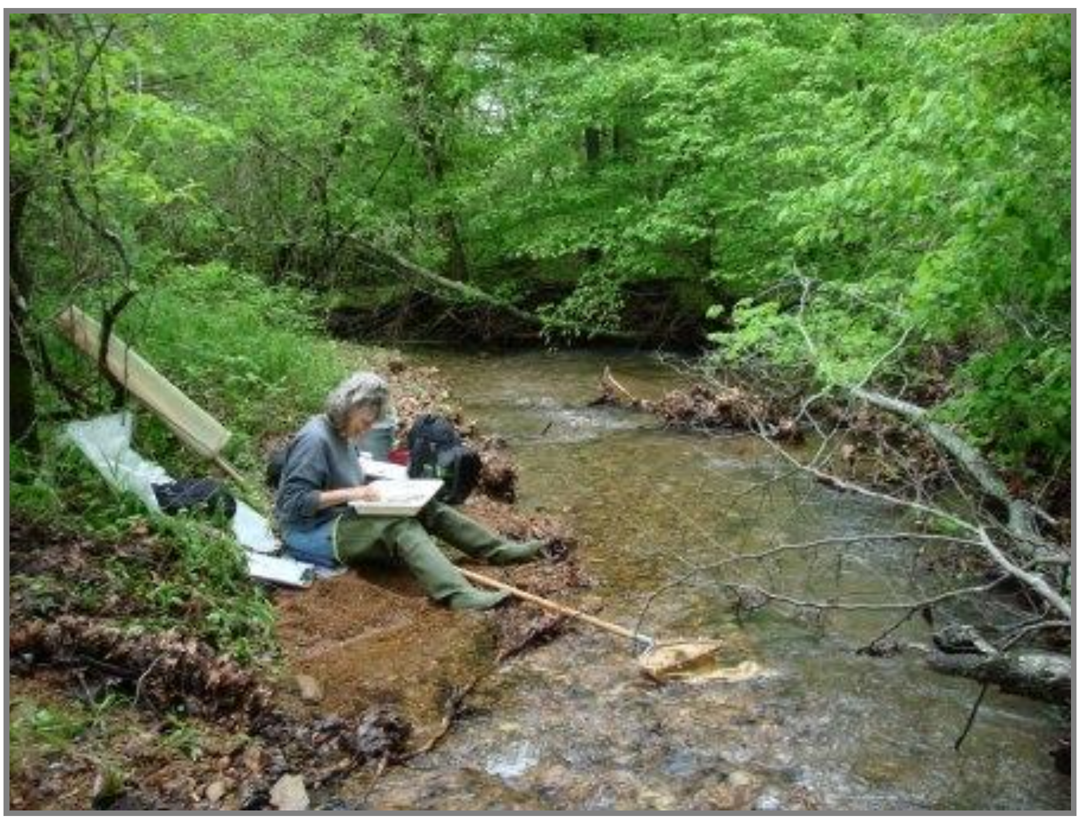
The five steps of the TMDL process are:

- Identify water quality problems in a waterbody.
- Prioritize water quality problems.
- Develop TMDL plan to control sources.
- Implement water quality improvement actions.
- Assess water quality improvement efforts.

5. **Permits.** Expiration and issuance of all discharge permits are synchronized to the five-year watershed cycle.

6. **Watershed Management Plans.** Each existing watershed plan contains a general description, management strategies, and information relevant to water quality. Future plans will focus on TMDL implementation.

More details may be found on the Watershed Management home page. http://www.tn.gov/environment/water/watershed/.

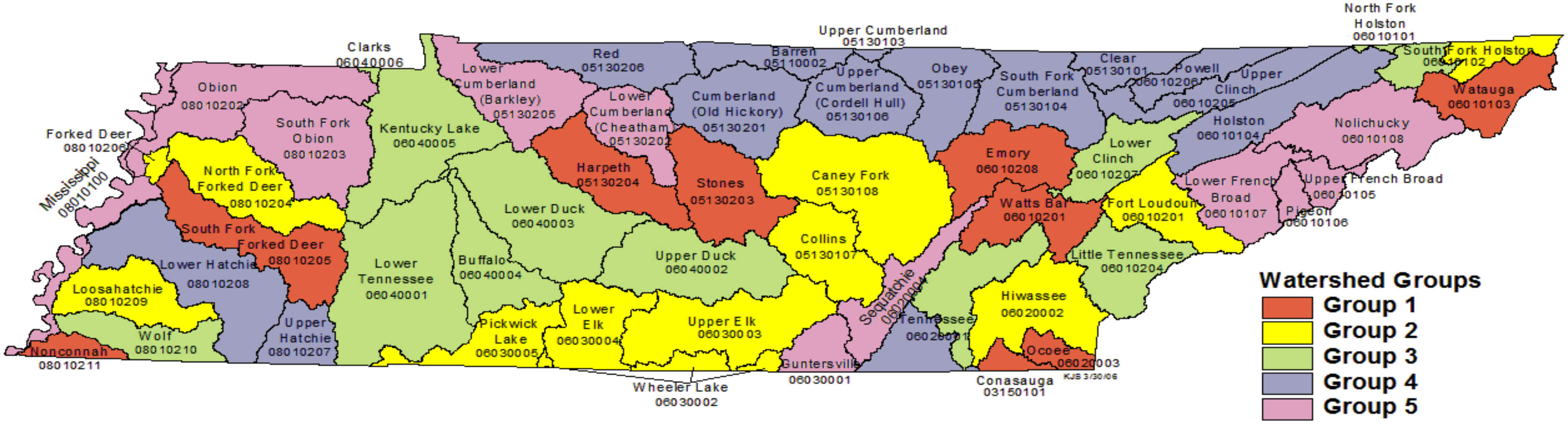


Streams in the Lower Duck River Watershed were assessed for the 2012 report. *Photo provided by Nashville EFO.*

Table 2: Watershed Groups and Monitoring Schedule

	Monitoring Years	West Tennessee	Middle Tennessee	East Tennessee
Group 1	1996 2001 2006 2011 2016	• Nonconnah • South Fork of the Forked Deer	• Harpeth • Wheeler Res.^ • Pickwick Res.^	• Upper Tennessee (Watts Bar Res.*)† • Ocoee • Emory* • Watauga • Conasauga
Group 2	1997 2002 2007 2012 2017	• Loosahatchie • North Fork Forked Deer • Forked Deer	• Stones • Caney Fork • Upper Elk • Lower Elk	• Hiwassee • Upper Tennessee (Fort Loudoun Res.*)† • South Fork Holston (part)†
Group 3	1998 2003 2008 2013 2018	• Wolf • TN Western Valley (KY Lake) • TN Western Valley (Beech) • Clarks	• Collins ^ • Lower Duck • Buffalo	• Lower Tennessee (Chickamauga Res.)† • Little Tennessee* • Lower Clinch* • North Fork Holston • South Fork Holston (part)†
Group 4	1999 2004 2009 2014 2019	• Upper Hatchie • Lower Hatchie	• Red • Barren • Cumberland (Old Hickory) • Obey • Upper Duck^	• South Fork Cumberland* • Upper Cumberland* • Powell* • Upper Clinch* • Holston* • Clear Fork • Lower Tennessee (Nickajack Res.)†
Group 5	2000 2005 2010 2015 2020	• Mississippi • Obion • South Fork Obion	• Barkley Reservoir • Cheatham Reservoir • Guntersville Reservoir • Upper Cumberland (Cordell Hull)^	• Sequatchie • Upper French Broad* • Lower French Broad* • Pigeon* • Nolichucky

*These watersheds are monitored the following year.
†These watersheds have been split into two watershed groups.
^ These watersheds were moved into a different group in 2012.



1996-2011

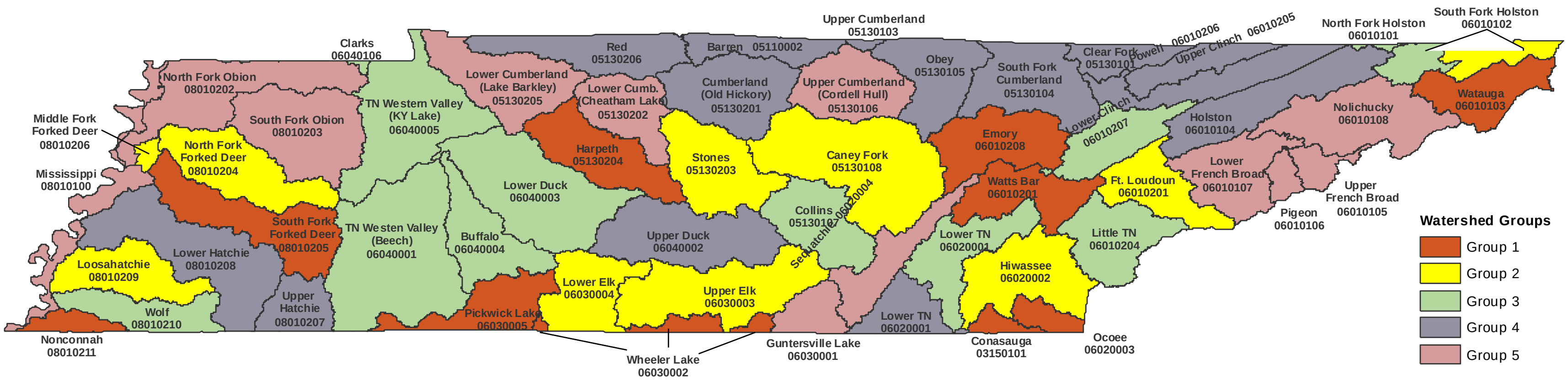


Figure 2: Watershed Monitoring Groups

2012

C. Types of Monitoring

The Division of Water Resources has developed a monitoring strategy based on the need to collect data for various program responsibilities. Biological, chemical, bacteriological, and physical data are collected to supply information for the activities listed below. Additional information concerning the monitoring strategy can be found in the in the Division of Water Resources Monitoring and Assessment Program Plan posted on the TDEC webpage (TDEC 2011).

1. Watershed Monitoring

Consistent with the division's watershed approach, as many additional stations as possible are monitored in order to collect information on waterbody segments that have not previously been assessed. If possible, sampling locations are located near the mouth of each tributary. Minimally, macroinvertebrate biorecons, habitat assessments, and field measurements of DO, conductivity, pH, and temperature are conducted at these sites.

If impairment is observed, and time and priorities allow, additional sites are located upstream of the impaired water reach to define the impairment length. Chemical samples are collected as needed to determine pollutant causes. Bacteriological samples are collected to determine recreational use support.

2. 303(d) Monitoring

During each watershed cycle, 303(d) listed streams are monitored. At a minimum, 303(d) stations are sampled three times for the pollutants of concern and a macroinvertebrate biological sample is collected. Additional monitoring is required for confirmation if water quality appears to have improved.

3. Long-Term Trend Station Monitoring

Approximately 60 long-term trend stations are monitored quarterly for chemical and bacteriological quality. These data are used to check for changes in water quality over time.

4. Antidegradation Monitoring

Before activities that degrade water quality can be authorized, a stream's proper status under the antidegradation policy must be determined. The division uses a standardized evaluation procedure for this purpose. These activities are difficult to plan, because waterbodies are evaluated as needed - generally in response to requests for new or expanded NPDES and Aquatic Resource Alteration Permit (ARAP) permits. The type of monitoring utilized for this purpose is the more intensive biological survey since the biological integrity of a stream is an important consideration.

5. Ecoregional Reference Stream Monitoring

Established reference stations are monitored in conjunction with the watershed cycle. Each station is sampled quarterly for chemistry and pathogens as well as in the spring and fall for macroinvertebrates. Semi-quantitative single habitat and biorecon samples are collected to establish biocriteria and biorecon guidelines. In 2007, the division also began collecting periphyton at these sites. If watershed screening results indicate a potential new reference site, more intensive reference stream monitoring protocols are used to evaluate potential inclusion in the reference database.

6. Permit Compliance/Complaint Investigation

Monitoring is undertaken each year to insure that facilities or other entities are in compliance with permit conditions. These monitoring efforts typically have one of the following designs:

- Above/Below Surveys – Samples are collected above and below an activity to determine the immediate effect the activity is having on the stream.

- Trend Determination – Samples are collected over time downstream of an activity to document if conditions are getting better or worse.

- Reference Approach - Data collected below an activity are compared to a suitable reference stream. This technique is particularly helpful when the activity is in a headwater reach or where the stream is also impacted upstream of the activity.

Additionally, the department receives numerous water quality complaints each year from citizens. These are handled as a priority activity and any data collected at these streams can be used to assess the waterbody.

7. Probabilistic Monitoring

Statistical survey designs have been used for many years to characterize the condition of large populations based on a representative sample of a relatively few members or sites within the population. The ability of these designs to provide accurate estimates, with documented confidence levels, of the condition of populations of interest is well documented. These surveys are used in a variety of fields including election polls, monthly labor estimates, forest inventory analysis, and the national wetlands inventory.

In 2001, the division began incorporating probabilistic survey design into its monitoring strategy. Probabilistic monitoring means that sites are selected using a random sample design. Every site in the target population has an equal chance of being selected for sampling can be extrapolated to the entire population of waterbodies represented by the subsample. Because of its consistent methods and sampling framework, probabilistic monitoring is useful as a baseline for trend analysis.

8. Fish Tissue Monitoring

Fish tissue samples are often the best way to document chronic low levels of persistent contaminants. Discovery of elevated levels of certain contaminants in fish tissue can lead to use advisories, which are discussed in greater detail in Chapter 5.

Fish tissue monitoring in Tennessee is planned by a workgroup consisting of TDEC staff (Water Resources and DOE-Oversight), TVA (Tennessee Valley Authority), TWRA (Tennessee Wildlife Resources Agency), and ORNL (Oak Ridge National Laboratory). The workgroup meets annually to discuss fish tissue monitoring needs for the following year. Data from these surveys help the division assess water quality and guide the issuance of fishing advisories.

TVA routinely collects fish tissue from reservoirs they manage. ORNL collects fish tissue samples from rivers and reservoirs that receive drainage from the Department of Energy Property in Oak Ridge. TWRA provides fish tissue samples to TDEC that are collected during population surveys.

TDEC contracts other needed fish sampling and analyses to the Aquatic Biology Section, Tennessee Department of Health. Targeted fish are five game fish, five rough fish, and five catfish of the same species. Samples are generally composited, although large fish may be analyzed individually. Only fillets (including belly flap) are analyzed for routine monitoring although wholebody fish may be used for special projects.

9. Sediment Monitoring

Although it is not commonly done, samples of the sediment at the bottom of a creek or lake can be collected to determine the presence of harmful amounts of metals or carcinogens. One of the reasons this type of monitoring is not frequently a part of monitoring plans is that few criteria exist to reliably assess the degree of harm to the waterbody.

Recent examples of sediment monitoring in Tennessee include documenting the extent of mercury contamination in Beech Creek in Wayne County, assessing levels of metals in coal ash spilled into the Emory River near Kingston, and looking for pesticides in Cypress Creek in Memphis.

As with all monitoring, field and laboratory staff use standardized procedures for the collection and analysis of sediment samples. Although Tennessee has no numeric sediment criteria, EPA literature and guidance developed by the National Oceanographic and Atmospheric Administration (NOAA) are used to assist in data interpretation.

D. Water Quality Data

1. Data Sources

The division used all reliable data that were readily available for the assessment of Tennessee's waterways. This included data from TDEC, other state and federal agencies, universities, NPDES permit holders, citizens, and the private sector (Table 3). In July 2008, January 2009, January 2010, and January 2011, the division issued public notices requesting water quality data for use in the statewide water quality assessment.

Agency information regarding Tennessee's water quality was received from the Environmental Protection Agency, Tennessee Valley Authority, U.S. Geological Survey, Tennessee Wildlife Resource Agency, and U.S. Army Corps of Engineers. Biological and pathogen data submitted by NPDES dischargers as part of permit requirements were used. Universities and watershed groups also supplied data.

All submitted data were considered in the assessment process. If data reliability could not be established, submitted data were used to screen waters for future studies. In situations where data from the division and another source did not agree, more weight was given to the division's data unless the other data were significantly more recent.

Table 3: Data Submitted to the Division for Consideration in the 2012 Assessment Process

Agency	Physical Data	Biological Data	Chemical Data	Bact. Data
US Army Corp of Engineers		X	X	
Tennessee Valley Authority	X	X	X	X
US Geological Survey	X	X	X	X
Tennessee Wildlife Resources Agency	X	X		
Phase II MS4 permittees	X	X	X	X
NPDES permittees (mining, municipalities, industries, other point source dischargers)	X	X	X	X
Universities	X	X	X	X

2. Data Quality Objectives

To assure the highest confidence in the assessment results, all data must be of reliable quality. As part of this goal, a *Quality Assurance Project Plan for 106 Monitoring* has been compiled by the division TDEC, 2011). This document defines monitoring, analyses, quality control, and assessment procedures.

In order to specify collection techniques within the state, standard procedures have been developed for collection of water quality samples. The procedures also identify appropriate quality control measures. The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2011) was first published in March of 2002 and revised in November 2003, October 2006, and July 2011. The *QSSOP for Chemical and Bacteriological Sampling of Surface Waters* (TDEC, 2011) was first published in March 2004 and revised in 2008, 2009, and 2011. The *QSSOP for Periphyton Stream Surveys* was published in 2010. These documents are reviewed annually and revised as needed. TDEC staff are trained annually on proper collection techniques.

3. Data Management

The division has several tools that have increased the efficiency, accuracy, and accessibility of assessments. Software programs, combined with increased computer capabilities have expanded the ability to organize, store, and retrieve monitoring and assessment information. These improvements have helped not only with the organization of large quantities of information, but also analysis of specific waterbodies.

a. STORET and WQX

Due to the large amount of data collected in monitoring activities, it was paramount for the division to utilize an electronic database to store and easily retrieve data for analyses and assessment. In the early 1970s, EPA developed the national water quality STOrage and RETrieval database called STORET. This database allowed for easy access to bacteriological and chemical information collected throughout the state and nation. TDEC Water Resources station locations and chemical and bacteriological data were uploaded into the database quarterly. In September 2009, EPA ceased support of the current format that the data is uploaded to STORET. The last upload of TDEC Water Pollution Control data was sent to EPA the end of September 2009. The data can be located at STORET at http://www.epa.gov/STORET.

Currently, the Division of Water Resources is working with EARTHSOFT to utilize the software EQuiS to upload data to the EPA WQX database. The Water Quality Exchange (WQX) is a new framework that makes it easier for States, Tribes, and others to submit and share water quality monitoring data over the Internet.

b. Water Quality Database

Tennessee's Water Quality Database (WQDB) is an interim storage database for chemical, biological, habitat and fish tissue data prior to upload to WQX. This database is updated and made available to Water Resources staff quarterly. Retrievals are made available to the public upon request.

c. Assessment Database

The Assessment Database (ADB) was developed by EPA to store assessment results for streams, rivers, and reservoirs. The ADB allows for specific analysis of small stream segments, as well as overall assessment of total watersheds. All waters are assigned a unique identification number based on the National Hydrology Database (NHD). All waterbody IDs begin with Tennessee's abbreviation (TN). The next 8 digits represent the numerical Hydrological Unit Code (HUC) assigned to each watershed by the U.S. Geological Survey (USGS). The next 3 digits represent a specific reach or subdivision of the waterbody. The final 4 digits specify a unique segment number. The resulting 15-digit waterbody ID is a unique identification number specific to a precise portion of a waterbody.

d. Geographic Information Systems

The ADB system is linked to the division's **Geographic Information System (GIS)**. The combination of these technologies allow for easy access to information on specific waterbodies by locating them on GIS maps.

e. Reach Indexing Tool and National Hydrography Dataset

EPA also developed the **Reach Indexing Tool (RIT)** and **National Hydrography Dataset (NHD)**. These software are linked to the ADB and GIS allowing quick georeferencing of assessment information.

f. Online Water Quality Assessment

An interactive map called Tennessee's Online Water Quality Assessment links the ADB and GIS through the RIT. This site allows the user to select a specific waterbody and read water quality assessment information. This site is reached through the division's home page at: http://tnmap.tn.gov/wpc/

g. Water Pollution Information Management System

The division also has an online database available to division employees. This database contains assessment data, plus lists of Exceptional Tennessee Waters and those waters that have been evaluated and are not Exceptional Tennessee Waters. This information is updated monthly. Water Resources is also developing on-line mapping for this information.

E. Water Quality Assessment Methodology

Water quality assessments are completed by comparing water quality data to the appropriate criteria to determine if waters are supportive of designated uses. To facilitate this process, several provisions have been made:

- Criteria have been refined to help evaluate data. The ecoregion project has dramatically reduced the uncertainty associated with the application of statewide narrative and numerical criteria. Guidance documents have been developed to assist in the interpretation of biological, nutrient, habitat, and periphyton data.

- Critical periods have been determined for various criteria. Certain collection seasons and types of data have proven more important for the protection of specific water uses. For instance, the critical period for parameters like toxic metals or organics is the low flow season of late summer and early fall. Likewise, most water contact, like swimming and wading, occurs in the summer. Therefore, that is the season when pathogen results are considered most significant.

- To ensure defensible assessments, data quality objectives have been set. For some parameters, a minimum number of observations are needed to assure confidence in the accuracy of the assessment.

- Provisions in the water quality criteria instruct staff to determine whether violations are caused by man-induced or natural conditions. Natural conditions are not considered pollution.

- The magnitude, frequency, and duration of violations are considered in the assessment process.

- Streams in some ecoregions naturally go dry or historically have only subsurface flow during prolonged periods of low flow. Evaluations of biological integrity attempt to differentiate whether waters have been recently dry or have been affected by man-induced conditions.

- Ecoregion reference sites are re-evaluated and data are statistically tested annually. New sites are added when possible. Existing sites are dropped if data show the water quality has degraded, the site is not typical of the region, or does not reflect the best attainable conditions. Data from bordering states that share the same ecoregions are used to test suitability of reference sites and augment the dataset. Currently the state is reviewing river, lakes, headwaters, and reservoir data to identify reference conditions in these systems.

1. Application Methodology for Specific Criteria

There are two types of criteria: numeric and narrative. Both types offer challenges. Numeric criteria provide a specific level that should not be exceeded. The regulation instructs staff to consider the frequency, magnitude, and duration of numeric criteria violations and to determine whether the appearance of pollution might be due to natural causes.

Narrative criteria are written descriptions of water quality. These descriptions generally state that the waters should be "free from" particular types or effects of pollution. The division's long-standing position is that narrative criteria should have a regional basis for interpretation. To help provide regional information for narrative criteria, guidance documents based on reference stream data have been developed for biological integrity (Arnwine and Denton, 2001), habitat (Arnwine and Denton, 2001), and nutrients (Denton *et al*., 2001). Guidelines for biological criteria and habitat are re-calibrated every three years and are published in the department's QSSOP for Macroinvertebrate Stream Surveys (TDEC, 2011).

a. Toxic Substances (Numeric)

- Metals data are appropriately "translated" according to the water quality standards before comparison to criteria. For example, toxicity of metals can be altered by the waterbody's hardness and the amount of total suspended solids in the water. Widely accepted methodologies are used to translate toxicity data.

- If more than ten percent of the observations of a specific metal is above chronic criteria, the stream is assessed as impaired by that metal.

b. Pathogen Criteria (Numeric)

- Waterbodies are not assessed as impaired due to high bacteria levels with less than four water samples. The only waters assessed with one or two observations are waterbodies previously listed due to elevated bacteria levels or streams with obviously gross conditions, such as failing animal waste lagoons.

- Tennessee utilizes *E.* coli as our indicator since this group is generally considered more reflective of true risk than are fecal coliform data.

- If flow data are available, low flow, dry season data are considered more meaningful than high flow, wet season data. In the absence of flow data, samples collected in late summer and fall are considered low flow or dry season samples. It is important to note that wet season pathogen samples are not disregarded.

c. Dissolved Oxygen (Numeric)

- Dissolved oxygen levels in streams are measured in flowing water. Data collected at extreme low flows must be interpreted with caution as any violations may be due to natural stagnation rather than pollution.

- If the source of the low DO is a natural condition such as ground water, spring, or wetland, then the low DO is considered a natural condition and not pollution.

d. Nutrient Criteria (Narrative)

- The only designated uses that have nutrient criteria are fish and aquatic life and recreation. A specific nutrient response criterion based on chlorophyll *a* has been adopted for Pickwick Lake.

- Regional nutrient goals (Denton *et al*., 2001) were used as guidance during this assessment cycle.

- Waters are not assessed as impaired by nutrients unless biological or aesthetic impacts, or downstream problems are also documented.

- At least four nutrient observations are needed for a valid assessment, unless biological impairment is also observed.

e. Turbidity/Suspended Solids Criteria (Narrative)

- Historically, silt has been one of the primary pollutants in Tennessee waterways. The division has experimented with multiple ways to determine if a stream, river, or reservoir is impaired due to silt. These methods include visual observations, chemical analysis (total suspended solids), and macroinvertebrate/ habitat surveys. The most satisfactory method for identification of impairment due to silt has been biological surveys that include habitat assessments.

- Ecoregions vary in the amount of silt that can be tolerated before aquatic life is impacted. Through work at reference streams, staff found that the appearance of sediment/silt in the water is often, but not always, associated with loss of biological integrity. Thus, for water quality assessment purposes, it is important to establish whether or not aquatic life is being impaired. For those streams where loss of biological integrity can be documented, the habitat assessment can determine if this loss is due to excessive silt deposits.

f. Biological Integrity Criteria (Narrative)

- Biological integrity criteria are designed to protect fish and aquatic life.

- Biological surveys using macroinvertebrates as the indicator organisms are the preferred method for assessing use support. Two standardized biological methods, biorecons and semi-quantitative samples, are used to produce a biological index score. These methods are described in *Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys* (TDEC, 2011) and are referenced in the water quality criteria.

- The most commonly utilized biological survey method is the biorecon. Biological scores are compared to the metric values obtained in ecoregion reference streams. Three metrics are examined: taxa richness, number of families or genera of caddisflies, mayflies, and stoneflies (EPT), and number of intolerant families or genera.

- If a more definitive assessment is needed, a single habitat, semi-quantitative sample is collected. Organisms are identified to genus and an index based on seven biological metrics is used for comparison to reference streams. Streams are considered impaired if the biological integrity falls below the target score for that region.

- If both biorecon and single habitat semi-quantitative data are available and the results do not agree, more weight is given to the single habitat semi-quantitative results. If data from the division and another agency do not agree, more weight is given to the state's data unless the other agency's data are considerably more recent.

- To be comparable to ecoregions guidance, streams must be similar size (order) and drainage as the reference streams in the ecoregion and must have at least 80 percent of the upstream drainage within that ecoregion.

g. pH (Numeric)

- The pH criterion range for wadeable streams is 6.0 - 9.0. For nonwadeable rivers, streams, reservoirs, and wetlands, the pH range is 6.5 – 9.0.

- A complicating factor is that increased acidity causes some metals to become more toxic. In many waterbodies assessed as impaired by acidity, it is difficult to discern whether the harm was caused by the reduced pH or the resulting metal toxicity, especially in areas with historical or active mining present. Conversely, increased alkalinity makes ammonia more toxic.

h. Habitat Data (Narrative)

- Habitat alteration is one of the major causes in stream impairment in the state.

- Division staff use a standardized scoring system developed by EPA to rate the habitat in a stream (Barbour, *et al*., 1999). The *QSSOP for Macroinvertebrate Stream Surveys* (TDEC, 2011) provides guidance for completing a habitat assessment and evaluating the results.

- Habitat scores calculated by division biologists are compared to the ecoregion reference stream database. Streams with habitat scores less than 75 percent of the median reference score for the ecoregion are considered impaired, unless biological integrity meets expectations.

- The habitat goals are referenced in the 2007 General Water Quality Criteria, (TDEC-WQOGB, 2007).

2. Assessment Rates for 2012

The division maintains a statewide monitoring system of approximately 7,000 stations (not all stations are monitored in each cycle). In addition, new stations are created every year to increase the number of assessed waterbodies. Data from approximately 1700 Group 3 and Group 4 stations monitored July 2007 – December 2011 were used for this report.

> Waterbodies were assessed using current (less than five years old) data, including biological and chemical results, field observations, and any other available

Chapter 3 of this report summarizes water quality in Tennessee's streams, rivers, reservoirs, and lakes. In order to determine use support, it must be decided if the waterbody meets the most protective water quality criterion for its assigned uses. Generally, the most stringent criteria are associated with recreational use and support of fish and aquatic life.

With available resources, it is not possible to monitor all of Tennessee's waterbodies. A strategy based on watershed cycles has been designed and implemented to systematically sample and monitor as many waterbodies as possible. Some waterbodies are difficult to access or are very small. Other streams have intermittent flows. During periods of low flow, some of these streams go dry or flow underground.

For this report, almost half (28,422 miles) of the stream miles (Figure 3) and almost all (565,595 acres) of the reservoir and lake acres (Figure 4) in the state were monitored and assessed. Fifty-three percent (31,996 miles) of Tennessee's streams and rivers were not assessed during this cycle. Only one percent (6,468 acres) of Tennessee's reservoir and lake acres have not been assessed.

3. Data Application – Categorization of Use Support

Waterbodies are assessed by comparing monitored water conditions to water quality standards for the waterbody's designated uses. Data that meet state quality control standards and collection techniques are used to generate assessments. After use support is determined, waterbodies are placed in one of the five categories recommended by EPA.

Use Support Categories

Category 1 waters are **fully supporting** of all designated uses. These streams, rivers, and reservoirs have been monitored and meet the most stringent water quality criteria for all designated uses for which they are classified. The biological integrity of Category 1 waters is favorably comparable with reference streams in the same subecoregion and pathogen concentrations are at acceptable levels.

Category 2 waters are **fully supporting** of some designated uses, but have not been assessed for all uses. In many cases, these waterbodies have been monitored and are fully supporting of fish and aquatic life, but have not been assessed for recreational use.

Category 3 waters are **not assessed** for any use due to insufficient or outdated data. However, streams previously identified as impaired are not moved to this category simply because data are old.

Category 4 waters are **impaired**, but a TMDL has been completed or is not required. Category 4 has been further subdivided into three subcategories.

- **Category 4a** impaired waters that have already had all necessary TMDLs approved by EPA.
- **Category 4b** impaired waters do not require TMDL development since "other pollution control requirements required by local, State or Federal authority are expected to address all water-quality pollutants" (EPA, 2003). An example of a 4b stream might be where a discharge point will be moved in the near future to another waterbody with more assimilative capacity.
- **Category 4c** impaired waters in which the impacts are not caused by a pollutant (e.g., flow alterations).

Category 5 waters have been monitored and found to not meet one or more water quality standards. These waters have been identified as **not supporting** one or more designated uses. Category 5 waterbodies are moderately to highly impaired by pollution and need to have TMDLs developed. These waters are included in the 303(d) List. The current 303(d) list may be viewed at http://www.tn.gov/environment/water.

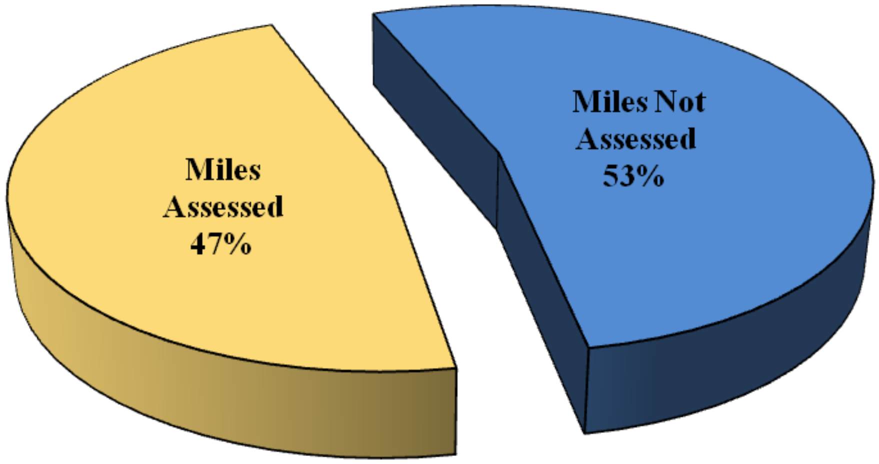


Figure 3: Percent of River and Stream Miles Monitored and Assessed

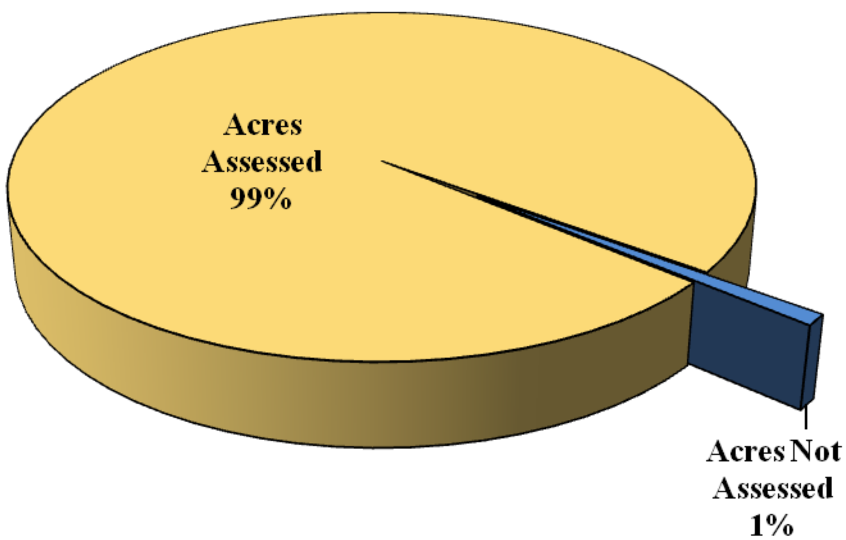


Figure 4: Percent of Reservoir and Lake Acres Monitored and Assessed

Chapter 2
Water Quality Standards Attainment Status

Consistent with the rotating watershed approach, the 12 watersheds in Group 3 and 14 watersheds in Group 4 have been assessed since the last 305(b) report was published in 2010. The assessment process considers existing water quality data to place each waterbody into one of the five categories.

A. Streams and Rivers

According to USGS's National Hydrography Dataset (NHD) at the 1:100,000 scale there are 60,418 miles of streams and rivers in Tennessee. The division was able to assess almost half (28,423 miles) of the stream miles in the state (Table 4 and Figure 5). Of the assessed streams, 52 percent are fully supporting of the designated uses for which they have been assessed.

1. 6,391 of the total stream miles (11%) are **Category 1**, fully supporting all designated uses.

2. 8,394 of the total stream miles (14%) are **Category 2**, which is fully supporting of some uses, but not assessed for others. Many of these streams and rivers have been assessed as fully supporting of fish and aquatic life, but have not been assessed for recreational uses.

3. 31,996 of the total stream miles (53%) are in **Category 3**. These waters have insufficient data to determine if classified uses are met.

4. 3,791 of the total stream miles (6.3%) have been identified as **Category 4,** impaired but TMDLs are not needed. 3,605 stream miles (6%) are **Category 4a**, which have had TMDLs for all impairments approved by EPA. Zero miles are **Category 4b**, which are impaired waters that do not require a TMDL. 186 stream miles (0.3%) are **Category 4c** where it has been determined that the cause of impairment is not a pollutant.

5. 9,847 of the total stream miles (16%) are in **Category 5**, waters that are impaired or threatened and need TMDLs for the identified pollutants.

Table 4: Assessed Stream Miles

Category Assessment	**Miles**
Total Miles	60,418
Total Assessed Miles	28,422
Category 1	6,391
Category 2	8,394
Category 3	31,996
Category 4a	3,605
Category 4b	0
Category 4c	186
Category 5	9,847

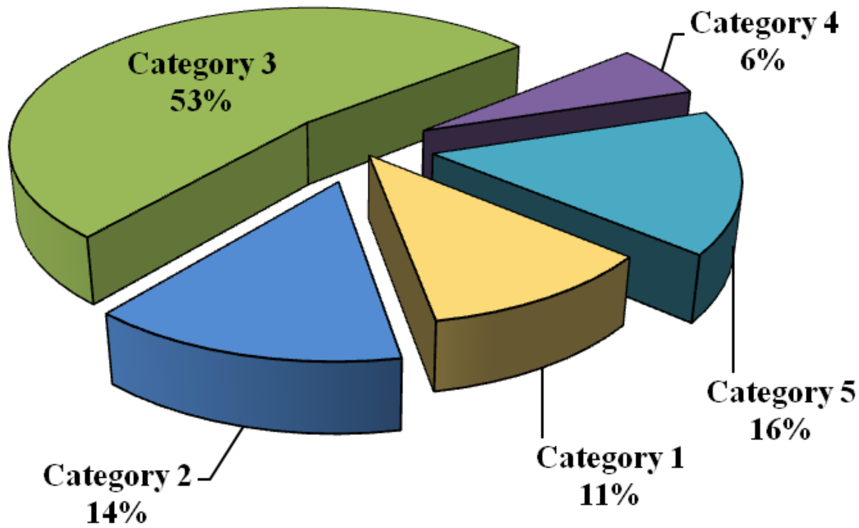


Figure 5: Percent of Rivers and Streams in Each Category

About 47 percent of the stream miles assessed for recreational use failed to meet the criteria assigned to that use. Approximately 38 percent of the assessed stream miles failed to meet fish and aquatic life criteria. Most or all waters classified for domestic water supply, irrigation, navigation, and industrial water supply uses were found to be fully supporting (Table 5 and Figure 6).

Table 5: Individual Classified Use Support for Rivers and Streams

Designated Uses	Miles Of Streams Classified	Classified Miles Assessed	Miles Meeting Use	Percentage Of Assessed Miles Meeting Use*
Fish and Aquatic Life Protection	60,418	27,496	17,084**	62%
Recreation	60,418	16,716	8,926	53%
Irrigation	60,418	27,919	27,918	100%
Livestock Watering and Wildlife	60,418	27,907	27,905	99.99%
Domestic Water Supply	3,696	3,218	3,152	98%
Navigation	1,307	1,307	1,307	100%
Industrial Water Supply	3,381	3,094	3,092	99.9%

*Note: All waters are classified for more than one use, but may or may not have all uses fully supporting. Thus, this table cannot be used to derive percentages for overall use support in Tennessee. In addition, assessment rates for individual uses may not match overall use assessment rates.

** Note: 50 miles are threatened for the protection of fish and aquatic life.

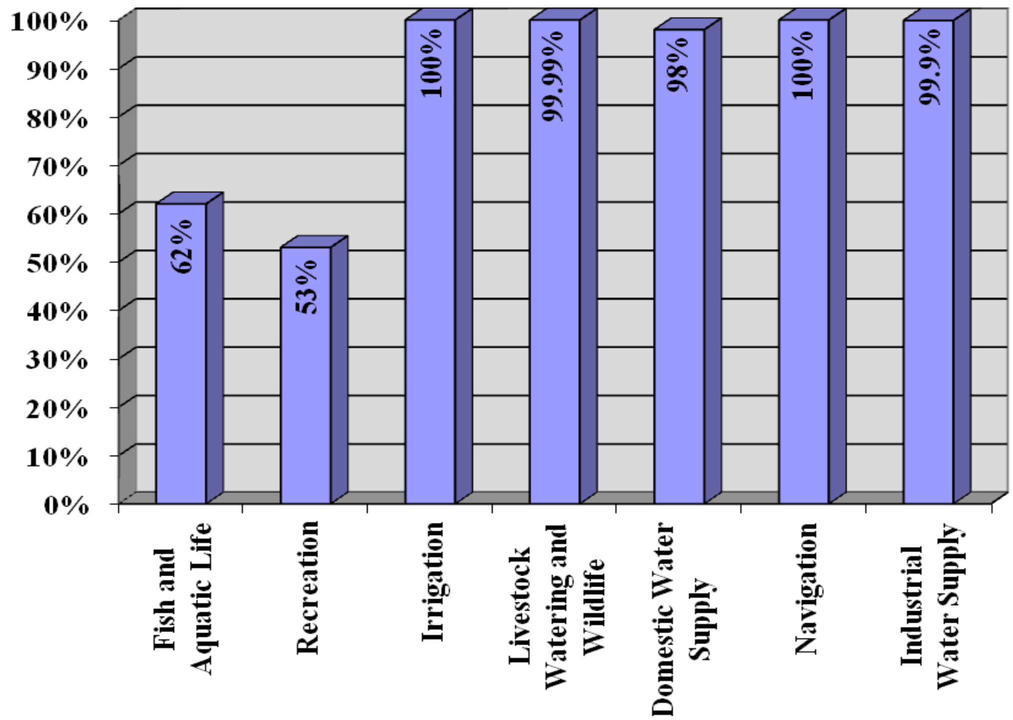


Figure 6: Percent Use Support for Individual Classified Uses in Assessed Rivers and Streams

B. Reservoirs and Reelfoot Lake

Overall Use Support

Table 6: Assessed Reservoir and Lake Acres

Category Assessment	Support Assessment
Total Acres	572,063
Total Assessed Acres	565,595
Category 1	383,630
Category 2	141
Category 3	6,468
Category 4	62,522
Category 5	119,302

Tennessee has over 90 public reservoirs or lakes with a total size over 572,000 acres (Table 6). For the purpose of this report, a reservoir or lake is publicly accessible and larger than five acres.

Most lakes in Tennessee are reservoirs that were created by the impoundment of a stream or river. The only large natural lake is Reelfoot Lake, thought to have been formed by a series of earthquakes in 1811 and 1812. For the purposes of this report, the generic term “lake acre” refers to both reservoirs and lakes.

By using available data, the Division of Water Resources was able to assess 565,595 lake acres. This means that 98.9 percent of the lake acres in Tennessee have been assessed. Of the assessed lake acres, 68 percent are fully supporting of the designated uses for which they have been assessed. All lake acres were placed into one of five use categories. The majority of lake acres were assessed as Category 1 (Figure 7).

1. 383,630 of the total lake acres (67.1%) are Category 1, fully supporting of all designated uses.

2. 141 of the total lake acres (0.02%) are Category 2, fully supporting of some uses, but without sufficient data to determine if other uses are being met.

3. 6,468 of the total lake acres (1.1%) are placed in Category 3, not assessed due to insufficient data to determine if uses are being met.

4. 62,522 of the total lake acres (10.9%) are assessed as Category 4, impaired for one or more uses, but a TMDL is not required.

5. 119,302 of the total lake acres (20.9%) are assessed as Category 5, impaired for one or more uses and needing a TMDL. These reservoirs and lakes are placed on the 303(d) List of impaired waters in Tennessee.

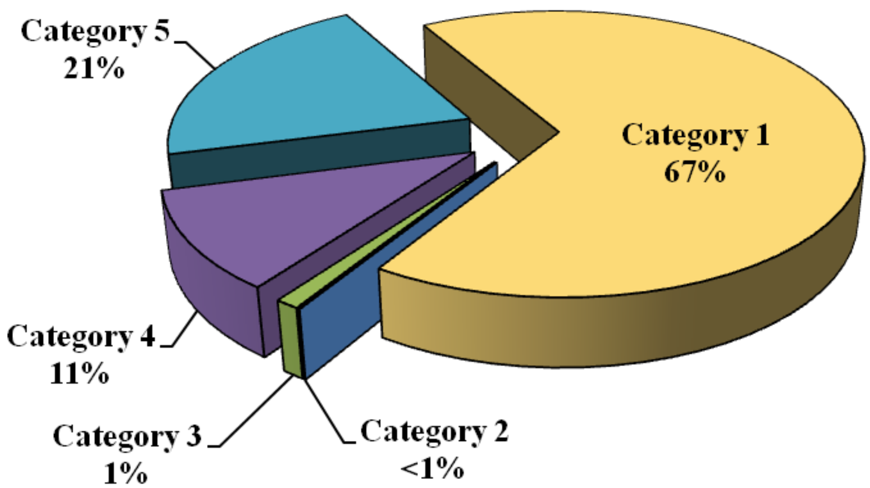


Figure 7: Percent of Reservoir and Lake Acres in Each Category
(Category 2 has less than 1 percent.)

Support of Individual Uses

The two most common use classifications not supported in lakes are fish and aquatic life and recreation (Table 7). Seventy percent of assessed reservoir/lake acres support recreational uses. Almost 93 percent of assessed reservoir/lake acres support fish and aquatic life uses. All other designated uses, with the exception of 455 acres classified for domestic water supply, were fully supporting for all assessed acres (Figure 8).

Table 7: Individual Classified Use Support for Reservoirs and Lakes

Designated Uses	Acres Classified	Classified Acres Assessed	Acres Meeting Use	Percentage of Assessed Acres Meeting Use*
Fish and Aquatic Life Protection	572,063	563,694	522,480	93%
Recreation	572,063	564,924	396,834	70%
Irrigation	572,063	563,634	563,634	100%
Livestock Watering and Wildlife	572,063	563,634	563,634	100%
Domestic Water Supply	529,081	526,637	526,182	99.9%
Navigation	1,971	1,971	1,971	100%
Industrial Water Supply	428,890	428,815	428,815	100%

*Note: Reservoirs are classified for more than one use, but may or may not have all uses fully supporting. Thus, this table cannot be used to derive percentages for overall use support in Tennessee. Also, assessment rates for individual uses may not match overall use assessment rates.

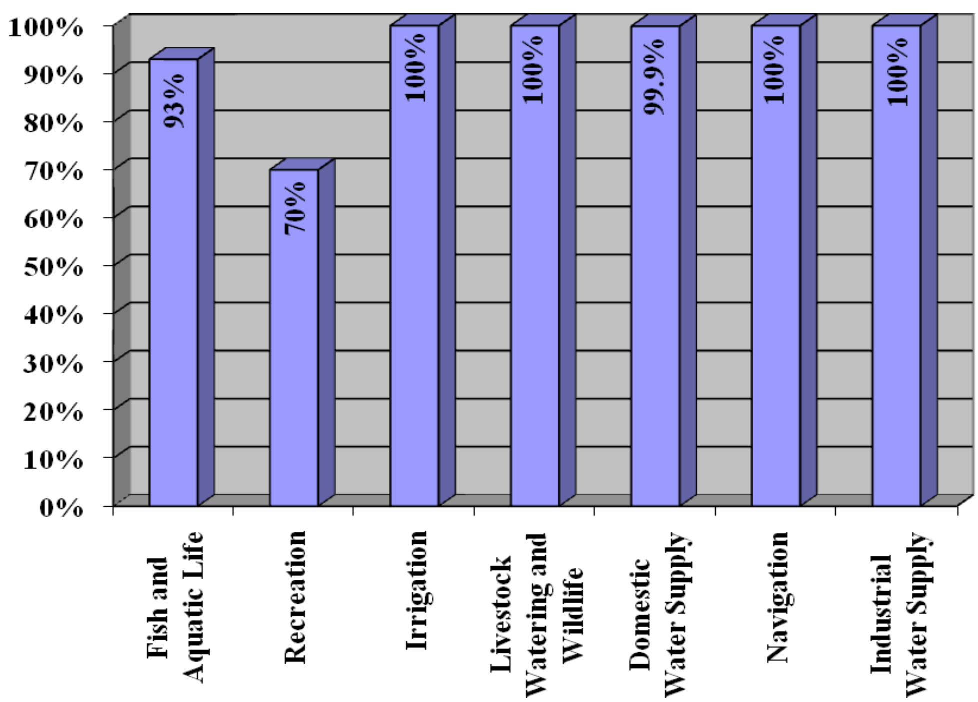


Figure 8: Percent Use Support for Individual Uses in Assessed Reservoirs and Lakes

C. Water Quality in Wetlands

Wetlands are some of Tennessee's most valuable natural resources. Wetlands serve as buffer zones along rivers, help filter pollutants from surface runoff, store floodwaters during times of high flows, serve as spawning areas for fish, and provide habitat for specialized plant and wildlife species. It is estimated that Tennessee has lost over 1 million acres of wetlands over the last century. The largest single cause of impact to those wetlands was channelization and drainage for agricultural conversion.

Tennessee Wetland Facts

Estimated Number of
Historical Wetland Acres…..1,937,000
Estimated Number of
Existing Wetland Acres………787,000
Percentage of Historical
Acres Lost ………………….60%
Number of Existing Wetland
Acres Considered Impaired
by Pollution and/or Loss
of Hydrologic Function………..54,811

Today, land development and transportation projects contribute most of the pollution, and are a significant cause of impacts to wetlands. A few wetlands have been contaminated by historical industrial activities. Several of these wetlands are now Superfund sites. Wetlands that have been altered without prior approval and have not yet been adequately restored are considered impaired. Where alteration permits have been approved, but the plan was not followed, wetlands are also considered impaired. In instances where the wetland was altered, but the state received compensatory mitigation for the loss of water resources, the resource was not considered impaired.

Tennessee was one of the first states in the nation to have a protection strategy and has been recognized by EPA as establishing a national model for wetlands planning. Tennessee's Wetlands Conservation Strategy was first published in 1994, in cooperation with other state and federal agencies, to plan for the protection and restoration of wetlands. To view the strategy, visit the web site at http://tennessee.gov/environment/na/wetlands.

TDEC has sought to stop the decline in wetlands through the adoption of Tennessee's Wetlands Conservation Strategy goal of achieving no overall net loss of the wetland acreage and functions in each hydrologic unit. In addition, the Rules of the Tennessee Water Quality, Oil & Gas Board (Chapter 1200-4-7) establish a standard of no net loss of water resource value in permitting alterations of streams and wetlands through either §401 Certifications or state Aquatic Resource Alteration Permits. The Strategy and the Rules include purchasing wetlands, establishing mitigation banks, and the processing of permits. The Tennessee Wetlands Conservation Strategy will be developed and implemented in a phased approach. A wetlands functional assessment method and procedure will increase the state's capabilities to assess the condition of wetlands as well as to measure the status of wetland acreage, function, and habitat availability.

Tennessee received a grant from EPA to develop a protocol for wetland assessment and to apply the state's antidegradation rules to wetlands permitting issues. Tennessee has completed its development of a rapid assessment methodology for wetlands. The Tennessee Rapid Assessment Methodology (TRAM) is based on models developed as part of the Hydrogeomorphic (HGM) approach for assessing wetland function in Tennessee. Tennessee has now developed HGM models for depressional, riverine, flat and slope wetlands.

The TRAM will allow for the identification of exceptional wetlands, impaired wetlands, aid in assessing the ecological consequences of §401 and ARAP permitting decisions, and assist in implementation the state's antidegradation rules. The Division of Water Resources' WaterLog database will enable the permitting program to track compliance and provide a source of wetland impact and mitigation data for use by agencies involved in wetland's monitoring and research.

In 2010 Tennessee partnered with U.S. Army Corps of Engineers (COE) and The Nature Conservancy to undertake one pilot watershed approach project in Tennessee to fulfill the requirements of the 2008 COE/ EPA Compensatory Mitigation Rule. The pilot Watershed Approach project in Tennessee is targeted for completion by the end of calendar year 2012. The end product of this project will be 1) a watershed plan that identifies viable/potential wetland and stream restoration and preservation priorities in the selected 8-digit watershed; and 2) a report that summarizes the methodology utilized to apply the Watershed Approach in development of the plan. The report will be designed to serve as a guide for the application of the Watershed Approach in the region.

Tennessee Tech University was awarded an EPA grant to assess wetland mitigation in Tennessee and updated their previous study from the late 1990's. The division is assisting in this assessment.

Today, approximately 787,000 acres of wetlands remain in Tennessee, a 60% loss from historic acreage. Pictured is a wetland in the South Fork Forked Deer River Bottom in the west Tennessee Coastal Plains.

Picture provided by Amy Fritz, JEFO.

Chapter 3
Causes of Water Pollution

Pollution is an alteration of the physical, chemical, biological, bacteriological, or radiological properties of water that results in an impairment of designated uses. To assess the causes of pollution in streams, rivers and reservoirs, the division follows the guidance provided by EPA. In order to help standardize the names of impairment causes across the country, EPA has provided a list of potential pollutants in the ADB.

A. Causes of Pollution in Streams and Rivers

Pollutants such as sediment/silt, habitat alteration, pathogens, and nutrients are the leading causes of impairment in Tennessee streams and rivers. Other frequent pollutants in streams and rivers include toxic substances, such as metals and organic pollutants. Flow alteration, pH changes, and low dissolved oxygen are other common causes of pollution (Figure 9 and Table 8).

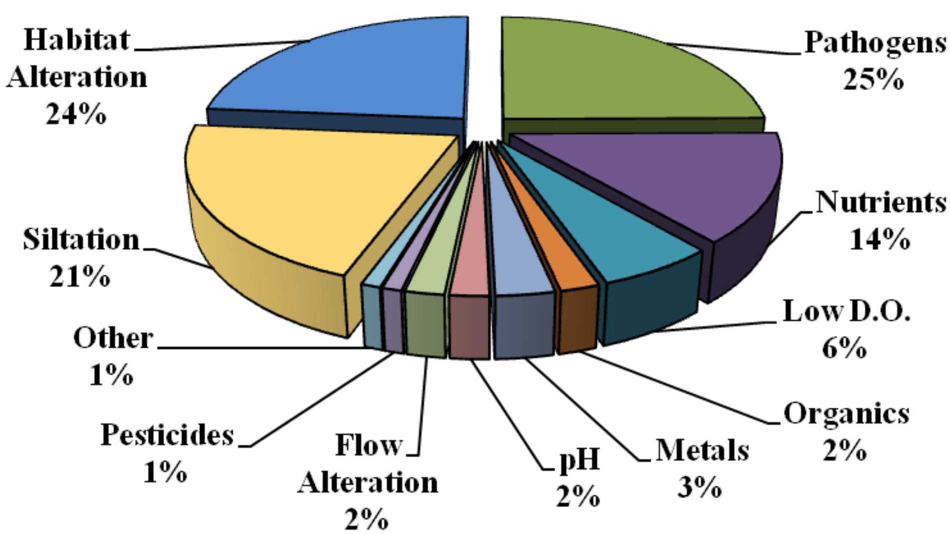


Figure 9: Relative Impacts of Pollution in Impaired Rivers and Streams (Stream Miles)

1. Habitat Alteration

Types of Habitat Alterations

Habitat Alteration	**Stream Miles Impaired**
Alteration in stream-side or littoral vegetative cover……………....	2,623
Other anthropogenic substrate alterations…………….………	425
Physical substrate habitat alterations……….……………	4,212

Note: Streams can be impaired by more than one type of habitat alteration. Totals are not additive.

Many streams in Tennessee appear to have impaired biological communities in the absence of obvious chemical pollutants. Often the cause is physical alteration of the stream which results in a loss of habitat.

Habitat alteration is the physical modification of a stream within the channel or along the banks. Common types of habitat alteration include loss of riparian habitat such as cutting trees or mowing along stream banks, destabilization of the banks from riparian grazing or channelization, gravel dredging or filling, culverting or directing streams through pipes, and upstream modifications such as dams.

Riparian habitat (streamside vegetation) is very important to help maintain a healthy aquatic environment. Optimal riparian habitat is a mature vegetation zone at least 60 feet wide on both banks. Riparian vegetation is important because it:

- Provides a buffer zone that prevents sediment in runoff from entering the water.
- Provides roots to hold banks in place, preventing erosion.
- Provides habitat for fish and other aquatic life.
- Provides canopy that shades the stream or river. This shading keeps water temperatures down and prevents excessive algal growth, which in turn prevents large fluctuations in dissolved oxygen levels.
- Provides a food source for aquatic invertebrates that eat fallen leaves and for fish that eat insects that fall from trees.

The division uses an EPA method to score the stream or river habitat by evaluating ten components of habitat stability (Barbour, *et al*., 1999). This is a standardized way to identify and quantify impacts to stream habitat. In 2001 Tennessee developed regional guidance based on reference data to evaluate habitat (Arnwine and Denton, 2001). Guidelines are recalibrated approximately every three years with the most current values published in the macroinvertebrate monitoring QSSOP (TDEC 2011).

An Aquatic Resources Alteration Permit (ARAP) is required to modify a stream or river in Tennessee. The permit will not be issued unless the water resources can be protected. Additional information can be found at http://www.tn.gov/environment/permits/whoami.shtml.

2. Pathogens

Pathogens are disease-causing organisms such as bacteria or viruses that can pose an immediate and serious health threat if ingested. Many bacteria and viruses that can be transferred through water are capable of causing serious or even fatal diseases. The main sources for pathogens are untreated or inadequately treated human or animal fecal matter.

Indicator organisms are used as water quality criteria to test for the presence of pathogens. Historically, Tennessee used total fecal coliform counts as the indicator of risk, but has revised criteria to comply with an EPA recommendation to shift to an *E. coli* - based criteria. The *E. coli* group is considered by EPA to be a better indicator of true human risk. Water quality criteria were revised to use *E. coli* in January 2004.

Maddie Denton collects *E. coli* samples at Town Creek in Murfreesboro for a research project at Siegel High School.

Currently, Tennessee has 48 streams and rivers posted with a water contact advisory due to high pathogen levels. There are 7,385 stream miles impaired by *E. coli*. See Chapter 5 for specific information on posted streams and rivers.

Problem concentrations of pathogens happen at different times in various streams across the state. High levels can be associated with rainfall events in urban areas with collection system problems and in rural areas with large concentrations of livestock with inadequate buffer zones adjacent to streams. *E. coli* can be elevated under low flows conditions also, especially in areas with failing or inadequate septic systems or places where livestock have direct access to streams.

3. Siltation/Suspended Solids

Silt is one of the most frequently cited pollutants in Tennessee, impacting almost 6,200 miles of streams and rivers. While some erosion is a natural process, tons of soil are lost every year as a result of human activities. Silt is generally associated with land disturbing activities such as agriculture and construction. Some of the significant economic impacts caused by silt are increased water treatment costs, filling in of reservoirs, loss of navigation channels and increased likelihood of flooding.

Siltation affects biological properties of waters by:

- Smothering eggs and nests of fish.
- Transporting other pollutants, in possibly toxic amounts, or providing a reservoir of toxic substances that may become concentrated in the food chain.
- Clogging the gills of fish and other forms of aquatic life.
- Covering substrate that provides habitat for aquatic insects, a main food source of fish.
- Reducing biological diversity by altering habitats to favor burrowing species.
- Accelerating growth of submerged aquatic plants and algae by providing more favorable substrate.

Chemical properties of waters are affected by:

- Interfering with photosynthesis.
- Decreasing available oxygen due to decomposition of organic matter.
- Increasing nutrient levels that accelerate eutrophication in reservoirs.
- Transporting organic chemicals and metals into the water column (especially if the original disturbed site was contaminated).

Physical properties of waters are affected by:

- Reducing or preventing light penetration.
- Changing temperature patterns.
- Decreasing the depth of pools or lakes.
- Changing flow patterns.

Preventive planning in land development projects can protect streams from silt and protect valuable topsoil. Best Management Practices (BMPs) such as the installation of silt fences and maintenance of trees and undergrowth as buffer zones along creek banks can prevent soil from entering the creek. Farming practices that minimize land disturbance, such as fencing livestock out of creeks and no-till practices not only protect water quality but also prevent the loss of topsoil.

Off-Highway vehicles can cause siltation problems in streams. *Photo provided by Chad Augustin, CLEFO.*

A growing concern in Tennessee is the use of Off-Highway Vehicles (OHV) in or near streams. TDEC is working with commercial operators to design trail systems that minimize erosion and are protective of aquatic systems.

4. Nutrients

A common problem in Tennessee waterways is elevated nutrient concentrations. The main sources for nutrient enrichment are livestock, municipal wastewater systems, urban runoff, and improper application of fertilizers. Nutrients stimulate algae growth that produces oxygen during daylight hours, but uses oxygen at night, leading to significant diurnal fluctuations in oxygen levels. Waters with elevated nutrients often have floating algal mats and clinging filamentous algae. Elevated nutrients cause the aquatic life to shift towards groups that eat algae and can tolerate dramatic dissolved oxygen fluctuations. Nutrient pollution is difficult to control. Restrictions on point source dischargers alone may not solve this problem.

Types of Nutrients

Nutrient	**Stream Miles Impaired**
Nutrient/Eutrophication Biological Indicators……	281
Total phosphorus...........	2,260
Nitrate/Nitrite…………...	1,600
Ammonia (un-ionized)…	47

Note: Streams can be impaired by more than one type of nutrient. These totals are not additive.

Some states have banned the use of laundry detergents containing phosphates. As a result, most commercially available detergents do not contain phosphates. Many fertilizers for crops or lawn application contain both nitrogen and phosphorus. If fertilizers are applied in heavy concentrations, rain will carry the fertilizer into nearby waterways.

Monitoring data from ecoregion reference streams has increased understanding of the natural distribution of nutrients throughout the state. Using this information, regional goals have been identified as part of the narrative nutrient criteria (Denton *et al*., 2001).

5. Low Dissolved Oxygen

Depleted dissolved oxygen in water will restrict or eliminate aquatic life. The water quality standard for dissolved oxygen in most non-trout streams is 5 mg/L. While some species of fish and aquatic insects can tolerate lower levels of oxygen for short periods, prolonged exposure will affect biological diversity and in extreme cases, cause massive fish kills. Over 1,800 stream miles in Tennessee have been impaired by low dissolved oxygen levels.

Low dissolved oxygen levels are usually caused by the decay of organic material. This condition can be improved by reducing the amount of organic matter entering a stream or river. Streams and rivers that receive substantial amounts of ground water inflow, or have very sluggish flow rates, can have naturally low dissolved oxygen levels.

The division commonly measures dissolved oxygen during daylight hours in conjunction with biological or chemical monitoring. When diurnal fluctuations are expected, continuous monitoring probes are deployed.

6. Metals

Types of Metals

Metal	Stream Miles Impaired	Metal	Stream Miles Impaired
Mercury	272	Copper	25
Iron	252	Lead	24
Manganese	204	Strontium	7
Arsenic	90	Chromium	6
Zinc	47	Cesium	5
Aluminum	35		

The most common metals impacting Tennessee waters include mercury, iron, manganese, arsenic, and lead. Zinc, copper, and chromium levels can also violate water quality standards. The major concern regarding metal contamination is toxicity to fish and aquatic life, plus the danger mercury poses to people who come in contact with the water or eat fish from the contaminated waterbody. The precipitation of metals such as iron and manganese streams can affect habitat.

Sections of ten rivers have been posted for elevated levels of mercury in fish tissue. Chapter 5 discusses this in more detail. Occasionally, metals are elevated in streams and rivers due to natural conditions. For example, elevated manganese levels in east Tennessee streams and rivers may be naturally occurring in the groundwater. However, it is relatively rare for waterbodies to violate criteria for metals simply based on natural conditions.

7. Organic Contaminants

Organic contaminants are man-made chemicals containing the element carbon. These include chemicals like PCBs, DDT, chlordane, and dioxins, which are listed by EPA as priority pollutants and classified as probable human carcinogens (cancer causing agents). In some waterbodies, these substances have accumulated in sediment and pose a health threat to those that consume fish or shellfish.

Types of Organic Contaminants

Organic Contaminant	Stream Miles Impaired
PCBs..………	320
Dioxin………..	256
Chlordane.……	256
RDX….………	63
PAHs………….	17
Creosote……..	16
Toluene…….	0.5

Note: Streams can be impaired by more than one type of organic contaminant. These totals are not additive.

Some organic pollutants in very low concentrations can pose a threat to human health. Many of these compounds have been banned from use for several decades. However, organic pollution that occurred decades ago still poses a serious threat, because these substances tend to remain in the environment for an extremely long time.

Dioxins are man-made by-products of herbicide manufacturing, certain historical paper mill manufacturing processes, and the incineration of chlorine-based chemicals. Dioxins are considered among the most toxic substances released into the environment. EPA has not found a safe exposure level. In fact, EPA has determined that dioxins, in addition to being probable human carcinogens, can cause reproductive and developmental problems.

One problem in identifying organic pollution is that water quality criteria are often below current detection levels. Detection of these substances is generally made either by analyzing fish tissue levels and/or by use of sediment screening values provided by EPA. Since organic contaminants can bioaccumulate in fish, it is important to make sure catfish and other species consumed by people are safe to eat. Children and pregnant or nursing women are the most sensitive populations.

8. pH

Low pH, elevated alkalinity, or a significant change in the pH or acidity of the water over a relatively short period of time, can greatly impact aquatic life. A common reason for a change in pH is acidic runoff from active or abandoned mine sites. Currently, 394 stream miles are listed as impaired by low pH, most in areas with historical mining activities. Disturbance of certain rock formations during road construction can also release acidity to streams. Excessive amounts of algae can cause streams and rivers to violate standards on the alkaline side, but this phenomenon more commonly occurs in lakes.

The pH level also plays an important role in the toxicity of metals, with pH levels below 5.5 generally increasing toxic effects. On the other hand, ammonia toxicity is increased in the presence of high pH. The statewide fish and aquatic life pH criterion for large rivers, reservoirs, and wetlands is 6.5 to 9.0. The pH criterion for wadeable streams and rivers is 6.0 – 9.0.

9. Flow Alteration

Four hundred sixty five (465) stream miles are currently assessed as impaired by flow alteration. Flow alteration is a change to the flow that leads to a loss of instream habitat. Impoundments and channelization are common sources of flow alteration. Increased water velocities also cause extreme down-cutting of stream and river channels, plus increase the sediment transported downstream. In extreme cases, flow alterations cause stream channels to be dry.

B. Causes of Pollution in Reservoirs and Lakes

Some of the same types of pollutants that occur in rivers and streams impact reservoirs, although in different magnitudes. The main pollutants in Tennessee reservoirs are toxic organics such as PCBs and dioxins. Other pollutants include mercury, nutrients, sediment/silt, low DO, and pesticides such as chlordane (Figure 10 and Table 8). The effects of most of these pollutants are the same as in flowing water, however, persistent substances are more likely to accumulate and remain in reservoirs for a very long time.

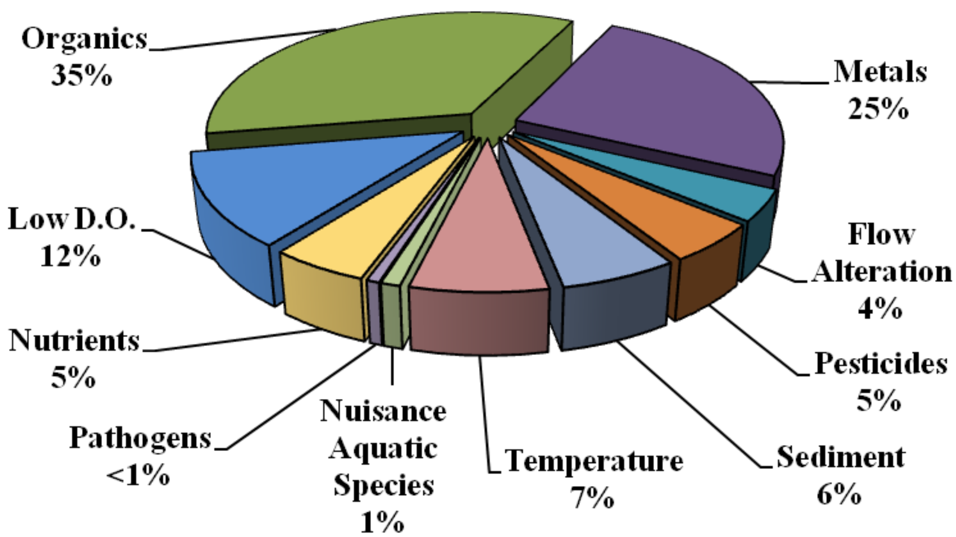


Figure 10: Relative Impacts of Pollution in Impaired Reservoir and Lake Acres

1. Organic Substances

Priority organic substances such as PCBs and dioxins are the cause of pollution in over a third of the impaired lake acres. Reservoirs serve as sediment traps and once a pollutant gets into the sediment it is very difficult to remove. These materials move through the food chain and can become concentrated in fish tissue. People eating fish from the waterbody may also concentrate these toxic substances in their bodies, which can lead to health problems. Currently, 95,438 lake acres are posted for organic contamination. Chapter 5 has specific information on posted reservoirs and the health hazards associated with eating contaminated fish.

PCBs were extensively used in the U.S. for industrial and commercial uses until they were banned in 1976. Unfortunately, over 1.5 billion pounds of PCBs were produced before the ban. It is not known how many tons ended up in waterways in Tennessee. Elevated levels of PCBs have been found in fish tissue collected from the following reservoirs:

- Fort Loudoun Reservoir
- Boone Reservoir
- Tellico Reservoir
- Watts Bar Reservoir
- Nickajack Reservoir
- Melton Hill Reservoir
- Woods Reservoir

Types of Organic Contaminants

Organic Contaminant	Lake Acres Impaired
PCBs…………	95,438
Dioxins……….	10,370

Note: Lakes can be impaired by more than one organic substance. These totals are not additive.

2. Metals

As in rivers and streams, metals can pose a serious health threat in reservoirs and lakes. The concerns with metals contamination include the danger it poses to people who eat fish from contaminated reservoirs as well as toxicity to fish and aquatic life.

The reservoirs in Tennessee assessed as impaired by metals have been impacted by legacy activities, atmospheric deposition, or industrial discharges. The copper, iron, and zinc found in three Ocoee River Reservoirs are from historical mining operations.

Mercury in the Clinch River section of Watts Bar Reservoir is from legacy activities at the Department of Energy (DOE) Reservation. Additional reservoirs or embayments impacted by mercury include upper Fort Loudoun, upper Cherokee, Beech, Watauga, South Holston, Tellico, Norris, and the Hiwassee embayment of Chickamauga Reservoir.

Types of Metals

Metal	Lake Acres Impaired
Mercury………	67,562
Copper………..	2,254
Iron……………	2,254
Zinc…………...	2,254
Aluminum…….	455
Arsenic.............	455

Note: Reservoirs can be impaired by more than one metal. These totals are not additive.

3. Temperature

The most stringent criterion for temperature is for the protection of fish and aquatic life. This criterion states:

> *The maximum water temperature change shall not exceed 3C° relative to an upstream control point. The temperature of the water shall not exceed 30.5°C and the maximum rate of change shall not exceed 2C° per hour.*

Reservoir discharges, power plants, and even some types of municipal discharges can cause violations of temperature criteria, usually due to the creation of a temperature change downstream when compared to an upstream point. The rapid changing or "pulsing" of temperature can be a problem below impoundments.

Under Federal law, specifically Section 316(a) of the Clean Water Act, dischargers of heat can apply for an alternative water quality standard. Where granted, a 316(a) permit substitutes a federal requirement to maintain a Balanced and Indigenous Population (BIP) of fish and aquatic life in the place of state numeric temperature criteria.

4. Nutrients

Another major cause of impacts in reservoirs and lakes is nutrients. Nearly 15,700 lake acres have been assessed as impaired due to nutrients. When reservoirs and lakes have elevated levels of nutrients, large amounts of algae and other aquatic plants can grow. Plants and algae produce oxygen during daylight hours. As aquatic vegetation dies and decays, oxygen can be depleted and dissolved oxygen may drop below the levels needed for fish and other aquatic life.

As reservoirs and lakes age, they go through a process called eutrophication. When this occurs naturally, it is caused by a gradual accumulation of the effects of nutrients over many of years. Ultimately, eutrophication results in the filling of the lake from soil, silt, and organic matter from the watershed. Pollution from human activities can greatly accelerate this process. Eutrophication that would naturally occur over centuries can be accelerated to a few decades.

Tennessee's water quality criterion for nutrients in lakes and reservoirs is currently narrative. The exception is Pickwick Reservoir where a numeric chlorophyll *a* criterion has been adopted. The assessment basis to consider lakes impaired is the level of eutrophication that interferes with the intended uses of the lake. This process is complicated by the complex nature of the public's uses for lakes and reservoirs. For example, algae production can help some species of fish thrive, benefiting sport fishermen. However, swimmers and boaters prefer clear water.

Chlorophyll *a* criterion has been adopted at Pickwick Reservoir. *Photo provided by Tennessee State Parks*

Stages of Eutrophication:

1. **Oligotrophic** lakes are young lakes with relatively low levels of nutrients and high levels of dissolved oxygen. Since these lakes have low nutrient levels, they also have less algae and aquatic vegetation.

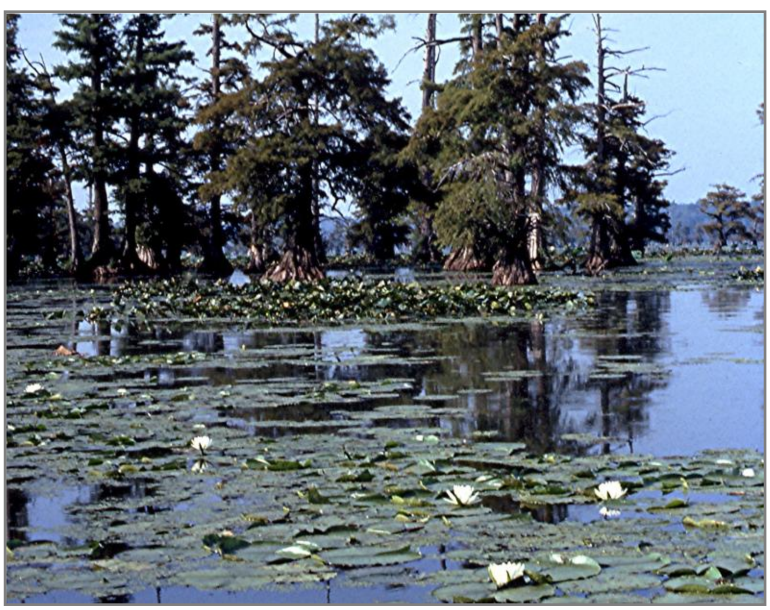
2. **Mesotrophic** lakes have moderate amounts of nutrients, but maintain a high level of dissolved oxygen. This results in more algae and aquatic vegetation that serve as a good food source for other aquatic life, yielding a high biological diversity.

3. **Eutrophic** lakes have high levels of nutrients and therefore, high amounts of algae. Often, in the summer, an algae bloom will occur which can cause the dissolved oxygen levels to drop in the lake's lower layer.

4. **Hypereutrophic** lakes have extremely high nutrient levels. The algae at this stage are so thick it can cause the lake to resemble pea soup. The dissolved oxygen in the lower layer of the lake may drop to the point where fish and other aquatic life cannot survive. Lakes that are hypereutrophic do not typically support the uses for which they are designated.

5. Sediment/Suspended Solids

Sediment and silt cause significant problems in reservoirs as well as flowing water. Over 18,100 lake acres have been assessed as impaired by sediment and silt. Since reservoirs and lakes serve as sediment traps, once sediment enters a lake it tends to settle out, initially in embayment and headwater areas, but ultimately throughout the reservoir. It is difficult and expensive to remove sediment from reservoirs. Three reservoirs, Ocoee #3, Ocoee #2, and Davy Crockett, have almost filled in with sediment caused by historic mining activity. Parksville Lake has significant delta formation in its upper reaches. Reelfoot Lake has also been impaired by sediment.



Reelfoot Lake has been impaired by sediment.
Photo provided by Jackson EFO

6. Dissolved Oxygen

The dissolved oxygen (DO) minimum water quality standard for reservoirs and lakes is 5 mg/L measured at a depth of five feet unless the lake is less than ten feet deep. If the lake is less than ten feet deep, the DO criterion is applied at mid-depth. In eutrophic reservoirs, the DO can be much lower than 5 mg/L. Even in reservoirs that have a DO of 5 mg/L at the prescribed depth, the dissolved oxygen levels can be near zero at greater depths.

The most common reason lakes and reservoirs have fish kills due to low DO is eutrophication. Overproduction of algae raises oxygen levels in sunshine, but on cloudy days and at night the resulting algae die-off can cause DO levels to plummet. Additionally, high levels of biomass will restrict light penetration to a few feet or even inches. Below the depth where light can penetrate, DO levels will be very low.

Lakes that are eutrophic often strongly stratify, which means that there is a layer of warm, well-oxygenated water on top of a cold, poorly oxygenated layer. Stratification limits the dissolved oxygen available to fish and other aquatic life. Currently, almost 38,000 lake acres are listed as impaired by oxygen depletion.

DO levels in lakes and reservoirs can also be affected by discharges from upstream dams. Water released from the bottom of the reservoir may have very low dissolved oxygen levels. Low dissolved oxygen in Barkley Reservoir is caused by the discharge of heat from TVA's Cumberland Steam Plant, combined with low flows due to drought and repairs to upstream reservoirs.

7. Pesticides

Pesticides, if used improperly, can cause harm to humans, animals, and the environment. Many pesticides have been banned in the U.S. but pollution that occurred decades ago still poses a serious threat, because they tend to remain in the environment for an extremely long time. In some waterbodies, these substances have accumulated in sediment and pose a health threat to those that consume fish or shellfish.

Although banned in 1988, nearly 14,000 acres are impaired by chlordane. Boone Reservoir has fish consumption advisories due to chlordane levels found in carp and catfish. Pesticides are more likely to bioaccumulate in these fish species since them tend to accumulate more in fattier fish.

Table 8: Causes of Impairment in Assessed Rivers and Reservoirs*

Cause Category	Impaired Rivers and Stream Miles	Impaired Reservoir/Lake Acres
Flow Alteration		
Low Flow Alterations	465	11,444**
Nuisance Aquatic Species		
Native Aquatic Plants		4,550**
Nutrients		
Nutrient/Eutrophication Biological Indicators	281	15,636**
Phosphate/Total Phosphorus	2,260	56
Nitrate/Nitrite	1,600	56
Ammonia (un-ionized)	47	56
Oxygen Depletion		
Oxygen, Dissolved	1,823	37,979
pH/Acidity/Caustic Conditions		
pH	394	56
Sediment		
Sediment/Silt	6,188	18,175**
Solids (Suspended/Bedload)	15	
Sludge	7	
Pesticides		
Aldrin	9	
Chlordane	256	13,873
DDT	9	
Dieldrin	9	
Endrin	9	
Metals		
Aluminum	35	455
Arsenic	90	455
Chromium, Hexavalent	6	
Copper	25	2,254
Iron	252	2,254
Lead	24	
Manganese	204	
Mercury	272	67,562
Zinc	47	2,254
Pathogens		
Escherichia coli	7,385	2,044
Radiation		
Cesium	5	
Strontium	7	

(Table continued on next page)

Table 8: Causes of Impairment in Assessed Rivers and Reservoirs (continued)

Toxic Organics		
Creosote	16	
Dioxins	256	10,370
Polychlorinated Biphenyls (PCBs)	320	95,438
Polycyclic Aromatic Hydrocarbons (PAHs)	17	
RDX	63	
Toluene	0.5	
Other		
Odor	7	
Taste & Odor		45
Total Dissolved Solids	5	
Impairment Unknown	101	
Habitat Alterations		
Alteration in Stream-side or Littoral Vegetative Cover	2,623	
Other Anthropogenic Substrate Alterations	425	
Physical Substrate Habitat Alterations	4,212	
Toxic Inorganics		
Chloride	24	56
Chlorine	3	
Sulfates	31	
Hydrogen Sulfide	10	
Observed Effects		
Color	5	
Oil and Grease		
Oil and Grease	9	
Thermal		
Temperature, Water	132	20,459
Bioassays		
Whole Effluent Toxicity (WET)	4	

*Note - Rivers and reservoirs can be impaired by more than one cause. Rivers include both river and stream miles. Data in this table should only be used to indicate relative contributions. Totals are not additive.
** The majority of impaired lake acres in these categories are in Reelfoot Lake.

Chapter 4
Sources of Water Pollution

Sources of pollutants in streams and rivers include agricultural activities, hydrologic modification (channelization, dams, and navigation dredging), municipal discharges, construction, industrial discharges, and mining activities. The major source of impairment to reservoirs is contaminated sediment from legacy pollutants. Table 9 provides a detailed breakdown of the various sources of pollution in Tennessee's streams, rivers, lakes, and reservoirs.

A. Relative Sources of Impacts to Rivers and Streams

Some impacts, like point source discharges and urban runoff, are evenly distributed across the state, while others are concentrated in particular areas. For instance, channelization and crop production is most widespread in west Tennessee. Dairy farming and other intensive livestock operations are concentrated in the Ridge and Valley region of east Tennessee and in southern middle Tennessee. An emerging threat in middle Tennessee is rapid commercial and residential development around Nashville and other urban areas. Mining continues to impair streams in the Cumberland Plateau and Central Appalachian regions. Figure 11 illustrates the percent contribution of pollution sources in impaired rivers and streams.

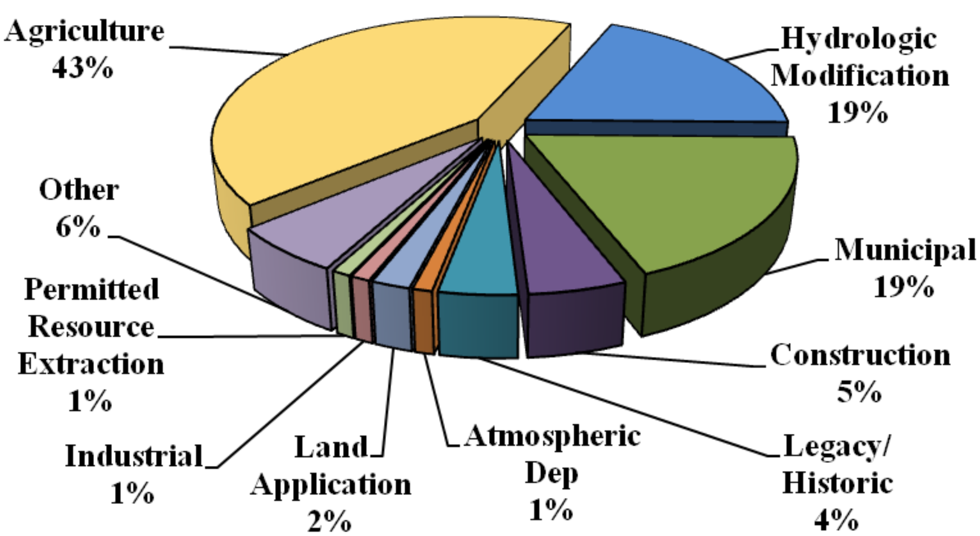


Figure 11: Percent Contribution of Pollution Sources in Impaired Rivers and Streams

Table 9: Sources of Pollutants in Assessed Rivers and Reservoirs*

Sources Category	Total Impaired River Miles	Total Impaired Reservoir/Lake Acres
Industrial Permitted Discharge		
RCRA Hazardous Waste Sites	100	
Industrial Point Source	60	7,791
Stormwater Discharge	30	
Petroleum/Natural Gas	1	
Industrial Thermal Discharges		20,459
Municipal Permitted Dischargers		
Separate Storm Sewer (MS4)	2,439	994
Package Plants	38	
Combined Sewer Overflows	10	994
Sanitary Sewer Overflows	715	
Urbanized (High Density Area)	448	45
Municipal Point Source	629	
Spills and Unpermitted Discharges		
Above Ground Storage Tank Leaks	0.5	
Other Spill Related Impacts		455
Agriculture		
Specialty Crop Production	59	
CAFOs	32	
Unrestricted Cattle Access	304	
Dairies (Outside Milk Parlor Areas)	15	
Irrigated Crop Production	47	
Grazing in Riparian or Shoreline Zones	6,057	481
Animal Feeding Operations (NPS)	240	34
Livestock (grazing or feeding)	7	
Aquaculture (permitted)	4	
Non-irrigated Crop Production	3,026	15,587**
Manure Run-off	1	
Permitted Resource Extraction		
Surface Mining	12	56
Subsurface/Hardrock	9	
Sand/Gravel/Rock	92	
Dredge Mining	50	
Coal Mining Discharge (permitted)	64	
Hydrologic Modification		
Channelization	3,506	
Dredging (Navigation Channel)	207	
Upstream Impoundment	622	2,469
Flow Regulation/Modification	15	

(Table continued on next page.)

Table 9: Sources of Pollutants in Assessed Rivers and Reservoirs (continued)

Sources Category	Total Impaired River Miles	Total Impaired Reservoir/Lake Acres
Habitat Alterations (Not directly related to hydromodification)		
Stream Bank Modification/ Destabilization	67	
Loss of Riparian Habitat	13	
Drainage/Filling/Wetland Loss		10,950**
Channel Erosion/Incision from Upstream Modification	12	
Legacy/Historical		
Contaminated Sediment	371	97,692
CERCLA NPL (Superfund)	30	
Abandoned Mine Lands (Inactive)	408	2,254
Internal Nutrient Cycling		15,500**
Mill Tailings	32	2,254
Mine Tailings	35	2,254
Silviculture		
Harvesting	72	
Land Application/Waste Sites		
On-site treatment systems (septic systems and similar)	359	4
Land Application of Wastewater Biosolids (Non-agricultural)	9	
Landfills	46	56
Land Application of Waste	12	
Construction		
Site Clearance	974	10,950**
Hwys. /Roads/Bridges, Infrastructure (new)	47	
Atmospheric Deposition		
Atmospheric Deposition of Acids	17	
Atmospheric Deposition-Toxics	230	67,421
Other Sources		
Sources Outside State Jurisdiction or Borders	239	4,223
Military Base (NPS)	13	
Sources Unknown	908	1,050
Off-Road Vehicles	60	
Hwy/Road/Bridge (runoff)	23	
Golf Courses	0.3	

*Rivers and reservoirs can be impaired by more than one source of pollutants. Data in this table should only be used to indicate relative contributions. Totals are not additive.
** Majority of impairment sources in these categories are in Reelfoot Lake.

1. Agriculture

Almost half of the land in Tennessee is used for agriculture. These activities contribute approximately 43 percent of the impaired stream miles in the state. Statewide, the largest single source of impacts is grazing of livestock, followed by crop production. In west Tennessee, tons of soil are lost annually due to erosion from crop production (mostly cotton and soybean). In middle Tennessee, cattle grazing and hog farms are the major agricultural activity and result in bank erosion, plus elevated bacteria and nutrient levels. In east Tennessee, runoff from feedlots and dairy farms greatly impact some waterbodies. Figure 12 illustrates the relative contributions of the primary agricultural sources.

Sources of Agricultural Impairment

Agricultural Source	Stream Miles Impaired
Grazing in Riparian Zone……...	6,057
Non-irrigated Crop Production..	3,026
Unrestricted Cattle Access........	304
Animal Feeding Operations…...	240
Specialty Crop Production…….	59
Irrigated Crop Production……..	47
CAFOs………………………...	32
Dairies (Outside Milk Parlor Areas)………………………….	15
Livestock (grazing or feeding)...	7
Aquaculture (permitted)……….	4
Manure Run-off……………….	1

Note: Pollutants in streams can come from more than one source. These totals are not additive.

The Tennessee Water Quality Control Act does not give the division authority to regulate water runoff originating from normal agricultural activities such as plowing fields, tending animals and crops, and cutting trees. However, agricultural activities that may result in significant point source of pollution, such as animal waste system discharges from concentrated livestock operations, are regulated.

Tennessee has made great strides in recent years to prevent agricultural and forestry impacts. Educational and cost-sharing projects promoted by the Department of Agriculture, Natural Resource Conservation Service (NRCS) and University of Tennessee Agricultural Extension Service have helped farmers install Best Management Practices (BMP's) all over the state. Farmers have voluntarily helped to decrease erosion rates and protect streams and rivers by increasing riparian habitat zones and setting aside conservation reserves.

The division has a memorandum of understanding with the Tennessee Department of Agriculture (TDA). Under this agreement, the division and TDA will continue to jointly resolve complaints about water pollution from agricultural activities. When a problem is found or a complaint has been filed, TDA has the lead responsibility to contact the farmer or logger. Technical assistance is offered to correct the problem. TDEC and TDA coordinate on water quality monitoring, assessment, 303(d) list development, TMDL generation, and control strategy implementation.

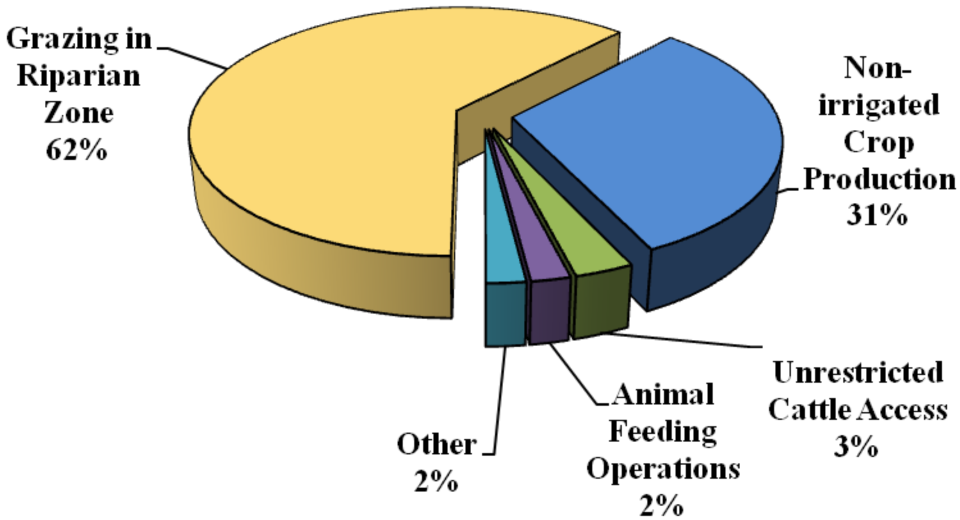


Figure 12: Sources of Agricultural Pollution in Impaired Rivers and Streams

2. Hydrologic Modification

Altering the physical and hydrological properties of streams and rivers is the source of impairment in about 19 percent of the impaired streams in Tennessee. Modifications include channelization (straightening streams), impoundments (construction of a reservoir), dredging for navigation, and flow regulation or modification. Figure 13 illustrates the types of modifications most frequently impairing streams and rivers.

Sources of Hydrologic Impairment

Sources of Hydrologic Modification	Stream Miles Impaired
Channelization………………….	3,506
Upstream Impoundment………..	622
Dredging (Navigation Channel)..	207
Flow Regulation/Modification…	14

Note: Pollutants in streams can come from more than one source. These totals are not additive.

Physical alteration of waterbodies can only be done as authorized by the state. Permits to alter streams or rivers called Aquatic Resource Alteration Permits (ARAPs) are issued by TDEC's Natural Resources Section. A 401 certification of a federal 404 permit is also considered an ARAP permit. Failure to obtain a permit before modifying a stream or river can lead to impairment and enforcement actions.

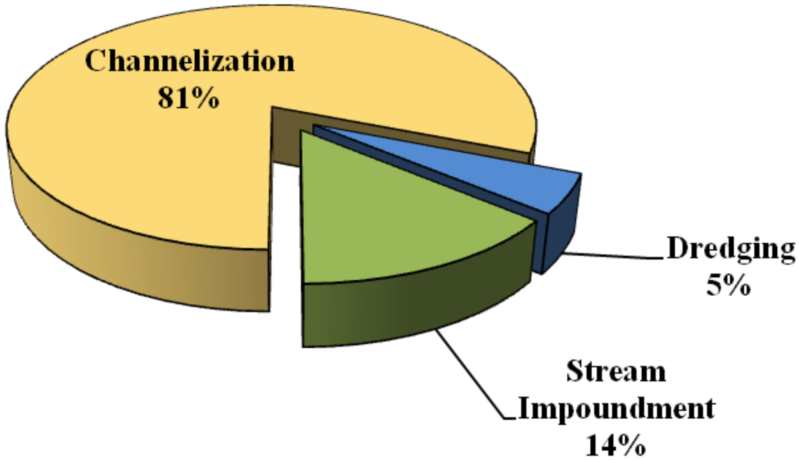


Figure 13: Sources of Hydrologic Impairment in Rivers and Streams. (Flow regulation and modification represent less than one percent of the impairments.)

a. Channelization

Channelization is the source of impairment for 81 percent of the streams and rivers assessed as impacted by habitat alteration. Originally, channelization was implemented to control flooding and protect croplands along rivers. In West Tennessee, channelization was used extensively to drain wetlands to create cropland. Throughout Tennessee, streams continue to be impaired by channelization and bank destabilization from vegetation removal.

Costs associated with channelization include:

- Increased erosion rates and soil loss.
- Elimination of valuable fish and wildlife habitat by draining wetlands and clearing riparian areas.
- Destruction of bottomland hardwood forests.
- Magnification of flooding problems downstream.
- “Down-cutting” of streambeds as the channel tries to regain stability.

In recent years, no large-scale channelization projects have been approved. Tennessee is working with the Corps of Engineers to explore methods to reverse some of the historical damage to water quality caused by channelization.

Some streams and rivers continue to be channelized by landowners. However, stream alteration without proper authorization is a violation of the Water Quality Control Act subject to enforcement.

b. Stream and River Impoundment

Problems associated with the impoundment of streams and rivers are increasing as more free flowing streams are dammed. It has been the experience of the division that very few of these impoundments can be managed in such a way as to avoid water quality problems.

Problems often associated with stream and river impoundment include:

- Erosion during dam construction.
- Loss of stream or river for certain kinds of recreational use.
- Changes in the flow downstream of the dam.
- Elevated metals downstream of the dam.
- Low dissolved oxygen levels in tailwaters, which decrease biological diversity downstream and threaten aquatic life, including endangered species.
- Habitat change resulting in loss of aquatic organisms.
- Barriers to fish migration.

Impoundments often result in altered flow patterns, erosion and loss of instream and riparian habitat.

Photo provided by Aquatic Biology Section, TDH.

c. Dredging

Dredging or removing substrate from a stream or river is done to deepen river channels for navigation or to mine sand or gravel for construction. Dredging can cause habitat disruption, substrate alteration, sedimentation, and erosion. Unfortunately, dredging is sometimes done without authorization.

3. Municipal Discharges

a. Municipal Stormwater Discharges

As stormwater drains through urban areas, it picks up pollutants from yards, streets, and parking lots and deposits them into nearby waterways. The runoff can be laden with silt, bacteria, metals, and nutrients. Following heavy rains, streams can contain various pollutants at elevated levels for several days. Water quality standards violations have been documented in Tennessee’s four largest cities: Memphis, Nashville, Chattanooga, and Knoxville, plus many other smaller towns.

The federal National Pollutant Discharge Elimination System (NPDES) program regulates stormwater runoff. Industries and large commercial operations must operate under the state’s general NPDES permit for industrial stormwater discharge. This permit requires site-specific stormwater pollution prevention plans and mandatory installation of pollution control measures.

Under Tennessee Municipal Separate Storm Sewer Systems (MS4) permits, cities must develop stormwater programs and regulate sources at a local level. In addition to Tennessee’s four MS4 Phase I cities (Memphis, Nashville, Chattanooga, and Knoxville) that are covered under individual NPDES permits, 78 other cities and counties are now covered by the MS4 Phase II general permits.

There are six Phase II MS4 program elements designed to further reduce pollutants from stormwater. The elements include public education and outreach, along with public participation and involvement. Further, a plan must be implemented to detect and eliminate illicit discharges to the storm sewer system.

Construction sites must obtain coverage under the state’s general NPDES permit for construction stormwater runoff if clearing, grading or excavating is planned on any site larger than one acre or any disturbance of less than one acre if it is part of a larger common plan of development or sale. Sites receiving coverage under the permit are required to control erosion as well as address post-construction stormwater runoff.

b. Combined Sewer Overflows

In Tennessee, only three cities (Nashville, Chattanooga, and Clarksville) have combined sewers (sanitary waste and storm water carried in the same sewer). Permits require that when these sewers overflow during large storm events, monitoring must be conducted. Several water contact advisories are due to combined sewer overflows.

c. Municipal Point Source Discharges

Municipal sewage treatment plants have permits designed to prevent impacts to the receiving waterbody. On rare occasions, sewage treatment systems fail to meet permit requirements. Sometimes, a waterbody downstream of a facility is found to not meet biological criteria and the upstream facility is listed as a potential source of the pollutant of concern, even if permit limits are being met. In those cases, permit requirements must be adjusted along with other watershed improvements to address water quality concerns.

d. Sanitary Sewer Overflows

Collection systems convey raw sewage to treatment plants through a series of pipes and pump stations. Unfortunately, these systems occasionally malfunction or become overloaded, which can result in the discharge of high volumes of untreated sewage to a stream or river. A serious concern near urban areas is children being exposed to elevated bacteria levels while playing in streams and rivers after heavy rains.

Sanitary sewer collection systems are monitored by municipalities to insure that they are not leaking. NPDES permits contain provisions that prohibit overflows and require that they be reported to TDEC. Enforcement action must be taken against cities that fail to report and correct sewage system problems.

4. Construction

The populations of many Tennessee communities have rapidly expanded in the last decade. The construction of subdivisions, shopping malls, and highways can harm water quality if the sites are not properly stabilized. The impacts most frequently associated with land development are silt and habitat alteration. Construction sites must obtain coverage under the state's general NPDES permit for construction stormwater runoff if clearing, grading or excavating is planned on any site larger than one acre or any disturbance of less than one acre if it is part of a larger common plan of development or sale.

In addition, local stormwater control programs and regulations have been helpful in controlling water quality impacts from land development. MS4 Phase I cities (Memphis, Nashville, Chattanooga, and Knoxville) already have construction stormwater control programs in effect. The 78 cities and counties covered under the Phase II MS4 general permit have developed construction stormwater control programs. In these cities, local staff help identify sources of stormwater runoff and develop control strategies.

5. Legacy/Historical

a. Impacts from Abandoned Mining

In the 1970's, coal mining was one of the largest pollution sources in the state. "Wildcat" operators strip-mined land without permits or regard for environmental consequences to provide low-priced coal to the growing electric industry. When the miners had removed all the readily available coal, they would abandon the site. In 1983, the price for coal fell so low it was no longer profitable to run "wildcat" mining operations, so most illegal mining operations stopped.

Although many streams and rivers are still impaired by runoff from abandoned mines, which contain pollutants such as silt, pH, manganese, and iron, significant progress has been made in site reclamation. Some abandoned strip mines are being reclaimed under the Abandoned Mine Reclamation program and others are naturally re-vegetating. New mining sites are required to provide treatment for runoff.

b. Contaminated Sediments

The main problem with toxic contaminants in sediment is they can become concentrated in the food chain. In most places in Tennessee, it is safe to eat the fish. However, in some waterbodies, organic pollutants (primarily PCBs, dioxins, chlordane and other pesticides in the sediment) and mercury are bioconcentrated through the food chain in the fish. See Chapter 5 for a list of streams, rivers, and reservoirs posted due to fish tissue contamination.

Fish tissue samples are collected and analyzed from waterbodies across the state. Results are compared to criteria developed by the Food and Drug Administration (FDA) and EPA. If fish tissue is contaminated and the public's ability to safely consume fish is impaired, the waterbody is posted with signs and assessed as not supporting recreational uses. The advisories are also listed on the TDEC website and included in sport fishing regulations. The Tennessee Valley Authority (TVA) and the Tennessee Wildlife Resources Agency (TWRA) share resources and expertise in this process.

Many substances found in fish tissue today, like DDT, PCBs, and chlordane, were widely distributed in the environment before they were banned. The levels of these substances will slowly decrease over time. Currently companies with permits to discharge organic substances have very restrictive limits.

6. Industrial Discharges

Although the number of waters impaired by industrial pollution is lower than it was a few decades ago, industrial facilities impact some streams and rivers in Tennessee. Streams impaired by industrial discharges include East Fork Poplar Creek, Pigeon River, North Fork Holston River, and Russell Branch. See the current 303(d) list of impaired waters for all waterbodies assessed as impacted by industrial discharges.

Industrial impacts include sporadic spills, temperature alterations, and historical discharge of substances that can concentrate in the food chain. Occasionally, industrial dischargers fail to meet permit requirements. Industries and large commercial operations such as junkyards are required to operate under the state's general NPDES permit for industrial stormwater discharge. This permit requires the development of site-specific stormwater pollution prevention plans and mandatory installation of pollution control measures.

Water samples are routinely collected downstream of permitted discharges.
Photo provided by Nashville EFO.

7. Land Application/Waste Sites

Solid waste and septic systems contribute to water quality problems in various ways. Solid waste in landfills can leach into groundwater and surface water if not prevented. Wastewater in failing septic tanks can leak into the ground causing water contamination. Treated wastewater and sludge are applied to land as fertilizers and can be washed into streams causing nutrient loading. Another concern is the use and maintenance of underground storage tanks that can contain substances like petroleum products, solvents, and other hazardous chemicals and wastes. These can leak into the groundwater and may reach the surface water.

B. Distribution of Sources of Impacts to Reservoirs

Like streams and rivers, reservoirs are impaired by many sources of pollution. However, the dominant pollutant impacting reservoirs is sediment contaminated by legacy toxic organic substances. Other significant sources are atmospheric deposition of mercury, industry, agricultural activities, hydrologic modification, and construction (Figure 14).

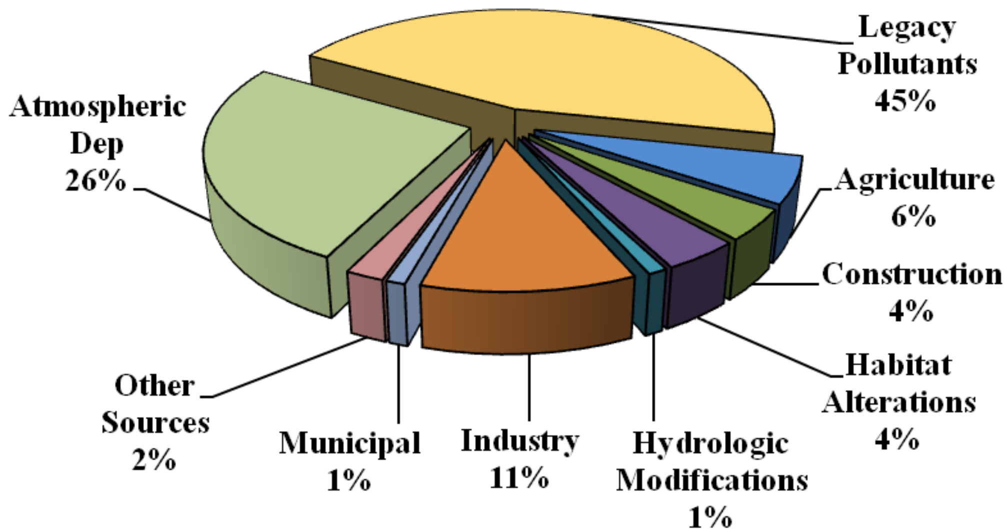


Figure 14: Percent Contribution of Pollution Sources in Impaired Reservoirs and Lakes

1. Legacy Pollutants

Legacy or historical pollutants are the number one source of contamination in reservoirs and lakes. These are pollutants that were introduced into the waterbodies prior to the enactment of water quality regulations or before EPA banned their use. Legacy pollutants include contaminated sediments, superfund sites, and abandoned mine lands (Figure 15).

a. Contaminated Sediments

The biggest problem with legacy pollutants is contaminated sediments. Two organic substances banned in the 1970's, chlordane and PCBs, are responsible for most of the continuing problem of sediment contamination today. These substances bind with the sediment and remain in the environment for a long time. Once in the sediment, they become part of the aquatic food chain. Bioaccumulation in fish tissue has resulted in consumption advisories in several reservoirs (Chapter 5). The levels of these substances will slowly decrease over time.

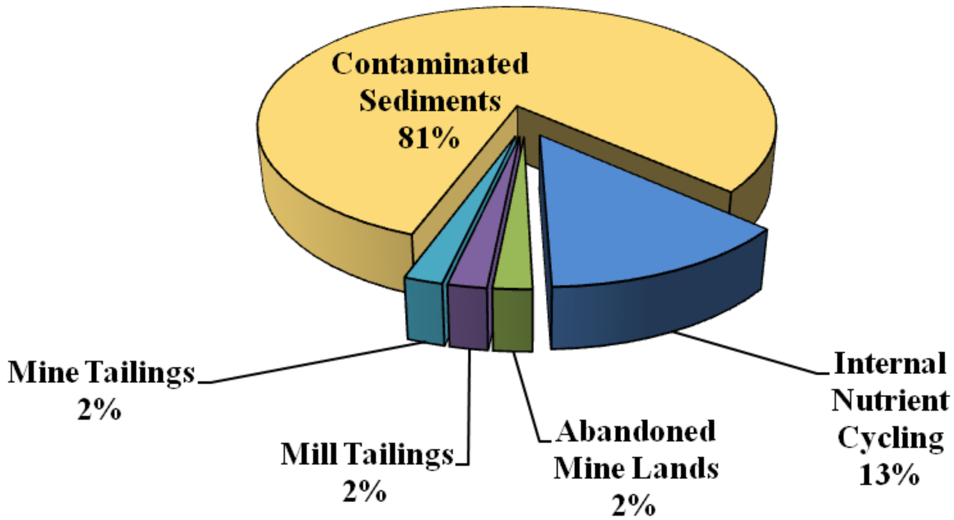


Figure 15: Sources of Legacy Pollutants in Reservoirs and Lakes

b. Internal Nutrient Cycling

Internal nutrient cycling is the release and recapture of nutrients from the sediment of a lake or reservoir, which functions to accelerate eutrophication. Reelfoot Lake in west Tennessee accounts for all the lake acres assessed as impaired by nutrient cycling. This lake is in an advanced state of eutrophication due to sediment and nutrients.

Eutrophication is a natural process that will occur in any lake. It becomes pollution when it is accelerated by human activities, interferes with the desired uses of the lake, or causes water quality standards to be violated in the reservoir or receiving stream. For additional information on eutrophication, see Chapter 3.

c. Abandoned Mines/Mine Tailings/Mill Tailings

The Copper Basin in the tri-state area of Tennessee, Georgia, and North Carolina was extensively mined beginning in 1843. Before 1900, this was the largest metal mining area in the southeast. The last mine closed in 1987. Runoff from disturbed areas has contaminated three downstream reservoirs on the Ocoee River. Much of the area has been reforested. Due to CERCLA activities, water quality in the Ocoee River has improved. Although much work remains to be done before water quality goals are met, the transport of pollutants to the Ocoee River appears to have diminished.

2. Agriculture

Similar to streams and rivers, reservoirs can be greatly impacted by agricultural activities. Plowing and fertilizing croplands can result in the runoff of tons of soil and nutrients annually. Over 16,000 lake acres in Tennessee are listed as impaired by farming activities. Most of these acres are represented by Reelfoot Lake, which is listed as impaired due to erosion from agricultural activities. Sources of agricultural impacts include non-irrigated crop production and livestock grazing.

3. Other Modifications

Loss of wetlands in Reelfoot Lake accounts for the majority of lake/reservoir acres impaired due to habitat modification. A small percentage of habitat impairment is due to hydrostructure flow modification and upstream impoundments.

4. Construction

Almost 100 percent of the lake acres assessed as impaired by construction are land development around Reelfoot Lake. Clearing land for development results in increased sedimentation, nutrient runoff, drainage, filling, and loss of wetlands.

5. Industrial and Municipal

Impairment to lakes and reservoirs from municipal sources includes discharges from separate storm sewer systems, collection system failures, and combined sewer overflows. Industrial sources include point source discharges, such as mercury to the Hiwassee embayment and upper Cherokee Reservoir, plus heat in Barkley Reservoir.

6. Atmospheric Deposition

Atmospheric deposition occurs when air pollutants are deposited to land or water. Primary anthropogenic sources of pollutants include burning fossil fuels, agricultural activities, and emissions from industrial operations. Tennessee currently has over 67,000 lake acres impaired by atmospheric deposition of mercury, most found in east Tennessee. The effects of mercury pollution are discussed in detail in Chapter 5.

In 2009, the division began a probabilistic study of fish tissue to test a model that may predict mercury air deposition (Chapter 7). The mercury levels found in fish tissue did not correlate with the REMSAD air deposition model that was used to model mercury deposition. Several fish taken from areas with predicted high levels of mercury air deposition contained relatively low levels of contamination. Other fish that had higher concentrations of mercury came from areas with low predicted depositional mercury.

Chapter 5
Posted Streams, Rivers, and Reservoirs

When streams or reservoirs are found to have significantly elevated bacteria levels or when fish tissue contaminant levels exceed risk-based criteria, it is the responsibility of the Department of Environment and Conservation to post warning signs so that people will be aware of the threat to public health. In Tennessee, the most common reasons for a river or reservoir to be posted are the presence of high levels of bacteria in the water or PCBs, chlordane, dioxins, or mercury in fish tissue. Currently 77 streams, rivers, and reservoirs in Tennessee have been posted due to a public health threat. A current list of advisories is posted on the department's home page at http://tn.gov/environment/wpc/publications/pdf/advisories.pdf.

> *The Commissioner shall have the power, duty, and responsibility to…post or cause to be posted such signs as required to give notice to the public of the potential or actual dangers of specific uses of such waters.*
>
> Tennessee Water Quality Control Act

Consistent with EPA guidance, any stream or reservoir in Tennessee with an advisory is assessed as not meeting the recreational designated use and therefore, included in the biennial 303(d) list of impaired waters. Clearly, if the fish cannot be safely eaten, the waterbody is not fully supporting its goal to be fishable. Likewise, streams, rivers, and reservoirs with high levels of bacteria are not suitable for recreational activities such as swimming or wading.

A. Bacteriological Contamination

About 176 river miles are posted due to bacterial contamination (Table 10). No reservoirs or lakes are posted due to bacterial contamination. The presence of pathogens, disease-causing organisms, affects the public's ability to safely swim, wade, and fish in streams, rivers and reservoirs. Bacteria, viruses, and protozoa are the primary water-borne pathogens in Tennessee. Improperly treated human wastes from such sources as failing septic tanks, collection system overflows and improper connection to sewer or sewage treatment plants are the reasons behind 62 percent of the posted river miles (Figure 16). The remaining stream miles are posted due to other sources such as failing animal waste systems or urban runoff (Figure 17).

The division's current water quality criterion for bacteria is based on levels of *E. coli*. While this test is not considered direct proof of human health threats, it can indicate the presence of water-borne diseases. Research is underway to find better indicators of risk and to differentiate between human and animal sources of bacteria. The presence of prescription medicines, caffeine, and hormones in water has been suggested as potential markers for contamination by human waste.

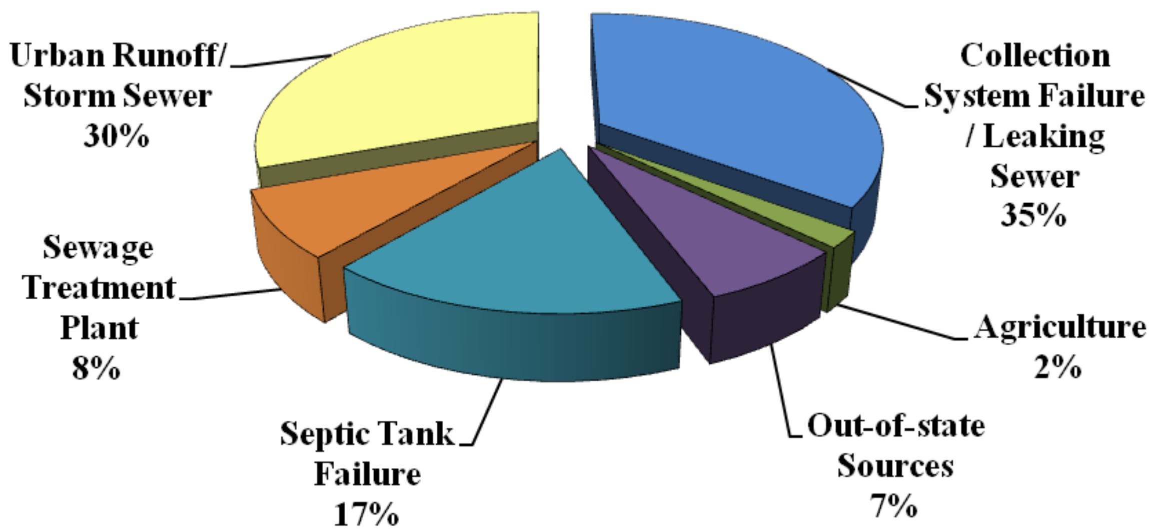


Figure 16: Percent Contribution of Stream Miles Posted for Pathogen Contamination

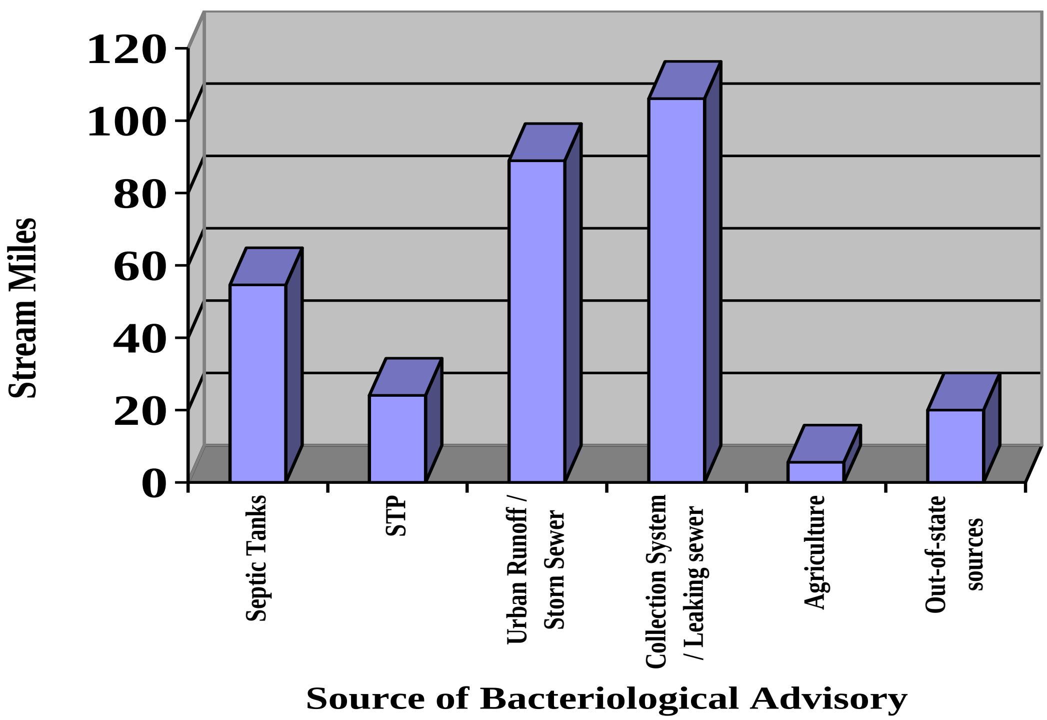


Figure 17: Stream Miles Contaminated by Various Pathogen Sources. (The same stream may be impaired by more than one source of pollution. Totals are not additive.)

Table 10: Bacteriological Advisories in Tennessee

For additional information:
http://www.tn.gov/environment/wpc/publications/pdf/advisories.pdf.

East Tennessee

Waterbody	Portion	County	Comments
Beaver Creek (Bristol)	TN/VA line to Boone Lake (20.0 miles)	Sullivan	Nonpoint sources in Bristol and Virginia
Cash Hollow Creek	Mile 0.0 to 1.4	Washington	Septic tank failures.
Coal Creek	STP to Clinch R. (4.7 miles)	Anderson	Lake City STP.
East Fork Poplar Creek	Mouth to Mile 15.0	Roane, Anderson	Oak Ridge area.
First Creek	Mile 0.2 to 1.5	Knox	Knoxville urban runoff.
Goose Creek	Entire Stream (4.0 miles)	Knox	Knoxville urban runoff.
Leadvale Creek	Douglas Lake to headwaters (1.5 miles)	Jefferson	White Pine STP.
Little Pigeon River	Mile 0.0 to 4.7	Sevier	Improper connections to storm sewers, leaking sewers, and failing septic tanks.
Pine Creek	Mile 0.0 to 10.1	Scott	Oneida STP and collection system.
Litton Fork of Pine Creek	Mile 0.0 to 1.0		
South Fork of Pine Creek	Mile 0.0 to 0.7		
East Fork of Pine Creek	Mile 0.0 to 0.8		
North Fork of Pine Creek	Entire Stream (1.5 Miles)		
Second Creek	Entire Stream (2.9) Miles	Knox	Knoxville urban runoff.
Sinking Creek	Mile 0.0 to 2.8	Washington	Agriculture & urban runoff.
Sinking Creek Embayment of Ft. Loudoun Res.	1.5 miles from head of embayment to cave	Knox	Knoxville Urban Runoff
Third Creek	Mile 0.0 to 1.4, Mile 3.3	Knox	Knoxville urban runoff.
East Fork of Third Creek	Mile 0.0 to 0.8	Knox	Knoxville urban runoff.

(Table continued on the next page)

Table 10: Bacteriological Advisories in Tennessee
(Continued from previous page)

East Tennessee (continued)

Waterbody	Portion	County	Comments
Johns Creek	Downstream portion (5.0 miles)	Cocke	Failing septic tanks.
Baker Creek	Entire stream (4.4 miles)	Cocke	Failing septic tanks.
Turkey Creek	Mile 0.0 to 5.3	Hamblen	Morristown collection system.
West Prong of Little Pigeon River	Mile 0.0 to 17.3	Sevier	Improper connections to storm sewers, leaking sewers, and failing septic tanks.
Beech Branch	Entire stream (1.0 mile)		
King Branch	Entire stream (2.5 miles)		
Gnatty Branch	Entire stream (1.8 miles)		
Holy Branch	Entire stream (1.0 mile)		
Baskins Branch	Entire stream (1.3 miles)		
Roaring Creek	Entire stream (1.5 miles)		
Dudley Creek	Entire stream (5.7 miles)		

Southeast Tennessee

Waterbody	Portion	County	Comments
Chattanooga Creek	Mouth to GA line (7.7 mi.)	Hamilton	Chattanooga collection system.
Little Fiery Gizzard	Upstream natural area to Grundy Lake (3.7 miles).	Grundy	Failing septic tanks in Tracy City.
Clouse Hill Creek	Entire Stream (1.9 miles)		
Hedden Branch	Entire Stream (1.5 miles)		
Oostanaula Creek	Mile 28.4 -31.2 (2.8 miles)	McMinn	Athens STP and upstream dairies.
Stringers Branch	Mile 0.0 to 5.4	Hamilton	Red Bank collection system.
Citico Creek	Mouth to headwaters (7.3 miles)	Hamilton	Chattanooga urban runoff and collection system.

(Table continued on the next page)

Table 10: Bacteriological Advisories in Tennessee

(Continued from previous page)

Middle Tennessee

Waterbody	Portion	County	Comments
Duck River	Old Stone Fort State Park (0.2 mile)	Coffee	Manchester collection system.
Little Duck River	Old Stone Fort State Park (0.2 mile)		
Mine Lick Creek	Mile 15.3 to 15.8 (0.5 mile)	Putnam	Baxter STP.
Nashville Area		Davidson	Metro Nashville collection system overflows and urban runoff.
Brown's Creek	Main Stem (4.3 miles)		
Dry Creek	Mile 0.0 to 0.1		
Gibson Creek	Mile 0.0 to 0.2		
McCrory Creek	Mile 0.0 to 0.2		
Tributary to McCrory Creek	Mile 0.0 to 0.1		
Richland Creek	Mile 0.0 to 2.2		
Whites Creek	Mile 0.0 to 2.1		
Cumberland River	Bordeaux Bridge (Mile 185.7) to Woodland Street Bridge (Mile 190.6)		

West Tennessee

Waterbody	Portion	County	Comments
Cypress Creek	Entire Stream (7.7 miles)	Shelby	Urban stormwater runoff.

B. Fish Tissue Contamination

Approximately 124,200 reservoir acres and 282 river miles are currently posted due to contaminated fish (Table 11). The contaminants most frequently found at elevated levels in fish tissue are PCBs, mercury, and chlordane (Figure 18 and 19).

The list of waterbodies with advisories is on the TDEC website and in TWRA fishing regulations given to sports fisherman when they purchase a fishing license. Signs are also mounted at public access points to posted waterbodies. There are two types of consumption advisories. The no consumption advisory targets the general population and warns that no one should eat specific fish from this body of water. The precautionary advisory specifies that children, pregnant women, and nursing mothers should not consume the fish species named, while all other people should limit consumption to one meal per month. If needed, TWRA can enforce a fishing ban.

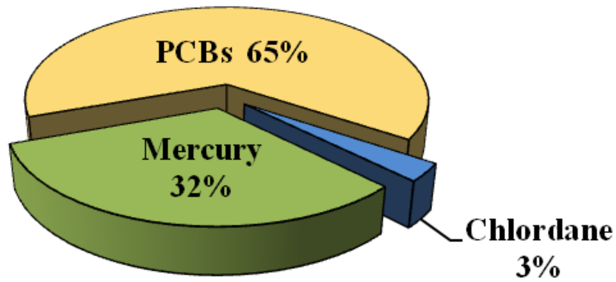


Figure 18: Percent Contribution of Reservoir Acres Posted for Fish Tissue Contamination

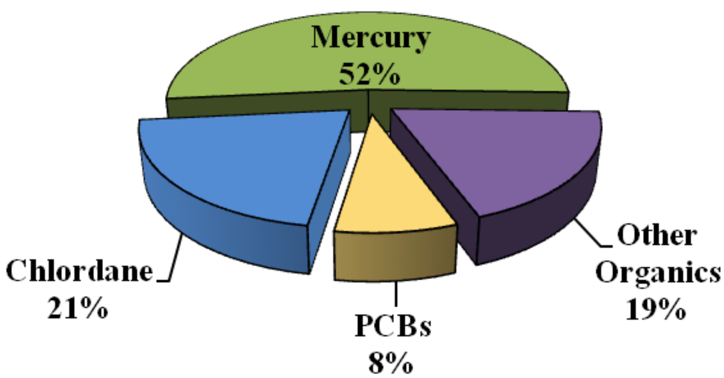


Figure 19: Percent Contribution of Stream Miles Posted for Fish Tissue Contamination

1. Organic contaminants

The majority of the lake reservoirs and about half of the stream miles posted for fish tissue contamination are affected by organic contaminants (Figures 18 and 19). These organic substances tend to bind with the sediment, settle out of the water, and persist in the environment for a very long time. In the sediment, they become part of the aquatic food chain and over time, bioconcentrate in fish tissue. Contaminants can be found in fish tissue even if the substance has not been used or manufactured in decades. A brief synopsis of the effects of some of these specific carcinogens and/or toxic substances appears below.

a. PCBs - PCBs were used in hundreds of commercial and industrial processes including electrical insulation, pigments for plastics, and plasticizers in paints. Over 1.5 billion pounds of PCBs were produced in the U.S. prior to the ban on the manufacture and distribution of PCBs in 1976.
Once PCBs enter a river or reservoir, they tend to bind with sediment particles. Over time, they enter the food chain and are concentrated in fish tissue. When people eat contaminated fish, PCBs are stored in the liver, fat tissue, and even excreted in breast milk. EPA has determined that PCBs are a probable human carcinogen (cancer causing agent). Additionally, in high enough concentrations, PCBs are likely to damage the stomach, liver, thyroid gland, and kidneys and cause a severe skin disorder.

b. Chlordane - Chlordane is a pesticide that was used on crops, lawns, and for fumigation from 1948 to 1978 when EPA banned all above ground use. For the next decade, termite control was the only approved usage of chlordane. In 1988, all use of chlordane in the U.S. was banned.

Like PCBs, chlordane bioconcentrates in the food chain and is detected in fish throughout Tennessee. In people, chlordane is stored in the liver and fat tissue. EPA has determined that chlordane is a probable human carcinogen. Other possible effects to people are damage to the liver, plus nervous and digestive system disorders.

c. Dioxins - Dioxins are the by-product of certain industrial processes and the combustion of chlorine-based chemicals. Dioxins refer to a class of compounds with a similar structure and toxic action. Most of these chemicals are produced from the incineration of chlorinated waste, the historical production of herbicides, the production of PVC plastics, and the bleaching process historically used by paper mills.

Like many other organic contaminants, dioxins are concentrated in fish. Even at extraordinarily low levels (i.e. parts per quadrillion), dioxins can exert a toxic effect on larval fish. Dioxins are classified as a probable human carcinogen. Other likely effects in people are changes in hormone levels and developmental harm to children.

2. Mercury

Mercury is a naturally occurring element found in air, water and soil. It exists in several forms: elemental or metallic mercury, inorganic mercury compounds, and organic mercury compounds. Natural sources of mercury include volcanoes, geysers, weathering of rocks, and forest fires. However, there are significant anthropogenic sources of mercury. Mercury is found in many rocks including coal. When coal is burned, mercury is released into the environment. According to the EPA 2005 national emissions inventory, coal-burning power plants are the largest human-caused source of mercury air emissions in the United States, accounting for over 50 percent of all domestic human-caused mercury emissions.

There is a well-documented link to human health impacts. Exposures to mercury can affect the human nervous system and harm the brain, heart, kidneys, lungs, and immune system. In pregnant women, ingested mercury is readily carried throughout the body by the bloodstream and easily migrates through the placenta to a developing fetus. The consumption of contaminated fish is considered to be the major pathway of mercury exposure for most people.

In 2007, the FDA and EPA issued a joint federal advisory of 0.3 ppm as the appropriately protective level for mercury in locally-consumed freshwater fish. Prior to 2007, TDEC used the FDA Action Level for fish sold in interstate commerce (0.5 ppm) as a trigger for considering advisories. The department considers the evidence compelling that fish tissue mercury levels over 0.3 ppm have a potentially detrimental effect on the health of Tennesseans and now uses this level as a trigger point for fishing advisories (Denton, 2007).

Fish are collected to check contaminant levels. *Photo provided by Aquatic Biology Section, TDH.*

The type of advisory considered appropriate when mercury levels are over 0.3 ppm, but not above 1.0 ppm will be a "precautionary advisory" which advises pregnant or nursing mothers, plus children, to avoid any consumption of fish. All other persons will be advised to limit fish consumption to one or one meal per month. If 1.0 ppm is exceeded, all persons will be advised to avoid consumption in any amount.

Reducing Risks from Contaminated Fish

The best way to protect yourself and your family from eating contaminated fish is by following the advice provided by the Department of Environment and Conservation. Cancer risk is accumulated over a lifetime of exposure to a carcinogen (cancer-causing agent). For that reason, eating an occasional fish, even from an area with a fishing advisory, will not measurably increase your cancer risk.

At greatest risk are children and people who eat contaminated fish for years, such as recreational or subsistence fishermen. People with a previous occupational exposure to a contaminant should also limit exposure to that pollutant. Studies have shown that contaminants can cross the placental barrier in pregnant women to enter the baby's body, thereby increasing the risk of developmental problems. These substances are also concentrated in breast milk.

The Division's goal in issuing fishing advisories is to provide the information necessary for people to make **informed choices** about their health. People concerned about their health will likely choose not to eat fish from contaminated sites. If you choose to eat fish in areas with elevated contaminant levels, here is some advice on how to reduce this risk:

1. **Throw back the big ones.** Smaller fish generally have lower concentrations of contaminants.

2. **Avoid fatty fish.** Organic carcinogens such as DDT, PCBs, and dioxins accumulate in fatty tissue. In contrast, however, mercury tends to accumulate in muscle tissue. Large carp and catfish tend to have more fat than gamefish. Moreover, the feeding habits of carp, sucker, buffalo, and catfish tend to expose them to the sediments, where contaminants are concentrated.

3. **Broil or grill your fish.** These cooking techniques allow the fat to drip away. Frying seals the fat and contaminants into the food.

4. **Throw away the fat if the pollutant is PCBs, dioxins, chlordane, or other organic contaminants.** Organic pesticides tend to accumulate in fat tissue, so cleaning the fish so the fat is discarded will provide some protection from these contaminants.

5. **If the pollutant is mercury, children in particular should not eat the fish.** Fish from the posted waterbodies (see Table 11) are likely to be contaminated with mercury, which is concentrated in the muscle tissue. It is very important that children not eat fish contaminated with mercury, as developmental problems have been linked to mercury exposure.

Table 11: Fish Tissue Advisories in Tennessee

For most current revisions: http://www.tn.gov/environment/wpc/publications/advisories.pdf)

West Tennessee

Waterbody	County	Portion	HUC Code	Pollutant	Comments
Beech Reservoir	Henderson	Entirety (877 acres)	06040001	Mercury	Precautionary advisory for largemouth bass. *
Cypress Creek	Shelby	Entirety (7.7 miles)	08010210	Chlordane, Other Organics, PCBs	Do not eat the fish.
Loosahatchie River	Shelby	Mile 0.0 – 17.0 (Hwy 14, Austin Peay Highway)	08010209	Chlordane, Other Organics, Mercury	Do not eat the fish.
McKellar Lake	Shelby	Entirety (13 miles)	08010100	Chlordane, Other Organics, Mercury	Do not eat the fish.
Mississippi River	Shelby	Mississippi Stateline to just downstream of Meeman-Shelby State Park (31 miles)	08010100	Chlordane, Other Organics, Mercury	Do not eat the fish. Commercial fishing prohibited by TWRA.
North Fork Forked Deer River	Gibson	From the mouth of the Middle Fork Forked Deer River (Mile 17.6) upstream to State Highway 188 (Mile 23.6).	08010204	Mercury	Precautionary advisory for largemouth bass. *
Nonconnah Creek	Shelby	Mile 0.0 to 1.8	08010201	Chlordane, Other Organics	Do not eat the fish. Advisory ends at Horn Lake Road Bridge
Wolf River	Shelby	Mile 0.0 – 18.9	08010210	Chlordane, Other Organics, Mercury	Do not eat the fish.

(Table continued on next page)

Table 11: Fish Tissue Advisories in Tennessee
(continued from previous page)

Middle Tennessee

Waterbody	County	Portion	HUC Code	Pollutant	Comments
Beech Creek	Wayne	From mouth to origin (Mile 16.7) including Tennessee River Embayment	06040001	Mercury	Do not eat the fish or wade/swim. Avoid contact with sediment between Leatherwood Branch and Smith Branch.
Buffalo River	Humphreys, Perry	From the mouth upstream to Highway 438 (Mile 31.6)	06040004	Mercury	Precautionary advisory for smallmouth bass. *
Duck River	Humphreys, Hickman	From mouth of Buffalo River (Mile 15.8) upstream to Interstate 40 (Mile 31.8).	06040003	Mercury	Precautionary advisory for largemouth, smallmouth, and spotted bass. *
Woods Reservoir	Franklin	Entirety (3,908 acres)	06030003	PCBs	Catfish should not be eaten.

East Tennessee

Waterbody	County	Portion	HUC Code	Pollutant	Comments
Boone Reservoir	Sullivan, Washington	Entirety (4,400 acres)	06010102	PCBs, chlordane	Precautionary advisory for carp and catfish. *
Chattanooga Creek	Hamilton	Mouth to Georgia Stateline (11.9 miles)	06020001	PCBs, chlordane	Fish should not be eaten. Also, avoid contact with water.

(Table continued on next page.)

Table 11: Fish Tissue Advisories in Tennessee
(continued from previous page)

Waterbody	County	Portion	HUC Code	Pollutant	Comments
East Fork of Poplar Creek including Poplar Creek embayment	Anderson, Roane	Mile 0.0 – 15.0 (entirety)	06010207	Mercury, PCBs	Fish should not be eaten. Also, avoid contact with water.
Emory River	Roane, Morgan	From Highway 27 near Harriman (Mile 12.4) upstream to Camp Austin Road Bridge (Mile 21.8)	06010208	Mercury	Precautionary advisory for all fish. *
Fort Loudoun Reservoir	Loudon, Blount	Entirety (14,600 acres)	06010201	PCBs Mercury (Upper portion only)	Commercial fishing for catfish prohibited by TWRA. No catfish or largemouth bass over two pounds should be eaten. Do not eat largemouth bass from the Little River embayment. Due to mercury, precautionary advisory for any sized largemouth bass from Highway 129 to the confluence of Holston and French Broad Rivers (534 acres). *

(Table continued on next page.)

Table 11: Fish Tissue Advisories in Tennessee
(continued from previous page)

Waterbody	County	Portion	HUC Code	Pollutant	Comments
French Broad River	Cocke	From Rankin Bridge (mile 71.4) to Hwy 321 near Newport (Mile 77.5)	06010105	Mercury	Precautionary advisory for largemouth bass. *
Hiwassee River	Meigs, McMinn, Bradley	From Highway 58 (Mile 7.4) upstream to the railroad bridge just upstream of U. S. Highway 11 (Mile 18.9)	06020002	Mercury	Precautionary advisory for largemouth bass. *
Holston River	Hawkins, Sullivan	From the mouth of Poor Valley Creek Embayment (Mile 89.0) upstream to the confluence of the North and South Forks of the Holston near Kingsport (Mile 142.3).	06010104	Mercury	Precautionary advisory for all fish *
Melton Hill Reservoir	Knox, Anderson	Entirety (5,690 acres)	06010207	PCBs	Catfish should not be eaten.
Nickajack Reservoir	Hamilton, Marion	Entirety (10,370 acres)	06020001	PCBs	Precautionary advisory for catfish. *
Norris Reservoir	Campbell, Anderson, Union, Claiborne, Grainger	Clinch River Portion (Powell River embayment not included in advisory.) (15,213 acres)	06010205	Mercury	Precautionary advisory for largemouth bass, striped bass, smallmouth bass, and sauger. *
North Fork Holston River	Sullivan, Hawkins	Mile 0.0 - 6.2 (VA stateline)	06010101	Mercury	Do not eat the fish. Advisory goes to TN/VA line.

(Table continued on next page.)

Table 11: Fish Tissue Advisories in Tennessee
(continued from previous page)

Sequatchie River	Marion	County from the Tennessee River (Mile 0.0) upstream to State Highway 283 near Whitwell (Mile 22.1)	06020004	Mercury	Precautionary advisory for largemouth bass. *
South Holston Reservoir	Sullivan	Portion within Tennessee (7,206 acres)	06010102	Mercury	Precautionary advisory for largemouth bass. *
Tellico Reservoir	Loudon, Monroe	Entirety (16,500 acres)	06010204	PCBs, Mercury	Catfish should not be eaten.
Watauga Reservoir	Carter, Johnson	Entirety (6,427 acres)	06010103	Mercury	Precautionary advisory for largemouth bass and channel catfish. *
Watts Bar Reservoir	Roane, Meigs, Rhea, Loudon	Tennessee River portion (38,000 acres)	06010201	PCBs	Catfish, striped bass, & hybrid (striped bass-white bass) should not be eaten. Precautionary advisory for white bass, sauger, carp, smallmouth buffalo and largemouth bass. *
Watts Bar Reservoir	Roane, Anderson	Clinch River arm (1,000 acres)	06010201	PCBs	Striped bass should not be eaten. Precautionary advisory for catfish and sauger. *

*Precautionary Advisory - Children, pregnant women, and nursing mothers should not consume the fish species named. All other persons should limit consumption of the named species to one meal per month.

Where contaminants are elevated in fish, they may also be present in other aquatic life as well. Therefore, the public is advised to limit or avoid consumption of other animals such as turtles, crayfish and mussels in waterbodies with a fishing advisory. Additional national fish tissue advisories have been issued for the most sensitive sub-populations: pregnant women, nursing mothers, children, and women who could become pregnant.

Chapter 6 SUCCESS STORIES

A. Ocoee River

The section of the Ocoee from the mouth of Davis Mill Creek to Parksville Reservoir has been polluted by extensive copper mining activities for over 150 years. Mining operations ceased in 1987, and sulfuric acid production was discontinued in 2000. Over the past 25 years, various government agencies and private parties have taken steps to stabilize and re-vegetate this large area.

The historic pollutants include acid, heavy metals, and sediment. According to the EPA, Davis Mill Creek makes up about one percent of the flow of the Ocoee, but is the largest single source of acidity and heavy metals (EPA 2005).

In November 2002, a wastewater treatment plan on Davis Mill Creek was refurbished by Glenn Spring Holding under agreement with EPA and TDEC to more efficiently treat the acid and metal laden waters of the creek, underground mine waters and contaminated stream water. The treatment plant has removed over 16 million pounds of metals (iron, zinc, manganese, copper, lead, cadmium) and neutralized approximately 28 million pounds of acid from the creek that would have otherwise flowed into the Ocoee River.

Other clean-up activities in the Davis Creek watershed include Belltown Creek and Gypsum Pond diversion system which routes clean water around the most contaminated parts of the watershed and reduces the volume of water requiring treatment. Three existing dams have been upgraded and modified to detain contaminated stormwater for treatment.

These activities have dramatically reduced the loading of metals to the Ocoee and monitoring downstream of the mouth of Davis Mill Creek indicates that water quality criteria are now being met.

This is a historic success story with the credit for water quality improvements being shared by many state and federal agencies More information related to the copper mining cleanup and ongoing efforts in the area can be found on EPA's website:

Some waste materials were historically deposited directly into, or very close to, Davis Mill Creek. *Photo from EPA*

http://www.epa.gov/aml/tech/copperbasin.pdf
http://www.epa.gov/region4/superfund/sites/npl/tennessee/copbastn.html

B. Burra Burra Creek Restoration Project

A second example of a successful treatment activity in the Copper Basin area is the Burra Burra Creek restoration. Glenn Springs Holdings, TDEC and EPA have been working in partnership on the restoration and remediation of North Potato Creek watershed since 2001. One of the projects included the restoration of Burra Burra Creek, a tributary to North Potato Creek in Polk County.

The Burra Burra Creek watershed was the primary site of sulfide ore processing for over one hundred years. This watershed was utilized as a waste treatment system with various dams built to dewater tailings and process ore sludge, as a conduit for the transport of wastewater away from the processing facilities, and the recipient of water leaching through overburden placed within the watershed. All of the alterations and uses yielded highly polluted waters resulting in Burra Burra Creek being devoid of aquatic life. Consequently, remediation and restoration of Burra Burra Creek became a central element in the restoration of the North Potato Creek watershed. The restoration of the 5,300 linear feet of Burra Burra Creek included:

1. Removal of 200,000 cubic yards of contaminated soil within the stream corridor;
2. Placement of 150, 000 cubic yards of clean soil within the stream corridor, creating a new channel alignment and floodplain;
3. Construction of a geomorphically stable stream channel;
4. Placement of 1,100 cubic yards of clean river rock for aquatic habitat in the new channel; and
5. Planted the riparian zones with native plants and trees.

The stream restoration project was completed on June 12, 2012, nineteen months after it was started.

Scientists are currently monitoring the development of the various biological communities in the newly restored Burra Burra Creek. To date, tadpoles and occasional fish have been documented to be living in the new stream. Monitoring the expansion and diversification of the aquatic communities is an integral part of the remedial actions for the Copper Basin Restoration Project.

Photo provided by Dave Turner, KEFO.

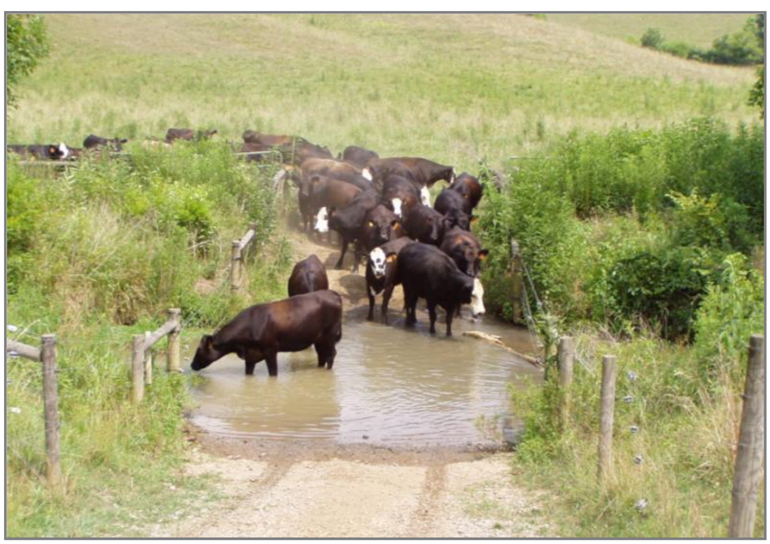
C. Gallagher Creek Restoration Project

Gallagher Creek, located in Blount County Tennessee is a 13.2 mile stream that runs through the town of Friendsville and empties into Fort Loudoun Reservoir. Agriculture accounts for 63% of the land use in the watershed. The creek was first 303(d) listed in 2002 for siltation due to pasture grazing. A siltation TMDL was approved for the Fort Loudoun Reservoir watershed in February 2006.

Many best management practices were installed along Gallagher Creek between 2000 and 2011. These included septic system improvements, alternative water sources, fencing, rotational grazing, critical area planting and crop conversion. The Tennessee Department of Agriculture helped landowners cost share for BMPs installed on their land. Partners included the Smoky Mountain Resource Conservation and Development (RC&D), Blount County Soil Conservation District (SCD) and TDEC. These actions helped the water quality and habitat improve in the Gallagher Creek watershed. Aquatic populations improved and the stream was delisted in 2010.

Alternative water sources keep livestock from polluting streams and eroding banks. Sheep drink at a watering tank provided by a farmer in the Gallagher Creek watershed. The fencing and tank were bought with cost share money through the state's Agricultural Resource Conservation Fund.

Photo provided by Carole Swann, *Tennessee Department of Agriculture (TDA).*



This stream crossing with exclusion fencing helps keep livestock out of the creek while still allowing access to other field areas. Note the gravel which helps to prevent cattle from eroding banks. Such efforts help to keep pathogens out of Gallagher Creek as well as sediment.

Photo provided by Carole Swann, TDA.

D. Harpeth River Dam Removal

In July 2012, a lowhead dam on the Harpeth River in Franklin was removed. The Harpeth River is a state designated scenic river and one of the most ecologically, culturally, historically, and recreationally significant rivers in the state. It drains nearly 900 square miles in Middle Tennessee and flows through one of the fastest growing areas in the country.

The six foot tall dam, which impounded about two miles of the Harpeth River, has been in place since 1963 as part of the City of Franklin's municipal water intake system. Improvements to the intake configuration no longer require the impoundment in order to withdraw water.

Removal of the dam makes the 125 mile long Harpeth River entirely free flowing. It is one of three of the last remaining rivers in Middle Tennessee with darter and mussel species that need riffle/run habitat. In addition to restoring riffle/run habitat the dam's removal will help stabilize banks and increase dissolved oxygen in the river. The project will also enhance public access and recreational opportunities on the Harpeth for fishing and paddling.

The removal of the Franklin's lowhead dam was part of a national effort over the past 50 years that has seen the removal of over 600 dams around the country according to a compilation by American Rivers. In Tennessee, 25 dams (8 to 160 feet tall) have been removed around the state in the last 40 years.

Photo courtesy of the Harpeth River Watershed Association's Dam Cam

The National Fish Habitat Partnership designated this project in their "2012 Ten Waters to Watch list." The Department of Interior also named this collaborative project as a model of America's Great Outdoors River Initiative to conserve and restore key rivers across the nation, expand outdoor recreational opportunities and support jobs in local communities.

Chapter 7 Special Projects

The division carries out special monitoring projects for a number of reasons. One reason is to supplement current narrative criteria and to refine existing numeric criteria to reflect natural regional differences. Another objective is to augment routine monitoring with specific studies. These projects are undertaken to answer specific questions about existing water quality or trends.

A. Headwater Reference Streams

TDEC has established macroinvertebrate and nutrient guidelines for narrative criteria for assessing wadeable streams throughout the state based on reference stream monitoring in 31 ecoregions. These guidelines are designed for streams with drainage areas greater than two square miles and are not always appropriate for comparison to headwater streams.

Headwater streams are an important component of every watershed. They comprise the highest percentage of stream miles in the state. The health of larger streams and rivers depends upon an intact primary headwater stream network. These small streams nourish downstream segments with essential supplies of water and food materials. Vegetated buffers assist in reducing sediment delivery to larger streams. They increase biodiversity, offering unique habitat niches and refugia from competitors, predators, and exotic species.

In 2008, the division began a seven year study to identify and monitor first and second order reference streams in 13 Tennessee bioregions to aid in development of biological and nutrient criteria guidelines in headwater streams.

A headwater reference stream for the Northern Hilly Gulf Coastal Plain (65e) is located in Natchez Trace State Park. *Photo provided by Amy Fritz, JEFO*

These guidelines will be used to assess headwater streams for the 305(b) and 303(d) reports, locate exceptional headwater streams through the antidegradation process, provide information for point-source discharge and aquatic resource alteration permits as well as provide information for TMDL studies. The study will also help Tennessee achieve three of its nutrient criteria workplan goals, develop nutrient criteria guidelines for headwater streams, develop associated biological criteria for headwater streams, and add a second biological indicator group (periphyton) to nutrient and biological criteria.

B. Mercury Air Deposition

Not all pollutants enter waterbodies directly from point source discharges or surface run-off. Some, such as air-borne mercury, can be carried by rain. In summer 2009 the division conducted a study to test fish and water from 33 waterbodies to test the accuracy of an air deposition model for predicting mercury contamination (Arnwine and Graf, 2010).

The study was designed to field test the Regional Modeling System for Aerosols and Deposition (REMSAD) model's ability to accurately predict waterbody and fish tissue contamination from air deposition of mercury in Tennessee. Thirty-three sites were targeted for this study in areas where the model predicted various levels of mercury deposition. Additional sites were located in areas where the model did not predict elevated mercury, but where potential sources of airborne mercury were located in the vicinity. Fish tissue and water samples were collected at each site.

Sampling results indicate the REMSAD model for air deposition of mercury does not appear to be a useful tool for predicting mercury contamination in Tennessee waterbodies. The mercury levels found in fish tissue did not correlate with the air deposition model. Several fish taken from areas with predicted high levels of mercury air deposition contained relatively low levels of contamination. Other fish that had higher concentrations of mercury came from areas with low predicted depositional mercury.

Several variables may account for the discrepancy between predicted air deposition and mercury concentrations in fish tissue. This may be in part because the top emitters according to the Tennessee Division of Air Pollution were not tagged as top emitters by the model, although they were probably included in the collective sources. Another factor is that the REMSAD model does not simulate all of the processes that occur as part of the mercury cycle, such as methylation and bioaccumulation. There may also be unknown sources of non-depositional mercury contributing to elevated levels in some areas.

The study does demonstrate that smaller waterbodies in isolated areas should be checked for mercury contamination particularly if largemouth bass are routinely consumed by the public.

The study also indicates that selenium levels in water and fish throughout the state are generally low. Fish concentrations were slightly elevated at two sites according to 2004 EPA draft guidance which is currently under revision. Both sites have large scale land disturbance through historic mining activities. Selenium was not detected in any of the water samples. The existing selenium criterion is based on water.

The full report is available online at:
http://tn.gov/environment/wpc/publications/pdf/air_deposition_rpt.pdf

C. 2010 Probabilistic Monitoring of Wadeable Streams

In 2010, the Division of Water Pollution Control conducted a statewide probabilistic monitoring study of 90 wadeable streams to supplement the traditional targeted watershed monitoring (Arnwine et al. 2011). This is a follow-up to a study initiated in 2007. Since this is only the second period of monitoring, it is too early to evaluate trends. However, it is possible to compare 2007 data, when most of the state was in a severe drought, to 2010 conditions.

In 2010 there was a 23% increase in sites meeting macroinvertebrate guidelines in west Tennessee. It is likely the severe drought affected 2007 scores in this part of the state. Passing scores decreased 13 % in middle Tennessee possibly due to effects of record spring floods. There was little change in the eastern division.

Overall habitat scores have fallen statewide in Tennessee. Large scale weather conditions and refinements to the habitat assessment protocol since the last study has probably affected scoring. Future habitat assessments will show if the lowering of scores this year was due to weather conditions, new protocols, or indicate a downward trend.

Statewide, the number of stations that met ecoregional guidelines for narrative criteria in summer for total phosphorus increased, while the number that met nitrate + nitrite criteria guidelines decreased. In 2010, mean and median phosphorus concentrations across the state were a little more than half the 2007 levels.

The 2010 study included the analysis of nine metals which were not in the previous study. Most of the metals, with the exception of chromium, mercury and zinc, were highest in west Tennessee and lowest in the middle division. Cadmium and selenium were not detected at any site. Mercury was only detected at one site, which has a historic source. The toxicity of certain metals on fish and aquatic life can vary based on the total hardness of the water and the level of total suspended solids. All metal exceedances of water quality criteria were in west Tennessee, where low hardness was often a factor.

It is important to realize that probabilistic monitoring is a useful tool for trend analysis and for statewide comparisons due to the consistency of methodology at every site. However, the 2007 and 2010 probabilistic studies were not intended to replace the more extensive targeted monitoring program designed for water quality assessments. The probabilistic study reports the percentage of criteria violations for individual parameters based on a single sample event at randomly selected sites. Assessments used for 305(b)/303(d) reporting are based on multiple samples from multiple sites within a single reach as well as evaluations of land-use and field observations.

The full report is available online at:
http://tn.gov/environment/wpc/publications/pdf/wsa2010.pdf

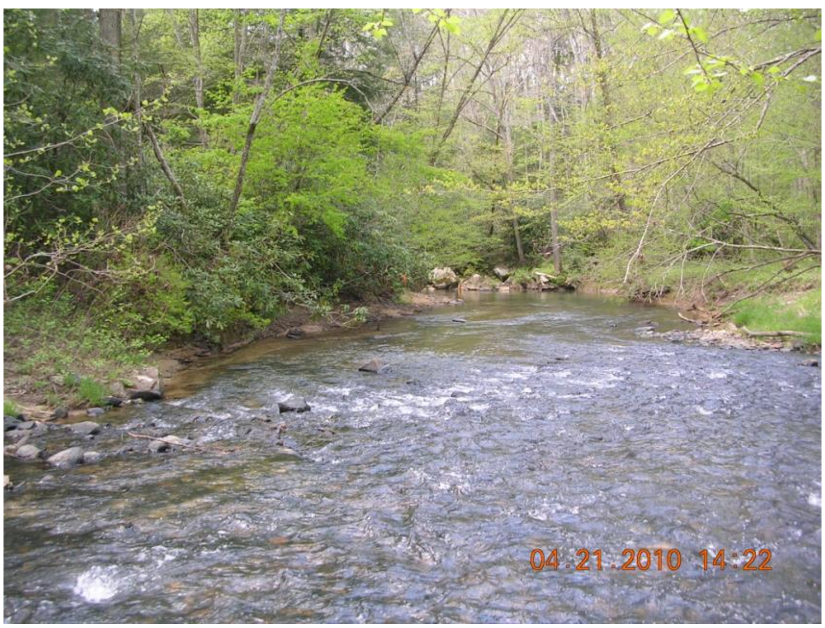
D. Coalfields Fish Tissue Monitoring

Tennessee has a history of surface coal mining in the Cumberland Plateau and Cumberland Mountain regions. Many of the streams draining these regions are on the 303(d) list for active or abandoned mining based on macroinvertebrate samples and appear to be improving. Fish tissue samples have not been collected at the majority of these sites. TDEC partnered with the Tennessee Valley Authority (TVA), to collect fish tissue samples of native game fish (preferably piscivores) between September 2011 and December 2011 to check for biological accumulation of metals in fillets.

Forty-three sites were targeted for sampling. Fifteen sites had active mining in the watershed. Twenty five were in areas of historic mining. One site drained an area with historic large scale copper mining, one was downstream of mica mines and one site had no history of mining. Three of the sites with historic mining were considered reference sites due to recovery and/or small area of disturbance.

Game fish were successfully collected fish at 22 of the 43 sites. Of the remaining 21 sites, two sites were dry, three sites had no fish present, and 16 sites either did not contain fish species targeted for study or the targeted species present were smaller than desired. Sufficient fish ovaries were collected at 15 sites and were analyzed for selenium in accordance with EPA's draft criteria guidance.

Physical and chemical water quality samples (metals, nutrients, temperature, dissolved oxygen, flow, etc.) were collected at 42 of the 43 study sites. Although two sites (Hicks and Woodcock) were observed to be dry during several site visits, TVA was able to collect samples at Woodcock following a period of substantial rainfall.



Tackett Creek in Claiborne County is one of the streams with active mining sampled for the study. *Photo provided by Dave Turner, TDEC Mining Section.*

Data are currently being analyzed and a final report should be available by the end of the year.

E. Study of Pharmaceuticals and Personal Care Products (PPCP)

Pharmaceutical and personal care products (PPCP) include prescription and over-the-counter drugs, diagnostic agents, dietary supplements, fragrances, soaps, conditioners, sunscreens, cosmetics, caffeine, and nicotine. PPCPs also include antibiotics used prophylactically to prevent disease in livestock production (feedlot) operations (many water-soluble compounds). The most common mechanism for their entry into the environment is through wastewater discharges (municipal and septic drainage), land application of sewage sludge and manure, and landfill leachate.

Over the past decade, water quality surveys have indicated that numerous areas of the United States, including Tennessee, have pharmaceuticals and steroid hormones in their waterways. Additional studies have linked the exposure of fish and amphibians to natural and synthetic steroids to harmful effects such as reproductive and endocrine disruption (estrogen and/or androgen).

Building upon work done by the Division of Water Supply (DWS) and the University of Tennessee, the Division of Water Resources began a study to test the presence of PCPPs in wastewater treatment plant (WWTP) effluents. Starting in July 2012, effluent samples began collecting from 115 actively discharging major WWTPs (once during high-flow and once during low-flow). Pharmaceutical compounds selected for monitoring include: caffeine, nicotine, antidepressants, anticonvulsants, insect repellants such as DEET, antibacterials, 17α-ethinyl estradiol, fluoxetine, estrogen and ibuprofen.
The University of Tennessee - Knoxville will analyze the sample and provide the division with a report detailing the results of the study in late 2013.

Photo provided by Planning and Standards Section, TDEC

In urban areas where many people are concentrated, personal care products such as pain medications, antidepressants, and hormones, may be passed into the collection system, through treatment plants not designed to remove them, then ultimately into surface waters.

F. Southeast Climate Change and Reference Monitoring Network

During the annual meeting of the Southeastern Water Pollution Biologist Association (SWPBA) in November 2011, the potential for stream community changes resulting from variations in hydrology and termperature as a result of changing climate was a main focus. The result was the creation of an interagency workgroup consisting of freshwater biologists from the eight EPA region IV states and the Tennessee Valley Authority (TVA) interested in developing a joint reference stream monitoring network. Staff from EPA, USFS and USGS are also on the committee to provide technical support and advice. Although two main goals of the group are to assess existing responses to climate change and identify climate-sensitive indicators, it was agreed that a reference network with consistent sampling methodology would be useful for establishing regional reference conditions and consistency in assessments of shared watersheds and ecoregions.

Each of the region IV states and TVA agreed to target and monitor reference streams beginning in 2013 and continue annual monitoring indefinitely. Existing monitoring programs will be adjusted at key reference sites to include additional parameters so that monitoring will be consistent for all sites in the network. At a minimum, sampling will include macroinvertebrates, habitat assessments, field parameters, flow and continuous temperature monitoring. Some agencies, including TDEC intend to add periphyton, water quality, channel profiles and continuous flow. TVA has agreed to sample fish at sites draining into the Tennessee River. Protocols and selection of vulnerable streams were based on studies done by the Northeast Climate Change Monitoring group.

The goal is to establish a minimum of 30 reference sites in protected watersheds where land-use is not expected to change significantly for at least 20 years. Tennessee has agreed to monitor 10 sites in ecoregions 66, 67, 68 and 71. Ten sites will enable some statistical determinations using state data in addition to analysis of grouped data.

Project Objectives

- Establish annual monitoring at 10 reference streams consistent with protocols agreed upon by Southeast Monitoring Network.
- Develop a formal interagency partnership to develop a monitoring program that is done consistently over the long-term and can withstand changes in staff.
- Combine data with other Southeastern states for statistical interpretation of current reference condition and changes over time in undisturbed systems.
- Determine whether stream communities are being affected by climate associated variables such as changes in hydrology, temperature or riparian vegetation species.
- Distinguish potential climate change effects from natural variation and other stressors.
- Isolate biometrics/taxa that would be reliable indicators of climate change.
- Detect potential climate-related changes early in a way that informs management strategies such as restoration and adaption.

Chapter 8
Public Participation

Everyone contributes pollution in large or small ways. Often a careless or thoughtless act results in far reaching damage. By understanding how pollution impacts our planet and what each of us can do to reduce pollution, collectively we can make a difference in Tennessee and the world.

Get Involved

Environmental laws encourage public participation. Ask that environmental issues be considered in the local planning process.

Find out which watershed you live in and attend TDEC's watershed meetings. Watershed meetings are held in the third and fifth years of the watershed cycle. The meeting dates and times are posted on the TDEC website at: http://tn.gov/environment/ppo/.

Sharon Kington uses a model "wetland" sponge to demonstrate the effects of groundwater pollution. *Photo provided by Sharon Kington, CKEFO.*

Reduce, Reuse, and Recycle

Whenever possible recycle metal, plastic, cardboard, and paper, so it can be reused to make new products. Always dispose of toxic materials properly. Most auto parts stores and many service stations collect used motor oil and auto batteries for recycling. Most counties have annual toxic waste collection days for old paints, pesticides, and other toxic chemicals. Check with your local waste management service for specific dates and times.

Conserve water and electricity both at home and at work. Every gallon of water that enters the sewer must be treated. The production of energy uses natural resources and produces pollution. You will not only prevent pollution, but also save money. For further information on pollution prevention please see the website.
http://tennessee.gov/environment/ea/tp3/

Be Part of the Solution, Not Part of the Problem

1. Dispose of chemicals properly

Always dispose of toxic chemicals properly. Never pour oil, paint, or other leftover toxic chemicals on the ground, in a sinkhole, or down a drain. If you have a septic system, check it periodically to make sure it is functioning correctly to protect surface and ground water.

2. Use chemicals properly

Use all chemicals, especially lawn chemicals, exactly as the label instructs. Every year millions of pounds of fertilizer and pesticides are applied to crops and lawns and some portion is carried by runoff to streams, rivers, and reservoirs. Over-application of fertilizers and pesticides wastes money, risks damage to vegetation, and pollutes waterways. Therefore, use all chemicals, especially lawn chemicals, cautiously.

3. Prevent erosion and runoff

It is important for farmers and loggers to work closely with the Department of Agriculture (TDA) personnel to prevent erosion and runoff pollution. TDA can recommend Best Management Practices (BMP's) to reduce soil loss and prevent pollution of waterbodies.

If you see any of the following problems, please call.

More than just a few dead fish in a stream or lake.

Someone pumping a liquid from a truck into a stream (especially at night).

Unusual colors, odors, or sheen in a stream or lake.

Construction activities without proper erosion control (silt fences, hay bales, matting).

Bulldozers or backhoes in a stream removing gravel or rocks.

Groups of people removing rocks from streams, especially on the Cumberland Plateau.

Sewage pumping stations discharging directly or indirectly into a stream.

Manholes overflowing.

4. Obtain a permit

Contractors wishing to alter a stream, river, or wetland need to obtain a permit from the TDEC, Natural Resources Section. Additionally, construction sites must be covered under a General Permit for the Discharge of Stormwater for a Construction Activity. Coverage can be obtained by contacting the local TDEC Environmental Field Office (EFO) at 1-888-891-TDEC. Never buy gravel or rocks that were illegally removed from streams or rivers.

A work site must be properly stabilized to avoid erosion. All silt retention devices must be properly installed to protect a site from soil loss and waterbodies from siltation. If you hire a contractor to do any work around a stream or river, make sure they obtain the proper permits and know how to protect the waterbody. The landowner is ultimately responsible for any work done on his land.

Report Pollution

The public is an important source of information on pollution. Call your local Water Resources office if you see a water pollution problem. A map of Tennessee's Environmental Field Offices (EFO) appears on the next page (Figure 22). If your EFO is not a local call, please use our toll free number that will connect you to your nearest office.

Call your local Environmental Field Office.
See Figure 28 on the next page.

or

If your local EFO is a long distance phone call,
please call toll free.
1-888-891-TDEC
1-888-891-8332

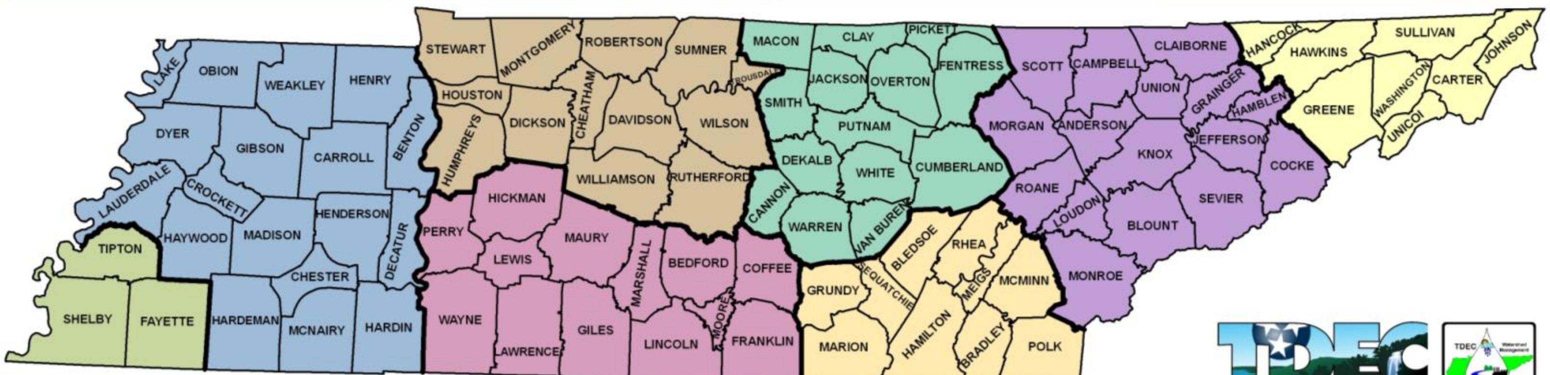
You may also contact the division by leaving a message on our website.

http://www.tn.gov/environment/

When a call is received from a citizen, division staff investigates the complaint and attempt to identify the source of pollution. If the polluter is identified, enforcement action can be taken.

Tennessee Department of Environment and Conservation
Environmental Field Offices
1-888-891-TDEC

JACKSON	NASHVILLE	COOKEVILLE	JOHNSON CITY
1625 Hollywood Drive Jackson, TN 38305	711 R.S. Gass Blvd. Nashville, TN 37243	1221 South Willow Avenue Cookeville, TN 38506	2305 Silverdale Road Johnson City, TN 37601
(731) 512-1300 **fax (731) 661-6283**	**(615) 687-7000** **fax (615) 687-7078**	**(931) 432-4015** **fax (931) 432-6952**	**(423) 854-5400** **fax (423) 854-5401**
Regional Director for External Affairs Rudy Collins (731) 512-1339	Regional Director for External Affairs Meredith Sullivan Benton (615) 687-7074	Regional Director for External Affairs Jeni Brinkman (931) 432- 7614	Regional Director for External Affairs Mark Braswell (423) 854-5459
Administrative Mgr-Carol Pollan (731) 512-1303	Administrative Mgr - Steve Janes (615) 687-7016	Administrative Mgr-Jan Tollett (931) 432-7605	Administrative Mgr-Judy Jarrett (423) 854-5404



MEMPHIS	COLUMBIA	CHATTANOOGA	KNOXVILLE
8383 Wolf Lake Drive Bartlett, TN 38133	1421 Hampshire Pike Columbia, TN 38401	Suite 550 - State Office Building 540 McCallie Avenue Chattanooga, TN 37402	3711 Middlebrook Pike Knoxville, TN 37921
(901) 371-3000 **fax (901) 371-3170**	**(931) 380-3371** **fax (931) 380-3397**	**(423) 634-5745** **fax (423) 634-6389**	**(865) 594-6038** **fax (865) 594-6105**
Regional Director for External Affairs Cindy Patton (901) 371-3001	Regional Director for External Affairs Karen Stevenson (931) 840-	Regional Director for External Affairs Steve Wilson (423) 634-5782	Regional Director for External Affairs Christine Thompson (865) 594-5524
Administrative Mgr-Lauranda Redmond (901) 371-3002	Administrative Mgr-Sheila Colston (931) 840-4142	Administrative Mgr-Andra Kelley (423) 634-5731	Administrative Mgr-Cynthia Mabe-Johnson (865)594-5450

Figure 27: TDEC Environmental Field Office Boundaries

Definitions and Acronyms

Definitions

Acute Toxicity: An adverse effect (usually death) resulting from short-term exposure to a toxic substance.

Benthic Community: Animals living on the bottom of the stream.

Biocriteria: Numerical values or narrative expressions that describe the reference biological condition of aquatic communities and set goals for biological integrity. Biocriteria are benchmarks for water resources evaluation and management decisions.

Biometric: A calculated value representing some aspect of the biological population's structure, function or other measurable characteristic that changes in a predictable way with increased human influence.

Bioregion: An ecological subregion, or group of ecological subregions, with similar aquatic macroinvertebrate communities that have been grouped for assessment purposes.

Chronic Toxicity: Sublethal or lethal effects resulting from repeated or long-term exposure to low doses of a toxic substance.

Diurnal: Having a daily cycle, with periodic fluctuation relating to day and night

Ecoregion: A relatively homogenous area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, and other ecologically relevant variables.

Ecological Subregion (or subecoregion): A smaller area that has been delineated within an ecoregion that has even more homogenous characteristics than does the original ecoregion.

Ecoregion Reference: Least impacted, yet representative, waters within an ecoregion that have been monitored to establish a baseline to which alteration of other waters can be compared.

Habitat: The instream and riparian physical features such as stones, roots, or woody debris, that influence the structure and function of the aquatic community in a stream.

Macroinvertebrate: Animals without backbones that are large enough to be seen by the unaided eye and which can be retained by a U.S. Standard No. 30 sieve (28 meshes/inch, 0.595 mm).

Periphyton: Benthic algae that are attached to surfaces such as rock or other plants.

Pathogens: Disease causing microorganisms.

Definitions (continued)

Regulated Sources: Pollution originating from sources governed by state or federal permitting requirements. These sources are typically from discrete conveyances, but also include stream alterations, urban runoff, and stormwater runoff from construction sites.

Non-Point Source Pollution: Pollution from diffuse sources as a result of rainfall or snowmelt moving over and through the ground into lakes, reservoirs, rivers, streams, wetlands, and aquifers.

Non-Regulated Sources: Activities exempted from state or federal permitting requirements. In Tennessee, these sources are agricultural and forestry activities which utilize appropriate management practices. Further, sources like atmospheric deposition might be considered unregulated sources, since they are not controllable through the water program.

Point Source Pollution: Waste discharged into receiving waters from a single source such as a pipe or drain.

Riparian Zone: An area that borders a waterbody.

Water Pollution: Alteration of the biological, physical, chemical, bacteriological or radiological properties of water resulting in loss of use support.

Watershed: A geographic area, which drains to a common outlet, such as a point on a larger lake, underlying aquifer, estuary, wetland, or ocean.

Acronyms

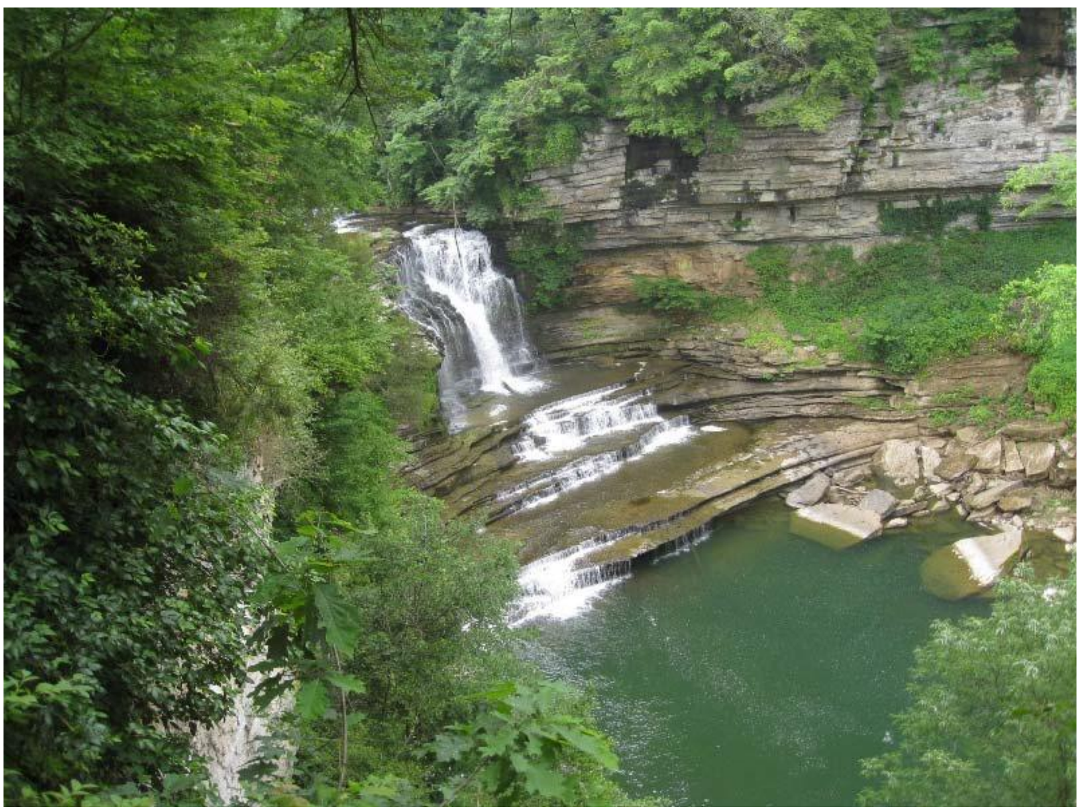
ADB:	Assessment Database
ARAP:	Aquatic Resource Alteration Permit
ATV:	All Terrain Vehicle
BMP:	Best Management Practices
CAFO:	Confined Animal Feeding Operation
CERCLA:	Comprehensive Environmental Response, Compensation, and Liability Act
CHEFO:	Chattanooga Environmental Field Office
CKEFO:	Cookeville Environmental Field Office
CLEFO:	Columbia Environmental Field Office
CWSRF:	Clean Water State Revolving Fund
DDT:	Dichloro-diphenyl-trichloroethane
DO:	Dissolved Oxygen
DOE:	Department of Energy
DIOSM:	U.S. Department of Interior Office of Surface Mining
EFO:	Environmental Field Office
EMAP:	Environmental Monitoring and Assessment Program

Acronyms (continued)

EPA:	United States Environmental Protection Agency
EPT:	Ephemeroptera (Mayflies) Plecoptera (Stoneflies) Trichoptera (Caddisflies)
ETW:	Exceptional Tennessee Waters
FAL:	Fish and Aquatic Life
FDA:	Food and Drug Administration
GIS:	Geographic Information System
GPS:	Global Positioning System
HGM:	Hydrogeomorphic
HUC:	Hydrological Unit Code (Watershed Code)
JEFO:	Jackson Environmental Field Office
JCEFO:	Johnson City Environmental Field Office
KEFO:	Knoxville Environmental Field Office
MCL:	Maximum Contaminant Level
MEFO:	Memphis Environmental Field Office
MS4:	Municipal Separate Storm Sewer Systems
NHD:	National Hydrography Dataset
NEFO:	Nashville Environmental Field Office
NPDES:	National Pollutant Discharge Elimination System
NPL:	National Priorities List
NPS:	Non-point Source
NRCS:	Natural Resource Conservation Service
OHV:	Off Highway Vehicle
ONRW:	Outstanding Natural Resource Waters
ORNL:	Oak Ridge National Laboratory
OSM:	Office of Surface Mining
PCB:	Polychlorinated Biphenyls
PAH:	Polycyclic Aromatic
PAS:	Planning and Standards Section
QAPP:	Quality Assurance Project Plan
QSSOP:	Quality System Standard Operating Procedure
PPM:	Parts Per Million
RDX:	Cyclotrimethylenetrinitramine
RIT:	Reach Indexing Tools
SOP:	Standard Operating Procedure
STORET:	EPA's STOrage and RETrieval Database
STP:	Sewage Treatment Plant
TDEC:	Tennessee Department of Environment and Conservation
TDA:	Tennessee Department of Agriculture
TDH:	Tennessee Department of Health

Acronyms (continued)

TKN:	Total Kjeldahl Nitrogen
TMDL:	Total Maximum Daily Load
TMI:	Tennessee Macroinvertebrate Index
TVA:	Tennessee Valley Authority
TWRA:	Tennessee Wildlife Resource Agency
USACE:	U.S. Army Corps of Engineers
USGS:	U.S. Geological Survey
USFWS:	U.S. Fish and Wildlife Service
WET:	Whole Effluent Toxicity
WPC:	Water Pollution Control
WSA:	Wadeable Streams Assessment
WQOGB:	Water Quality, Oil & Gas Board
WQDB:	Water Quality Database
WQX:	Water Quality Exchange
WWTP:	Waste Water Treatment Plant



Cummins Falls in Jackson County is the newest Tennessee State Park designated May 22, 2012. *Photo from TDEC Field Explorer.*

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To reach your local
ENVIRONMENTAL FIELD OFFICE
Call 1-888-891-8332 or 1-888-891-TDEC